## Contents

<table>
<thead>
<tr>
<th>1 What's New</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 v0.23.2</td>
<td></td>
</tr>
<tr>
<td>1.1.1 Logical Reductions over Entire DataFrame</td>
<td>3</td>
</tr>
<tr>
<td>1.1.2 Fixed Regressions</td>
<td>4</td>
</tr>
<tr>
<td>1.1.3 Build Changes</td>
<td>4</td>
</tr>
<tr>
<td>1.1.4 Bug Fixes</td>
<td>4</td>
</tr>
<tr>
<td>1.2 v0.23.1</td>
<td></td>
</tr>
<tr>
<td>1.2.1 Fixed Regressions</td>
<td>5</td>
</tr>
<tr>
<td>1.2.2 Performance Improvements</td>
<td>6</td>
</tr>
<tr>
<td>1.2.3 Bug Fixes</td>
<td>6</td>
</tr>
<tr>
<td>1.3 v0.23.0 (May 15, 2018)</td>
<td></td>
</tr>
<tr>
<td>1.3.1 New features</td>
<td>8</td>
</tr>
<tr>
<td>1.3.1.1 JSON read/write round-trippable with <code>orient='table'</code></td>
<td>10</td>
</tr>
<tr>
<td>1.3.1.2 <code>.assign()</code> accepts dependent arguments</td>
<td>11</td>
</tr>
<tr>
<td>1.3.1.3 Merging on a combination of columns and index levels</td>
<td>12</td>
</tr>
<tr>
<td>1.3.1.4 Sorting by a combination of columns and index levels</td>
<td>13</td>
</tr>
<tr>
<td>1.3.1.5 Extending Pandas with Custom Types (Experimental)</td>
<td>13</td>
</tr>
<tr>
<td>1.3.1.6 New observed keyword for excluding unobserved categories in <code>groupby</code></td>
<td>14</td>
</tr>
<tr>
<td>1.3.1.7 Rolling/Expanding.apply() accepts <code>raw=False</code> to pass a <code>Series</code> to the function</td>
<td>16</td>
</tr>
<tr>
<td>1.3.1.8 <code>DataFrame.interpolate</code> has gained the <code>limit_area</code> kwarg</td>
<td>17</td>
</tr>
<tr>
<td>1.3.1.9 <code>get_dummies</code> now supports <code>dtype</code> argument</td>
<td>18</td>
</tr>
<tr>
<td>1.3.1.10 <code>Timedelta</code> mod method</td>
<td>18</td>
</tr>
<tr>
<td>1.3.1.11 <code>.rank()</code> handles <code>inf</code> values when <code>NaN</code> are present</td>
<td>19</td>
</tr>
<tr>
<td>1.3.1.12 <code>Series.str.cat</code> has gained the <code>join</code> kwarg</td>
<td>20</td>
</tr>
<tr>
<td>1.3.1.13 <code>DataFrame.astype</code> performs column-wise conversion to <code>Categorical</code></td>
<td>21</td>
</tr>
<tr>
<td>1.3.1.14 Other Enhancements</td>
<td>21</td>
</tr>
<tr>
<td>1.3.2 Backwards incompatible API changes</td>
<td>23</td>
</tr>
<tr>
<td>1.3.2.1 Dependencies have increased minimum versions</td>
<td>23</td>
</tr>
<tr>
<td>1.3.2.2 Instantiation from dicts preserves dict insertion order for python 3.6+</td>
<td>24</td>
</tr>
<tr>
<td>1.3.2.3 Deprecate <code>Panel</code></td>
<td>24</td>
</tr>
<tr>
<td>1.3.2.4 <code>pandas.core.common</code> removals</td>
<td>25</td>
</tr>
<tr>
<td>1.3.2.5 Changes to make output of <code>DataFrame.apply</code> consistent</td>
<td>26</td>
</tr>
<tr>
<td>1.3.2.6 Concatenation will no longer sort</td>
<td>28</td>
</tr>
<tr>
<td>1.3.2.7 Build Changes</td>
<td>28</td>
</tr>
<tr>
<td>1.3.2.8 Index Division By Zero Fills Correctly</td>
<td>28</td>
</tr>
<tr>
<td>1.3.2.9 Extraction of matching patterns from strings</td>
<td>29</td>
</tr>
<tr>
<td>1.3.2.10 Default value for the <code>ordered</code> parameter of <code>CategoricalDtype</code></td>
<td>30</td>
</tr>
<tr>
<td>1.3.2.11 Better pretty-printing of DataFrames in a terminal</td>
<td>31</td>
</tr>
<tr>
<td>1.3.2.12 Datetimelike API Changes</td>
<td>32</td>
</tr>
<tr>
<td>1.3.2.13 Other API Changes</td>
<td>33</td>
</tr>
</tbody>
</table>
## Deprecations
1.3.7
1.3.7.1 Categorical .................................................. 39
1.3.7.2 Datetimelike .................................................. 39
1.3.7.3 Timedelta ...................................................... 40
1.3.7.4 Timezones .................................................... 41
1.3.7.5 Offsets ........................................................ 42
1.3.7.6 Numeric ........................................................ 42
1.3.7.7 Strings ........................................................ 42
1.3.7.8 Indexing ......................................................... 42
1.3.7.9 MultiIndex ....................................................... 43
1.3.7.10 I/O ............................................................... 44
1.3.7.11 Plotting ......................................................... 45
1.3.7.12 Groupby/Resample/Rolling ............................... 45
1.3.7.13 Sparse ......................................................... 46
1.3.7.14 Reshaping ..................................................... 46
1.3.7.15 Other ........................................................... 47

## New features
1.6.1
1.6.1.1 Integration with Apache Parquet file format .......... 57
1.6.1.2 Rename, reindex now also accept axis keyword .... 59
1.6.1.3 Improved warnings when attempting to create columns 58
1.6.1.4 infer_objects type conversion .......................... 57
1.6.1.5 CategoricalDtype for specifying categoricals ........ 60
1.6.1.6 GroupBy objects now have a pipe method .......... 61
1.6.1.7 Categorical.rename_categories accepts a dict-like .... 62

## Bug Fixes
1.3.7
1.3.7.1 Categorical .................................................. 39
1.3.7.2 Datetimelike .................................................. 39
1.3.7.3 Timedelta ...................................................... 40
1.3.7.4 Timezones .................................................... 41
1.3.7.5 Offsets ........................................................ 42
1.3.7.6 Numeric ........................................................ 42
1.3.7.7 Strings ........................................................ 42
1.3.7.8 Indexing ......................................................... 42
1.3.7.9 MultiIndex ....................................................... 43
1.3.7.10 I/O ............................................................... 44
1.3.7.11 Plotting ......................................................... 45
1.3.7.12 Groupby/Resample/Rolling ............................... 45
1.3.7.13 Sparse ......................................................... 46
1.3.7.14 Reshaping ..................................................... 46
1.3.7.15 Other ........................................................... 47

## Other
1.3.7.15 Other ........................................................... 47

## Grouping
1.6.1
1.6.1.1 Integration with Apache Parquet file format .......... 57
1.6.1.2 Rename, reindex now also accept axis keyword .... 59
1.6.1.3 Improved warnings when attempting to create columns 58
1.6.1.4 infer_objects type conversion .......................... 57
1.6.1.5 CategoricalDtype for specifying categoricals ........ 60
1.6.1.6 GroupBy objects now have a pipe method .......... 61
1.6.1.7 Categorical.rename_categories accepts a dict-like .... 62

## Categorical
1.6.1.6 CategoricalDtype for specifying categoricals ........ 60

## Timezones
1.3.7.4 Timezones .................................................... 41

## Reshaping
1.3.7.14 Reshaping ..................................................... 46

## I/O
1.5.5.2 Indexing ......................................................... 54
1.5.5.3 I/O ............................................................... 54
1.5.5.4 Plotting ......................................................... 54
1.5.5.5 Groupby/Resample/Rolling ............................... 54
1.5.5.6 Reshaping ..................................................... 55
1.5.5.7 Numeric ........................................................ 55
1.5.5.8 Categorical ................................................... 55
1.5.5.9 String .......................................................... 55

## Time Series
1.3.7.4 Timezones .................................................... 41
1.3.7.5 Offsets ........................................................ 42
1.3.7.6 Numeric ........................................................ 42
1.3.7.7 Strings ........................................................ 42
1.3.7.8 Indexing ......................................................... 42
1.3.7.9 MultiIndex ....................................................... 43
1.3.7.10 I/O ............................................................... 44
1.3.7.11 Plotting ......................................................... 45
1.3.7.12 Groupby/Resample/Rolling ............................... 45
1.3.7.13 Sparse ......................................................... 46
1.3.7.14 Reshaping ..................................................... 46
1.3.7.15 Other ........................................................... 47

## Indexing
1.3.7.8 Indexing ......................................................... 42
1.3.7.9 MultiIndex ....................................................... 43
1.3.7.10 I/O ............................................................... 44
1.3.7.11 Plotting ......................................................... 45
1.3.7.12 Groupby/Resample/Rolling ............................... 45
1.3.7.13 Sparse ......................................................... 46
1.3.7.14 Reshaping ..................................................... 46
1.3.7.15 Other ........................................................... 47

## Plotting
1.3.7.11 Plotting ......................................................... 45
1.3.7.12 Groupby/Resample/Rolling ............................... 45
1.3.7.13 Sparse ......................................................... 46
1.3.7.14 Reshaping ..................................................... 46
1.3.7.15 Other ........................................................... 47

## I/O
1.5.5.3 I/O ............................................................... 54
1.5.5.4 Plotting ......................................................... 54
1.5.5.5 Groupby/Resample/Rolling ............................... 54
1.5.5.6 Reshaping ..................................................... 55
1.5.5.7 Numeric ........................................................ 55
1.5.5.8 Categorical ................................................... 55
1.5.5.9 String .......................................................... 55

## Codebase
1.6.1
1.6.1.1 Integration with Apache Parquet file format .......... 57
1.6.1.2 Rename, reindex now also accept axis keyword .... 59
1.6.1.3 Improved warnings when attempting to create columns 58
1.6.1.4 infer_objects type conversion .......................... 57
1.6.1.5 CategoricalDtype for specifying categoricals ........ 60
1.6.1.6 GroupBy objects now have a pipe method .......... 61
1.6.1.7 Categorical.rename_categories accepts a dict-like .... 62

## Backwards incompatible change
1.4.1
1.4.1.1 Backwards incompatible API changes ................. 48
1.4.1.2 Grouping by a Categorical ............................... 49
1.4.1.3 Resample ...................................................... 49
1.4.1.4 Rolling and Expanding .................................... 51

## improvements
1.5.5
1.5.5.1 Conversion ..................................................... 53
1.5.5.2 Indexing ......................................................... 54
1.5.5.3 I/O ............................................................... 54
1.5.5.4 Plotting ......................................................... 54
1.5.5.5 Groupby/Resample/Rolling ............................... 54
1.5.5.6 Reshaping ..................................................... 55
1.5.5.7 Numeric ........................................................ 55
1.5.5.8 Categorical ................................................... 55
1.5.5.9 String .......................................................... 55

## Other
1.5.7
1.5.7.1 Conversion ..................................................... 53
1.5.7.2 Indexing ......................................................... 54
1.5.7.3 I/O ............................................................... 54
1.5.7.4 Plotting ......................................................... 54
1.5.7.5 Groupby/Resample/Rolling ............................... 54
1.5.7.6 Reshaping ..................................................... 55
1.5.7.7 Numeric ........................................................ 55
1.5.7.8 Categorical ................................................... 55
1.5.7.9 String .......................................................... 55

## Other
1.5.7
1.5.7.1 Conversion ..................................................... 53
1.5.7.2 Indexing ......................................................... 54
1.5.7.3 I/O ............................................................... 54
1.5.7.4 Plotting ......................................................... 54
1.5.7.5 Groupby/Resample/Rolling ............................... 54
1.5.7.6 Reshaping ..................................................... 55
1.5.7.7 Numeric ........................................................ 55
1.5.7.8 Categorical ................................................... 55
1.5.7.9 String .......................................................... 55

## Other
1.5.7
1.5.7.1 Conversion ..................................................... 53
1.5.7.2 Indexing ......................................................... 54
1.5.7.3 I/O ............................................................... 54
1.5.7.4 Plotting ......................................................... 54
1.5.7.5 Groupby/Resample/Rolling ............................... 54
1.5.7.6 Reshaping ..................................................... 55
1.5.7.7 Numeric ........................................................ 55
1.5.7.8 Categorical ................................................... 55
1.5.7.9 String .......................................................... 55

## New features
1.6.1
1.6.1.1 Integration with Apache Parquet file format .......... 57
1.6.1.2 Rename, reindex now also accept axis keyword .... 59
1.6.1.3 Improved warnings when attempting to create columns 58
1.6.1.4 infer_objects type conversion .......................... 57
1.6.1.5 CategoricalDtype for specifying categoricals ........ 60
1.6.1.6 GroupBy objects now have a pipe method .......... 61
1.6.1.7 Categorical.rename_categories accepts a dict-like .... 62

## New features
1.6.1
1.6.1.1 Integration with Apache Parquet file format .......... 57
1.6.1.2 Rename, reindex now also accept axis keyword .... 59
1.6.1.3 Improved warnings when attempting to create columns 58
1.6.1.4 infer_objects type conversion .......................... 57
1.6.1.5 CategoricalDtype for specifying categoricals ........ 60
1.6.1.6 GroupBy objects now have a pipe method .......... 61
1.6.1.7 Categorical.rename_categories accepts a dict-like .... 62
1.6.1.9 Other Enhancements .............................................. 62
1.6.2 Backwards incompatible API changes .............................. 64
  1.6.2.1 Dependencies have increased minimum versions ................. 64
  1.6.2.2 Sum/Prod of all-NaN or empty Series/DataFrames is now consistently NaN .... 64
  1.6.2.3 Indexing with a list with missing labels is Deprecated .......... 65
  1.6.2.4 NA naming Changes .......................................... 66
  1.6.2.5 Iteration of Series/Index will now return Python scalars ........ both 66
  1.6.2.7 PeriodIndex resampling .................................... 68
  1.6.2.8 Improved error handling during item assignment in pd.eval ....... 69
  1.6.2.9 Dtype Conversions .......................................... 70
  1.6.2.10 MultiIndex Constructor with a Single Level .................... 71
  1.6.2.11 UTC Localization with Series ................................ 71
  1.6.2.12 Consistency of Range Functions .............................. 72
  1.6.2.13 No Automatic Matplotlib Converters ........................... 73
  1.6.2.14 Other API Changes ......................................... 73

1.6.3 Deprecations ....................................................... 74
  1.6.3.1 Series.select and DataFrame.select ............................ 75
  1.6.3.2 Series.argmax and Series.argmin ............................. 75

1.6.4 Removal of prior version deprecations/changes ..................... 75
1.6.5 Performance Improvements ....................................... 76
1.6.6 Documentation Changes ......................................... 76
1.6.7 Bug Fixes ........................................................... 76
  1.6.7.1 Conversion .................................................. 76
  1.6.7.2 Indexing .................................................... 77
  1.6.7.3 I/O .......................................................... 77
  1.6.7.4 Plotting ..................................................... 78
  1.6.7.5 Groupby/Resample/Rolling ................................... 78
  1.6.7.6 Sparse ...................................................... 79
  1.6.7.7 Reshaping ................................................... 79
  1.6.7.8 Numeric ..................................................... 80
  1.6.7.9 Categorical ................................................ 80
  1.6.7.10 PyPy ...................................................... 80
  1.6.7.11 Other ...................................................... 80

1.7 v0.20.3 (July 7, 2017) .............................................. 81
  1.7.1 Bug Fixes .......................................................... 81
    1.7.1.1 Conversion .................................................. 81
    1.7.1.2 Indexing .................................................... 81
    1.7.1.3 I/O .......................................................... 81
    1.7.1.4 Plotting ..................................................... 82
    1.7.1.5 Reshaping ................................................... 82
    1.7.1.6 Categorical ................................................ 82

1.8 v0.20.2 (June 4, 2017) .............................................. 82
  1.8.1 Enhancements ..................................................... 82
  1.8.2 Performance Improvements ...................................... 83
  1.8.3 Bug Fixes .......................................................... 83
    1.8.3.1 Conversion .................................................. 83
    1.8.3.2 Indexing .................................................... 83
    1.8.3.3 I/O .......................................................... 84
    1.8.3.4 Plotting ..................................................... 84
    1.8.3.5 Groupby/Resample/Rolling ................................... 84
    1.8.3.6 Sparse ...................................................... 84
    1.8.3.7 Reshaping ................................................... 85
    1.8.3.8 Numeric ..................................................... 85
1.9.1 New features

1.9.1.1 aggregate API for DataFrame/Series
1.9.1.2 dtype keyword for data IO
1.9.1.3 .to_datetime() has gained an origin parameter
1.9.1.4 Groupby Enhancements
1.9.1.5 Better support for compressed URLs in read_csv
1.9.1.6 Pickle file I/O now supports compression
1.9.1.7 UInt64 Support Improved
1.9.1.8 GroupBy on Categoricals
1.9.1.9 Table Schema Output
1.9.1.10 SciPy sparse matrix from/to SparseDataFrame
1.9.1.11 Excel output for styled DataFrames
1.9.1.12 IntervalIndex
1.9.1.13 Other Enhancements

1.9.2 Backwards incompatible API changes

1.9.2.1 Possible incompatibility for HDF5 formats created with pandas < 0.13.0
1.9.2.2 Map on Index types now return other Index types
1.9.2.3 Accessing datetime fields of Index now return Index
1.9.2.4 pd.unique will now be consistent with extension types
1.9.2.5 S3 File Handling
1.9.2.6 Partial String Indexing Changes
1.9.2.7 Concat of different float dtypes will not automatically upcast
1.9.2.8 Pandas Google BigQuery support has moved
1.9.2.9 Memory Usage for Index is more Accurate
1.9.2.10 DataFrame.sort_index changes
1.9.2.11 Groupby Describe Formatting
1.9.2.12 Window Binary Corr/Cov operations return a MultiIndex DataFrame
1.9.2.13 HDFStore where string comparison
1.9.2.14 Index.intersection and inner join now preserve the order of the left Index
1.9.2.15 Pivot Table always returns a DataFrame
1.9.2.16 Other API Changes

1.9.3 Reorganization of the library: Privacy Changes

1.9.3.1 Modules Privacy Has Changed
1.9.3.2 pandas.errors
1.9.3.3 pandas.testing
1.9.3.4 pandas.plotting
1.9.3.5 Other Development Changes

1.9.4 Deprecations

1.9.4.1 Deprecate .ix
1.9.4.2 Deprecate Panel
1.9.4.3 Deprecate groupby.agg() with a dictionary when renaming
1.9.4.4 Deprecate .plotting
1.9.4.5 Other Deprecations

1.9.5 Removal of prior version deprecations/changes

1.9.6 Performance Improvements

1.9.7 Bug Fixes

1.9.7.1 Conversion
1.9.7.2 Indexing
1.9.7.3 I/O
1.9.7.4 Plotting
1.9.7.5 Groupby/Resample/Rolling
1.12 v0.19.2 (December 24, 2016) .......... 126
  1.12.1 New features .......................... 132
  1.12.2 API changes .......................... 145
    1.12.2.1 Series.tolist() will now return Python types . 145
    1.12.2.2 Series operators for different indexes . 146
    1.12.2.3 Series type promotion on assignment . 149
    1.12.2.4 .to_datetime() changes ............... 150
    1.12.2.5 Merging changes ........................ 150
    1.12.2.6 .describe() changes ................... 151
    1.12.2.7 Period changes ........................ 150
    1.12.2.8 Index +/- no longer used for set operations . 154
    1.12.2.9 Index.difference and .symmetric_difference changes . 155
    1.12.2.10 Index.unique consistently returns Index . 156
    1.12.2.11 MultiIndex constructors, groupby and set_index preserve categorical dtypes . 156
    1.12.2.12 read_csv will progressively enumerate chunks . 158
    1.12.2.13 Sparse Changes ........................ 158
    1.12.2.14 Indexer dtypes changes ............... 161
    1.12.2.15 Other API Changes .................... 162
  1.12.3 Deprecations .......................... 163
  1.12.4 Removal of prior version deprecations/changes ...... 163
  1.12.5 Performance Improvements .................. 164
  1.12.6 Bug Fixes ............................ 165
1.13 v0.18.1 (May 3, 2016) .................. 170
  1.13.1 New features .......................... 171
    1.13.1.1 Custom Business Hour ..................... 171
    1.13.1.2 .groupby(...) syntax with window and resample operations .... 172
    1.13.1.3 Method chaining improvements ............. 174
    1.13.1.4 Partial string indexing on DateTimeIndex when part of a MultiIndex . 176
    1.13.1.5 Assembling Datetimes ..................... 177
    1.13.1.6 Other Enhancements .................... 178
1.13.2 Sparse changes .......................................................... 179
1.13.3 API changes ............................................................. 180
  1.13.3.1 groupby(..).nth() changes ..................................... 180
  1.13.3.2 numpy function compatibility ................................ 182
  1.13.3.3 Using .apply on groupby resampling ....................... 182
  1.13.3.4 Changes in read_csv exceptions ............................. 183
  1.13.3.5 to_datetime error changes ................................. 184
  1.13.3.6 Other API changes ........................................... 185
  1.13.3.7 Deprecations ................................................ 185
1.13.4 Performance Improvements ....................................... 185
1.13.5 Bug Fixes ............................................................ 186
1.14 v0.18.0 (March 13, 2016) ............................................. 188
  1.14.1 New features ...................................................... 190
    1.14.1.1 Window functions are now methods ....................... 190
    1.14.1.2 Changes to rename ....................................... 192
    1.14.1.3 Range Index ............................................. 192
    1.14.1.4 Changes to str.extract ................................. 193
    1.14.1.5 Addition of str.extractall ............................. 194
    1.14.1.6 Changes to str.cat ..................................... 195
    1.14.1.7 Datetimelike rounding .................................. 195
    1.14.1.8 Formatting of Integers in FloatIndex ................... 197
    1.14.1.9 Changes to dtype assignment behaviors ................. 198
    1.14.1.10 to_xarray ............................................. 199
    1.14.1.11 Latex Representation .................................. 200
    1.14.1.12 pd.read_sas() changes ................................ 200
    1.14.1.13 Other enhancements .................................. 200
  1.14.2 Backwards incompatible API changes .......................... 201
    1.14.2.1 NaT and Timedelta operations ........................... 201
    1.14.2.2 Changes to msgpack ..................................... 202
    1.14.2.3 Signature change for .rank ............................. 203
    1.14.2.4 Bug in QuarterBegin with n=0 .......................... 204
    1.14.2.5 Resample API ........................................... 204
    1.14.2.6 Changes to eval ......................................... 209
    1.14.2.7 Other API Changes .................................... 211
    1.14.2.8 Deprecations ........................................... 212
    1.14.2.9 Removal of deprecated float indexers .................. 212
    1.14.2.10 Removal of prior version deprecations/changes ......... 215
  1.14.3 Performance Improvements ..................................... 215
  1.14.4 Bug Fixes ........................................................ 215
1.15 v0.17.1 (November 21, 2015) ...................................... 218
  1.15.1 New features .................................................... 219
    1.15.1.1 Conditional HTML Formatting ............................ 219
  1.15.2 Enhancements .................................................... 219
  1.15.3 API changes .................................................... 221
    1.15.3.1 Deprecations ........................................... 221
  1.15.4 Performance Improvements .................................... 221
  1.15.5 Bug Fixes ........................................................ 222
1.16 v0.17.0 (October 9, 2015) .......................................... 223
  1.16.1 New features .................................................... 225
    1.16.1.1 Datetime with TZ ........................................ 225
    1.16.1.2 Releasing the GIL ....................................... 227
    1.16.1.3 Plot submethods ....................................... 227
    1.16.1.4 Additional methods for dt accessor ..................... 228
    1.16.1.5 Period Frequency Enhancement .......................... 230
<table>
<thead>
<tr>
<th>Version</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.16.1.6</td>
<td>Support for SAS XPORT files</td>
</tr>
<tr>
<td>1.16.1.7</td>
<td>Support for Math Functions in .eval()</td>
</tr>
<tr>
<td>1.16.1.8</td>
<td>Changes to Excel with MultiIndex</td>
</tr>
<tr>
<td>1.16.1.9</td>
<td>Google BigQuery Enhancements</td>
</tr>
<tr>
<td>1.16.1.10</td>
<td>Display Alignment with Unicode East Asian Width</td>
</tr>
<tr>
<td>1.16.1.11</td>
<td>Other enhancements</td>
</tr>
<tr>
<td><strong>1.16.2</strong></td>
<td>Backwards incompatible API changes</td>
</tr>
<tr>
<td>1.16.2.1</td>
<td>Changes to sorting API</td>
</tr>
<tr>
<td>1.16.2.2</td>
<td>Changes to to_datetime and to_timedelta</td>
</tr>
<tr>
<td>1.16.2.3</td>
<td>Changes to Index Comparisons</td>
</tr>
<tr>
<td>1.16.2.4</td>
<td>Changes to Boolean Comparisons vs. None</td>
</tr>
<tr>
<td>1.16.2.5</td>
<td>HDFStore dropna behavior</td>
</tr>
<tr>
<td>1.16.2.6</td>
<td>Changes to <code>display.precision</code> option</td>
</tr>
<tr>
<td>1.16.2.7</td>
<td>Changes to <code>Categorical.unique</code></td>
</tr>
<tr>
<td>1.16.2.8</td>
<td>Changes to <code>bool</code> passed as <code>header</code> in Parsers</td>
</tr>
<tr>
<td>1.16.2.9</td>
<td>Other API Changes</td>
</tr>
<tr>
<td>1.16.2.10</td>
<td>Deprecations</td>
</tr>
<tr>
<td>1.16.2.11</td>
<td>Removal of prior version deprecations/changes</td>
</tr>
<tr>
<td><strong>1.16.3</strong></td>
<td>Performance Improvements</td>
</tr>
<tr>
<td><strong>1.16.4</strong></td>
<td>Bug Fixes</td>
</tr>
<tr>
<td><strong>1.17</strong></td>
<td>v0.16.2 (June 12, 2015)</td>
</tr>
<tr>
<td>1.17.1</td>
<td>New features</td>
</tr>
<tr>
<td>1.17.1.1</td>
<td>Pipe</td>
</tr>
<tr>
<td>1.17.1.2</td>
<td>Other Enhancements</td>
</tr>
<tr>
<td>1.17.2</td>
<td>API Changes</td>
</tr>
<tr>
<td>1.17.3</td>
<td>Performance Improvements</td>
</tr>
<tr>
<td>1.17.4</td>
<td>Bug Fixes</td>
</tr>
<tr>
<td><strong>1.18</strong></td>
<td>v0.16.1 (May 11, 2015)</td>
</tr>
<tr>
<td>1.18.1</td>
<td>Enhancements</td>
</tr>
<tr>
<td>1.18.1.1</td>
<td>CategoricalIndex</td>
</tr>
<tr>
<td>1.18.1.2</td>
<td>Sample</td>
</tr>
<tr>
<td>1.18.1.3</td>
<td>String Methods Enhancements</td>
</tr>
<tr>
<td>1.18.1.4</td>
<td>Other Enhancements</td>
</tr>
<tr>
<td>1.18.2</td>
<td>API changes</td>
</tr>
<tr>
<td>1.18.2.1</td>
<td>Deprecations</td>
</tr>
<tr>
<td>1.18.3</td>
<td>Index Representation</td>
</tr>
<tr>
<td>1.18.4</td>
<td>Performance Improvements</td>
</tr>
<tr>
<td>1.18.5</td>
<td>Bug Fixes</td>
</tr>
<tr>
<td><strong>1.19</strong></td>
<td>v0.16.0 (March 22, 2015)</td>
</tr>
<tr>
<td>1.19.1</td>
<td>New features</td>
</tr>
<tr>
<td>1.19.1.1</td>
<td>DataFrame Assign</td>
</tr>
<tr>
<td>1.19.1.2</td>
<td>Interaction with scipy.sparse</td>
</tr>
<tr>
<td>1.19.1.3</td>
<td>String Methods Enhancements</td>
</tr>
<tr>
<td>1.19.1.4</td>
<td>Other enhancements</td>
</tr>
<tr>
<td>1.19.2</td>
<td>Backwards incompatible API changes</td>
</tr>
<tr>
<td>1.19.2.1</td>
<td>Changes in Timedelta</td>
</tr>
<tr>
<td>1.19.2.2</td>
<td>Indexing Changes</td>
</tr>
<tr>
<td>1.19.2.3</td>
<td>Categorical Changes</td>
</tr>
<tr>
<td>1.19.2.4</td>
<td>Other API Changes</td>
</tr>
<tr>
<td>1.19.2.5</td>
<td>Deprecations</td>
</tr>
<tr>
<td>1.19.2.6</td>
<td>Removal of prior version deprecations/changes</td>
</tr>
<tr>
<td>1.19.3</td>
<td>Performance Improvements</td>
</tr>
<tr>
<td>1.19.4</td>
<td>Bug Fixes</td>
</tr>
<tr>
<td><strong>1.20</strong></td>
<td>v0.15.2 (December 12, 2014)</td>
</tr>
<tr>
<td>Version</td>
<td>Date</td>
</tr>
<tr>
<td>---------</td>
<td>---------------</td>
</tr>
<tr>
<td>1.25</td>
<td>v0.13.1</td>
</tr>
<tr>
<td>1.22</td>
<td>v0.15.0</td>
</tr>
<tr>
<td>1.21</td>
<td>v0.15.1</td>
</tr>
<tr>
<td>1.20</td>
<td>v0.14.1</td>
</tr>
<tr>
<td>1.24</td>
<td>v0.14.0</td>
</tr>
<tr>
<td>1.23</td>
<td>v0.14.1</td>
</tr>
<tr>
<td>1.20</td>
<td>v0.14.0</td>
</tr>
</tbody>
</table>

### 1.25 v0.13.1 (February 3, 2014)

* Output Formatting Enhancements
* Prior Version Deprecations/Changes

### 1.24 v0.14.0 (May 31, 2014)

* API changes
* Display Changes
* Text Parsing API Changes
* Groupby API Changes
* SQL
* MultiIndexing Using Slicers
* Plotting
* Prior Version Deprecations/Changes
* Deprecations
* Known Issues
* Enhancements
* Performance
* Experimental
* Bug Fixes

### 1.23 v0.14.1 (July 11, 2014)

* API changes
* Enhancements
* Performance
* Bug Fixes

### 1.22 v0.15.0 (October 18, 2014)

* API changes
* Enhancements
* Bug Fixes

### 1.21 v0.15.1 (November 9, 2014)

* API changes
* Enhancements
* Bug Fixes

### 1.20 v0.14.1 (July 11, 2014)

* API changes
* Performance
* Bug Fixes

### 1.20 v0.14.0 (May 31, 2014)

* API changes
* Enhancements
* Bug Fixes

### 1.20 v0.13.1 (February 3, 2014)

* API changes
* Enhancements
* Performance
* Bug Fixes
<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.25.8</td>
<td>Bug Fixes</td>
<td></td>
</tr>
<tr>
<td>1.26</td>
<td>v0.13.0 (January 3, 2014)</td>
<td>API changes, Prior Version Deprecations/Changes, Deprecations, Indexing API Changes, Float64Index API Change, HDFStore API Changes, DataFrame repr Changes, Enhancements, Experimental, Internal Refactoring, Bug Fixes</td>
</tr>
<tr>
<td>1.27</td>
<td>v0.12.0 (July 24, 2013)</td>
<td>API changes, I/O Enhancements, Other Enhancements, Experimental Features, Bug Fixes</td>
</tr>
<tr>
<td>1.28</td>
<td>v0.11.0 (April 22, 2013)</td>
<td>Selection Choices, Selection Deprecations, Dtypes, Dtype Conversion, Dtype Gotchas, Datetimes Conversion, API changes, Enhancements</td>
</tr>
<tr>
<td>1.29</td>
<td>v0.10.1 (January 22, 2013)</td>
<td>API changes, New features, HDFStore</td>
</tr>
<tr>
<td>1.30</td>
<td>v0.10.0 (December 17, 2012)</td>
<td>File parsing new features, API changes, New features, Wide DataFrame Printing, Updated PyTables Support, N Dimensional Panels (Experimental)</td>
</tr>
<tr>
<td>1.31</td>
<td>v0.9.1 (November 14, 2012)</td>
<td>New features, API changes</td>
</tr>
<tr>
<td>1.32</td>
<td>v0.9.0 (October 7, 2012)</td>
<td>New features, API changes</td>
</tr>
<tr>
<td>1.33</td>
<td>v0.8.1 (July 22, 2012)</td>
<td>New features, Performance improvements</td>
</tr>
<tr>
<td>1.34</td>
<td>v0.8.0 (June 29, 2012)</td>
<td>Support for non-unique indexes, NumPy datetime64 dttype and 1.6 dependency, Time series changes and improvements, Other new features, New plotting methods</td>
</tr>
</tbody>
</table>
1.34.6 Other API changes ................................................. 434
1.34.7 Potential porting issues for pandas <= 0.7.3 users ............... 434
1.35 v.0.7.3 (April 12, 2012) ........................................... 436
1.35.1 New features .................................................... 437
1.35.2 NA Boolean Comparison API Change ............................. 438
1.35.3 Other API Changes .............................................. 439
1.36 v.0.7.2 (March 16, 2012) ........................................ 440
1.36.1 New features .................................................... 440
1.36.2 Performance improvements ................................. 440
1.37 v.0.7.1 (February 29, 2012) ....................................... 440
1.37.1 New features .................................................... 441
1.37.2 Performance improvements ................................. 441
1.38 v.0.7.0 (February 9, 2012) ....................................... 441
1.38.1 New features .................................................... 441
1.38.2 API Changes to integer indexing ............................. 442
1.38.3 API tweaks regarding label-based slicing ...................... 444
1.38.4 Changes to Series [ operator .............................. 445
1.38.5 Other API Changes ............................................. 446
1.38.6 Performance improvements ................................. 446
1.39 v.0.6.1 (December 13, 2011) ..................................... 447
1.39.1 New features .................................................... 447
1.39.2 Performance improvements ................................. 447
1.40 v.0.6.0 (November 25, 2011) .................................... 447
1.40.1 New Features .................................................... 447
1.40.2 Performance Enhancements ................................... 449
1.41 v.0.5.0 (October 24, 2011) ....................................... 449
1.41.1 New Features .................................................... 449
1.41.2 Performance Enhancements ................................... 450
1.42 v.0.4.3 through v0.4.1 (September 25 - October 9, 2011) ........ 450
1.42.1 New Features .................................................... 450
1.42.2 Performance Enhancements ................................... 451

2 Installation ......................................................... 453
  2.1 Plan for dropping Python 2.7 ...................................... 453
  2.2 Python version support ......................................... 453
  2.3 Installing pandas ................................................. 453
    2.3.1 Installing with Anaconda ................................. 453
    2.3.2 Installing with Miniconda ............................... 454
    2.3.3 Installing from PyPI ...................................... 455
    2.3.4 Installing with ActivePython ............................ 455
    2.3.5 Installing using your Linux distribution’s package manager. ........................................ 455
    2.3.6 Installing from source .................................... 455
  2.4 Running the test suite ........................................... 455
  2.5 Dependencies .................................................... 456
    2.5.1 Recommended Dependencies ............................... 456
    2.5.2 Optional Dependencies .................................... 456

3 Contributing to pandas ........................................... 459
  3.1 Where to start? .................................................. 460
  3.2 Bug reports and enhancement requests ........................... 460
  3.3 Working with the code ......................................... 461
    3.3.1 Version control, Git, and GitHub .......................... 461
    3.3.2 Getting started with Git .................................. 461
    3.3.3 Forking ...................................................... 461

x
3.3.4 Creating a development environment ............................................ 461
3.3.4.1 Installing a C Compiler ...................................................... 462
3.3.4.2 Creating a Python Environment ........................................... 462
3.3.4.3 Creating a Python Environment (pip) ................................... 463
3.3.5 Creating a branch ......................................................................... 463

3.4 Contributing to the documentation ..................................................... 464
3.4.1 About the pandas documentation .................................................. 464
3.4.1.1 pandas docstring guide ...................................................... 464
3.4.2 How to build the pandas documentation ........................................ 480
3.4.2.1 Requirements ...................................................................... 480
3.4.2.2 Building the documentation ................................................. 480
3.4.2.3 Building master branch documentation ................................... 481

3.5 Contributing to the code base ............................................................. 481
3.5.1 Code standards ............................................................................. 482
3.5.1.1 C (cpplint) .......................................................................... 482
3.5.1.2 Python (PEP8) ...................................................................... 483
3.5.1.3 Backwards Compatibility ...................................................... 483
3.5.2 Testing With Continuous Integration .............................................. 484
3.5.3 Test-driven development/code writing .......................................... 484
3.5.3.1 Writing tests ......................................................................... 485
3.5.3.2 Transitioning to pytest ......................................................... 485
3.5.3.3 Using pytest ......................................................................... 486
3.5.4 Running the test suite .................................................................... 487
3.5.5 Running the performance test suite ................................................. 488
3.5.6 Documenting your code ............................................................... 489

3.6 Contributing your changes to pandas .................................................. 489
3.6.1 Committing your code ................................................................... 489
3.6.2 Pushing your changes ................................................................... 490
3.6.3 Review your code ......................................................................... 490
3.6.4 Finally, make the pull request ....................................................... 491
3.6.5 Updating your pull request ........................................................... 491
3.6.6 Delete your merged branch (optional) ........................................... 491

4 Package overview ................................................................................. 493
4.1 Data Structures .................................................................................. 493
4.1.1 Why more than one data structure? .............................................. 493
4.2 Mutability and copying of data ........................................................... 494
4.3 Getting Support .................................................................................. 494
4.4 Community ........................................................................................ 494
4.5 Project Governance ............................................................................ 494
4.6 Development Team ............................................................................ 494
4.7 Institutional Partners .......................................................................... 495
4.8 License .............................................................................................. 495

5 10 Minutes to pandas ........................................................................... 497
5.1 Object Creation .................................................................................. 497
5.2 Viewing Data ..................................................................................... 499
5.3 Selection ............................................................................................ 500
5.3.1 Getting ......................................................................................... 500
5.3.2 Selection by Label ........................................................................ 501
5.3.3 Selection by Position .................................................................... 502
5.3.4 Boolean Indexing ......................................................................... 503
5.3.5 Setting ......................................................................................... 504
5.4 Missing Data ..................................................................................... 505
<table>
<thead>
<tr>
<th>7.6</th>
<th>Timeseries</th>
<th>547</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.6.1</td>
<td>Resampling</td>
<td>547</td>
</tr>
<tr>
<td>7.7</td>
<td>Merge</td>
<td>548</td>
</tr>
<tr>
<td>7.8</td>
<td>Plotting</td>
<td>549</td>
</tr>
<tr>
<td>7.9</td>
<td>Data In/Out</td>
<td>550</td>
</tr>
<tr>
<td>7.9.1</td>
<td>CSV</td>
<td>550</td>
</tr>
<tr>
<td>7.9.1.1</td>
<td>Reading multiple files to create a single DataFrame</td>
<td>551</td>
</tr>
<tr>
<td>7.9.1.2</td>
<td>Parsing date components in multi-columns</td>
<td>551</td>
</tr>
<tr>
<td>7.9.1.3</td>
<td>Skip row between header and data</td>
<td>552</td>
</tr>
<tr>
<td>7.9.2</td>
<td>SQL</td>
<td>553</td>
</tr>
<tr>
<td>7.9.3</td>
<td>Excel</td>
<td>553</td>
</tr>
<tr>
<td>7.9.4</td>
<td>HTML</td>
<td>553</td>
</tr>
<tr>
<td>7.9.5</td>
<td>HDFStore</td>
<td>553</td>
</tr>
<tr>
<td>7.9.6</td>
<td>Binary Files</td>
<td>554</td>
</tr>
<tr>
<td>7.10</td>
<td>Computation</td>
<td>555</td>
</tr>
<tr>
<td>7.11</td>
<td>Timedeltas</td>
<td>555</td>
</tr>
<tr>
<td>7.12</td>
<td>Aliasing Axis Names</td>
<td>557</td>
</tr>
<tr>
<td>7.13</td>
<td>Creating Example Data</td>
<td>558</td>
</tr>
<tr>
<td>8</td>
<td>Intro to Data Structures</td>
<td>559</td>
</tr>
<tr>
<td>8.1</td>
<td>Series</td>
<td>559</td>
</tr>
<tr>
<td>8.1.1</td>
<td>Series is ndarray-like</td>
<td>561</td>
</tr>
<tr>
<td>8.1.2</td>
<td>Series is dict-like</td>
<td>562</td>
</tr>
<tr>
<td>8.1.3</td>
<td>Vectorized operations and label alignment with Series</td>
<td>563</td>
</tr>
<tr>
<td>8.1.4</td>
<td>Name attribute</td>
<td>564</td>
</tr>
<tr>
<td>8.2</td>
<td>DataFrame</td>
<td>564</td>
</tr>
<tr>
<td>8.2.1</td>
<td>From dict of Series or dicts</td>
<td>565</td>
</tr>
<tr>
<td>8.2.2</td>
<td>From dict of ndarrays / lists</td>
<td>566</td>
</tr>
<tr>
<td>8.2.3</td>
<td>From structured or record array</td>
<td>566</td>
</tr>
<tr>
<td>8.2.4</td>
<td>From a list of dicts</td>
<td>567</td>
</tr>
<tr>
<td>8.2.5</td>
<td>From a dict of tuples</td>
<td>567</td>
</tr>
<tr>
<td>8.2.6</td>
<td>From a Series</td>
<td>567</td>
</tr>
<tr>
<td>8.2.7</td>
<td>Alternate Constructors</td>
<td>567</td>
</tr>
<tr>
<td>8.2.8</td>
<td>Column selection, addition, deletion</td>
<td>568</td>
</tr>
<tr>
<td>8.2.9</td>
<td>Assigning New Columns in Method Chains</td>
<td>570</td>
</tr>
<tr>
<td>8.2.10</td>
<td>Indexing / Selection</td>
<td>572</td>
</tr>
<tr>
<td>8.2.11</td>
<td>Data alignment and arithmetic</td>
<td>573</td>
</tr>
<tr>
<td>8.2.12</td>
<td>Transposing</td>
<td>576</td>
</tr>
<tr>
<td>8.2.13</td>
<td>DataFrame interoperability with NumPy functions</td>
<td>576</td>
</tr>
<tr>
<td>8.2.14</td>
<td>Console display</td>
<td>577</td>
</tr>
<tr>
<td>8.2.15</td>
<td>DataFrame column attribute access and IPython completion</td>
<td>580</td>
</tr>
<tr>
<td>8.3</td>
<td>Panel</td>
<td>580</td>
</tr>
<tr>
<td>8.3.1</td>
<td>From 3D ndarray with optional axis labels</td>
<td>581</td>
</tr>
<tr>
<td>8.3.2</td>
<td>From dict of DataFrame objects</td>
<td>581</td>
</tr>
<tr>
<td>8.3.3</td>
<td>From DataFrame using to_panel method</td>
<td>582</td>
</tr>
<tr>
<td>8.3.4</td>
<td>Item selection / addition / deletion</td>
<td>583</td>
</tr>
<tr>
<td>8.3.5</td>
<td>Transposing</td>
<td>583</td>
</tr>
<tr>
<td>8.3.6</td>
<td>Indexing / Selection</td>
<td>583</td>
</tr>
<tr>
<td>8.3.7</td>
<td>Squeezing</td>
<td>584</td>
</tr>
<tr>
<td>8.3.8</td>
<td>Conversion to DataFrame</td>
<td>584</td>
</tr>
<tr>
<td>8.4</td>
<td>Deprecate Panel</td>
<td>585</td>
</tr>
<tr>
<td>9</td>
<td>Essential Basic Functionality</td>
<td>589</td>
</tr>
<tr>
<td>9.1</td>
<td>Head and Tail</td>
<td>589</td>
</tr>
</tbody>
</table>
12.16.5 Special use of the == operator with list objects ............................. 730
12.16.6 Boolean Operators .................................................................. 732
12.16.7 Performance of query() ......................................................... 733
12.17 Duplicate Data ............................................................................ 733
12.18 Dictionary-like get() method ...................................................... 736
12.19 The lookup() Method .................................................................. 737
12.20 Index objects .............................................................................. 737
12.20.1 Setting metadata .................................................................... 738
12.20.2 Set operations on Index objects .............................................. 739
12.20.3 Missing values ....................................................................... 739
12.21 Set / Reset Index ........................................................................ 740
12.21.1 Set an index ........................................................................... 740
12.21.2 Reset the index ...................................................................... 741
12.21.3 Adding an ad hoc index ............................................................ 742
12.22 Returning a view versus a copy .................................................... 742
12.22.1 Why does assignment fail when using chained indexing? ....... 743
12.22.2 Evaluation order matters ......................................................... 744

13 MultiIndex / Advanced Indexing ....................................................... 747
13.1 Hierarchical indexing (MultiIndex) .............................................. 747
13.1.1 Creating a MultiIndex (hierarchical index) object ................. 747
13.1.2 Reconstructing the level labels ................................................. 750
13.1.3 Basic indexing on axis with MultiIndex .................................... 750
13.1.4 Defined Levels ...................................................................... 751
13.1.5 Data alignment and using reindex ......................................... 752
13.2 Advanced indexing with hierarchical index ................................. 753
13.2.1 Using slicers .......................................................................... 755
13.2.2 Cross-section ........................................................................ 759
13.2.3 Advanced reindexing and alignment ...................................... 761
13.2.4 Swapping levels with swaplevel() .......................................... 762
13.2.5 Reordering levels with reorder_levels() ............................... 762
13.3 Sorting a MultiIndex .................................................................... 763
13.4 Take Methods .............................................................................. 766
13.5 Index Types ................................................................................. 767
13.5.1 CategoricalIndex ................................................................. 767
13.5.2 Int64Index and RangeIndex .................................................. 770
13.5.3 Float64Index ........................................................................ 770
13.5.4 IntervalIndex ....................................................................... 773
13.5.4.1 Generating Ranges of Intervals ........................................... 774
13.6 Miscellaneous indexing FAQ ....................................................... 776
13.6.1 Integer indexing .................................................................... 776
13.6.2 Non-monotonic indexes require exact matches ...................... 776
13.6.3 Endpoints are inclusive ........................................................... 778
13.6.4 Indexing potentially changes underlying Series dtype ............ 778

14 Computational tools ....................................................................... 781
14.1 Statistical Functions .................................................................... 781
14.1.1 Percent Change ...................................................................... 781
14.1.2 Covariance ............................................................................ 781
14.1.3 Correlation ............................................................................ 783
14.1.4 Data ranking .......................................................................... 784
14.2 Window Functions ........................................................................ 785
14.2.1 Method Summary .................................................................... 788
14.2.2 Rolling Windows .................................................................... 790
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>17.1</td>
<td>Concatenating objects</td>
<td>877</td>
</tr>
<tr>
<td></td>
<td>17.1.1</td>
<td>Set logic on the other axes</td>
<td>880</td>
</tr>
<tr>
<td></td>
<td>17.1.2</td>
<td>Concatenating using <code>append</code></td>
<td>881</td>
</tr>
<tr>
<td></td>
<td>17.1.3</td>
<td>Ignoring indexes on the concatenation axis</td>
<td>882</td>
</tr>
<tr>
<td></td>
<td>17.1.4</td>
<td>Concatenating with mixed ndims</td>
<td>883</td>
</tr>
<tr>
<td></td>
<td>17.1.5</td>
<td>More concatenating with group keys</td>
<td>884</td>
</tr>
<tr>
<td></td>
<td>17.1.6</td>
<td>Appending rows to a DataFrame</td>
<td>885</td>
</tr>
<tr>
<td></td>
<td>17.2</td>
<td>Database-style DataFrame joining/merging</td>
<td>889</td>
</tr>
<tr>
<td></td>
<td>17.2.1</td>
<td>Brief primer on merge methods (relational algebra)</td>
<td>891</td>
</tr>
<tr>
<td></td>
<td>17.2.2</td>
<td>Checking for duplicate keys</td>
<td>894</td>
</tr>
<tr>
<td></td>
<td>17.2.3</td>
<td>The merge indicator</td>
<td>895</td>
</tr>
<tr>
<td></td>
<td>17.2.4</td>
<td>Merge DTypes</td>
<td>896</td>
</tr>
<tr>
<td></td>
<td>17.2.5</td>
<td>Joining on index</td>
<td>897</td>
</tr>
<tr>
<td></td>
<td>17.2.6</td>
<td>Joining key columns on an index</td>
<td>898</td>
</tr>
<tr>
<td></td>
<td>17.2.7</td>
<td>Joining a single Index to a Multi-index</td>
<td>899</td>
</tr>
<tr>
<td></td>
<td>17.2.8</td>
<td>Joining with two multi-indexes</td>
<td>900</td>
</tr>
<tr>
<td></td>
<td>17.2.9</td>
<td>Merging on a combination of columns and index levels</td>
<td>901</td>
</tr>
<tr>
<td></td>
<td>17.2.10</td>
<td>Overlapping value columns</td>
<td>902</td>
</tr>
<tr>
<td></td>
<td>17.2.11</td>
<td>Joining multiple DataFrame or Panel objects</td>
<td>903</td>
</tr>
<tr>
<td></td>
<td>17.2.12</td>
<td>Merging together values within Series or DataFrame columns</td>
<td>904</td>
</tr>
<tr>
<td></td>
<td>17.3</td>
<td>Timeseries friendly merging</td>
<td>905</td>
</tr>
<tr>
<td></td>
<td>17.3.1</td>
<td>Merging Ordered Data</td>
<td>906</td>
</tr>
<tr>
<td></td>
<td>17.3.2</td>
<td>Merging AsOf</td>
<td>907</td>
</tr>
<tr>
<td>18</td>
<td>18.1</td>
<td>Reshaping by pivoting DataFrame objects</td>
<td>909</td>
</tr>
<tr>
<td></td>
<td>18.2</td>
<td>Reshaping by stacking and unstacking</td>
<td>911</td>
</tr>
<tr>
<td></td>
<td>18.2.1</td>
<td>Multiple Levels</td>
<td>912</td>
</tr>
<tr>
<td></td>
<td>18.2.2</td>
<td>Missing Data</td>
<td>913</td>
</tr>
<tr>
<td></td>
<td>18.2.3</td>
<td>With a MultiIndex</td>
<td>914</td>
</tr>
<tr>
<td></td>
<td>18.3</td>
<td>Reshaping by Melt</td>
<td>915</td>
</tr>
<tr>
<td></td>
<td>18.4</td>
<td>Combining with stats and GroupBy</td>
<td>916</td>
</tr>
<tr>
<td></td>
<td>18.5</td>
<td>Pivot tables</td>
<td>917</td>
</tr>
<tr>
<td></td>
<td>18.5.1</td>
<td>Adding margins</td>
<td>918</td>
</tr>
<tr>
<td></td>
<td>18.6</td>
<td>Cross tabulations</td>
<td>919</td>
</tr>
<tr>
<td></td>
<td>18.6.1</td>
<td>Normalization</td>
<td>920</td>
</tr>
<tr>
<td></td>
<td>18.6.2</td>
<td>Adding Margins</td>
<td>921</td>
</tr>
<tr>
<td></td>
<td>18.7</td>
<td>Tiling</td>
<td>922</td>
</tr>
</tbody>
</table>

17 Merge, join, and concatenate

18 Reshaping and Pivot Tables
19 Time Series / Date functionality

19.1 Overview ................................................. 934
19.2 Timestamps vs. Time Spans ................................. 934
19.3 Converting to Timestamps .......................... 936
19.3.1 Providing a Format Argument ......................... 936
19.3.2 Assembling Datetime from Multiple DataFrame Columns ................................. 937
19.3.3 Invalid Data .................................. 937
19.3.4 Epoch Timestamps .................................. 937
19.3.5 From Timestamps to Epoch ........................ 938
19.3.6 Using the origin Parameter ..................... 939
19.4 Generating Ranges of Timestamps ................. 939
19.4.1 Custom Frequency Ranges ....................... 942
19.5 Timestamp Limitations ............................... 942
19.6 Indexing .............................................. 943
19.6.1 Partial String Indexing .......................... 944
19.6.2 Slice vs. Exact Match .................................. 948
19.6.3 Exact Indexing ................................ 950
19.6.4 Truncating & Fancy Indexing ................... 951
19.7 Time/Date Components .............................. 951
19.8 DateOffset Objects ................................. 952
19.8.1 Parametric Offsets .................................. 954
19.8.2 Using Offsets with Series / DatetimeIndex .... 955
19.8.3 Custom Business Days ......................... 956
19.8.4 Business Hour ................................ 958
19.8.5 Custom Business Hour .......................... 960
19.8.6 Offset Aliases ................................ 961
19.8.7 Combining Aliases .................................. 961
19.8.8 Anchored Offsets .................................. 962
19.8.9 Anchored Offset Semantics ..................... 963
19.8.10 Holidays / Holiday Calendars .................. 965
19.9 Time Series-Related Instance Methods .......... 967
19.9.1 Shifting / Lagging ................................ 967
19.9.2 Frequency Conversion ................................. 968
19.9.3 Filling Forward / Backward ..................... 968
19.9.4 Converting to Python Datetimes ............. 969
19.10 Resampling ........................................ 969
19.10.1 Basics ........................................ 969
19.10.2 Upsampling ...................................... 971
19.10.3 Sparse Resampling ................................. 972
19.10.4 Aggregation ..................................... 973
19.11 Time Span Representation ............................ 976
19.11.1 Period ............................................. 976
19.11.2 PeriodIndex and period_range .................. 977
19.11.3 Period Dtypes .................................. 979
19.11.4 PeriodIndex Partial String Indexing ........ 980
19.11.5 Frequency Conversion and Resampling with PeriodIndex .................... 982
19.12 Converting Between Representations ........ 983
19.13 Representing Out-of-Bounds Spans .............. 984
19.14 Time Zone Handling ............................... 985
19.14.1 Working with Time Zones ....................... 985
19.14.2 Ambiguous Times when Localizing ........ 990
# 20 Time Deltas

## 20.1 Parsing

- `to_timedelta`
- `Timedelta limitations`

## 20.2 Operations

## 20.3 Reductions

## 20.4 Frequency Conversion

## 20.5 Attributes

## 20.6 TimedeltaIndex

- `Generating Ranges of Time Deltas`
- `Using the TimedeltaIndex`
- `Operations`
- `Conversions`

## 20.7 Resampling

# 21 Categorical Data

## 21.1 Object Creation

- `Series Creation`
- `DataFrame Creation`
- `Controlling Behavior`
- `Regaining Original Data`

## 21.2 CategoricalDtype

- `Equality Semantics`

## 21.3 Description

## 21.4 Working with categories

- `Renaming categories`
- `Appending new categories`
- `Removing categories`
- `Removing unused categories`
- `Setting categories`

## 21.5 Sorting and Order

- `Reordering`
- `Multi Column Sorting`

## 21.6 Comparisons

## 21.7 Operations

## 21.8 Data munging

- `Getting`
- `String and datetime accessors`
- `Setting`
- `Merging`
- `Unioning`
- `Concatenation`

## 21.9 Getting Data In/Out

## 21.10 Missing Data

## 21.11 Differences to R's `factor`

## 21.12 Gotchas

- `Memory Usage`
- `Categorical is not a numpy array`
- `dtype in apply`
- `Categorical Index`
- `Side Effects`
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.1.1 Orient Options</td>
<td>1158</td>
</tr>
<tr>
<td>24.1.2 Date Handling</td>
<td>1160</td>
</tr>
<tr>
<td>24.1.3 Fallback Behavior</td>
<td>1161</td>
</tr>
<tr>
<td>24.2.2 Reading JSON</td>
<td>1161</td>
</tr>
<tr>
<td>24.2.2.1 Data Conversion</td>
<td>1162</td>
</tr>
<tr>
<td>24.2.2.2 The Numpy Parameter</td>
<td>1165</td>
</tr>
<tr>
<td>24.2.3 Normalization</td>
<td>1166</td>
</tr>
<tr>
<td>24.2.4 Line delimited json</td>
<td>1167</td>
</tr>
<tr>
<td>24.2.5 Table Schema</td>
<td>1168</td>
</tr>
<tr>
<td>24.3 HTML</td>
<td>1172</td>
</tr>
<tr>
<td>24.3.1 Reading HTML Content</td>
<td>1172</td>
</tr>
<tr>
<td>24.3.2 Writing to HTML files</td>
<td>1176</td>
</tr>
<tr>
<td>24.3.3 HTML Table Parsing Gotchas</td>
<td>1179</td>
</tr>
<tr>
<td>24.4 Excel files</td>
<td>1180</td>
</tr>
<tr>
<td>24.4.1 Reading Excel Files</td>
<td>1180</td>
</tr>
<tr>
<td>24.4.1.1 ExcelFile class</td>
<td>1181</td>
</tr>
<tr>
<td>24.4.1.2 Specifying Sheets</td>
<td>1181</td>
</tr>
<tr>
<td>24.4.1.3 Reading a MultiIndex</td>
<td>1182</td>
</tr>
<tr>
<td>24.4.1.4 Parsing Specific Columns</td>
<td>1183</td>
</tr>
<tr>
<td>24.4.1.5 Parsing Dates</td>
<td>1183</td>
</tr>
<tr>
<td>24.4.1.6 Cell Converters</td>
<td>1184</td>
</tr>
<tr>
<td>24.4.1.7 dtype Specifications</td>
<td>1184</td>
</tr>
<tr>
<td>24.4.2 Writing Excel Files</td>
<td>1184</td>
</tr>
<tr>
<td>24.4.2.1 Writing Excel Files to Disk</td>
<td>1184</td>
</tr>
<tr>
<td>24.4.2.2 Writing Excel Files to Memory</td>
<td>1185</td>
</tr>
<tr>
<td>24.4.3 Excel writer engines</td>
<td>1185</td>
</tr>
<tr>
<td>24.4.4 Style and Formatting</td>
<td>1186</td>
</tr>
<tr>
<td>24.5 Clipboard</td>
<td>1186</td>
</tr>
<tr>
<td>24.6 Pickling</td>
<td>1187</td>
</tr>
<tr>
<td>24.6.1 Compressed pickle files</td>
<td>1188</td>
</tr>
<tr>
<td>24.7 msgpack</td>
<td>1190</td>
</tr>
<tr>
<td>24.7.1 Read/Write API</td>
<td>1192</td>
</tr>
<tr>
<td>24.8 HDF5 (PyTables)</td>
<td>1193</td>
</tr>
<tr>
<td>24.8.1 Read/Write API</td>
<td>1195</td>
</tr>
<tr>
<td>24.8.2 Fixed Format</td>
<td>1196</td>
</tr>
<tr>
<td>24.8.3 Table Format</td>
<td>1197</td>
</tr>
<tr>
<td>24.8.4 Hierarchical Keys</td>
<td>1197</td>
</tr>
<tr>
<td>24.8.5 Storing Types</td>
<td>1199</td>
</tr>
<tr>
<td>24.8.5.1 Storing Mixed Types in a Table</td>
<td>1199</td>
</tr>
<tr>
<td>24.8.5.2 Storing Multi-Index DataFrames</td>
<td>1200</td>
</tr>
<tr>
<td>24.8.6 Querying</td>
<td>1201</td>
</tr>
<tr>
<td>24.8.6.1 Querying a Table</td>
<td>1201</td>
</tr>
<tr>
<td>24.8.6.2 Using timedelta64[ns]</td>
<td>1204</td>
</tr>
<tr>
<td>24.8.6.3 Indexing</td>
<td>1205</td>
</tr>
<tr>
<td>24.8.6.4 Query via Data Columns</td>
<td>1206</td>
</tr>
<tr>
<td>24.8.6.5 Iterator</td>
<td>1208</td>
</tr>
<tr>
<td>24.8.6.6 Advanced Queries</td>
<td>1209</td>
</tr>
<tr>
<td>24.8.6.7 Multiple Table Queries</td>
<td>1211</td>
</tr>
<tr>
<td>24.8.7 Delete from a Table</td>
<td>1213</td>
</tr>
<tr>
<td>24.8.8 Notes &amp; Caveats</td>
<td>1213</td>
</tr>
<tr>
<td>24.8.8.1 Compression</td>
<td>1213</td>
</tr>
<tr>
<td>24.8.8.2 ptrepack</td>
<td>1214</td>
</tr>
<tr>
<td>24.8.8.3 Caveats</td>
<td>1215</td>
</tr>
<tr>
<td>24.8.9 DataTypes</td>
<td>1215</td>
</tr>
</tbody>
</table>
# Enhancing Performance

## Cython (Writing C extensions for pandas)

### 25.1 Cython (Writing C extensions for pandas)

- **25.1.1** Pure python
- **25.1.2** Plain Cython
- **25.1.3** Adding type
- **25.1.4** Using ndarray
- **25.1.5** More advanced techniques

## Using Numba

### 25.2 Using Numba

- **25.2.1** Jit
- **25.2.2** Vectorize
- **25.2.3** Caveats

### 25.3 Expression Evaluation via eval()

- **25.3.1** Supported Syntax
- **25.3.2** eval() Examples
- **25.3.3** The DataFrame.eval method
- **25.3.4** Local Variables
- **25.3.5** pandas.eval() Parsers
- **25.3.6** pandas.eval() Backends
- **25.3.7** pandas.eval() Performance
- **25.3.8** Technical Minutia Regarding Expression Evaluation

## Sparse data structures

### 26 Sparse data structures

- **26.1** SparseArray
- **26.2** SparseIndex objects
- **26.3** Sparse Dtypes
- **26.4** Sparse Calculation
27 Frequently Asked Questions (FAQ)

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.1</td>
<td>DataFrame memory usage</td>
<td>1267</td>
</tr>
<tr>
<td>27.2</td>
<td>Using If/Truth Statements with pandas</td>
<td>1267</td>
</tr>
<tr>
<td>27.2.1</td>
<td>Bitwise boolean</td>
<td>1267</td>
</tr>
<tr>
<td>27.2.2</td>
<td>Using the <code>in</code> operator</td>
<td>1269</td>
</tr>
<tr>
<td>27.3</td>
<td>NaN, Integer NA values and NA type promotions</td>
<td>1270</td>
</tr>
<tr>
<td>27.3.1</td>
<td>Choice of NA representation</td>
<td>1270</td>
</tr>
<tr>
<td>27.3.2</td>
<td>Support for integer NA</td>
<td>1271</td>
</tr>
<tr>
<td>27.3.3</td>
<td>NA type promotions</td>
<td>1271</td>
</tr>
<tr>
<td>27.3.4</td>
<td>Why not make NumPy like R?</td>
<td>1272</td>
</tr>
<tr>
<td>27.4</td>
<td>Differences with NumPy</td>
<td>1272</td>
</tr>
<tr>
<td>27.5</td>
<td>Thread-safety</td>
<td>1272</td>
</tr>
<tr>
<td>27.6</td>
<td>Byte-Ordering Issues</td>
<td>1272</td>
</tr>
</tbody>
</table>

28 rpy2 / R interface

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>28.1</td>
<td>Transferring R data sets into Python</td>
<td>1275</td>
</tr>
<tr>
<td>28.2</td>
<td>Converting DataFrames into R objects</td>
<td>1275</td>
</tr>
</tbody>
</table>

29 pandas Ecosystem

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.1</td>
<td>Statistics and Machine Learning</td>
<td>1277</td>
</tr>
<tr>
<td>29.1.1</td>
<td>Statsmodels</td>
<td>1277</td>
</tr>
<tr>
<td>29.1.2</td>
<td>sklearn-pandas</td>
<td>1277</td>
</tr>
<tr>
<td>29.1.3</td>
<td>Featuretools</td>
<td>1277</td>
</tr>
<tr>
<td>29.2</td>
<td>Visualization</td>
<td>1277</td>
</tr>
<tr>
<td>29.2.1</td>
<td>Bokeh</td>
<td>1277</td>
</tr>
<tr>
<td>29.2.2</td>
<td>seaborn</td>
<td>1278</td>
</tr>
<tr>
<td>29.2.3</td>
<td>yhat/ggplot</td>
<td>1278</td>
</tr>
<tr>
<td>29.2.4</td>
<td>Vincent</td>
<td>1278</td>
</tr>
<tr>
<td>29.2.5</td>
<td>IPython Vega</td>
<td>1278</td>
</tr>
<tr>
<td>29.2.6</td>
<td>Plotly</td>
<td>1278</td>
</tr>
<tr>
<td>29.2.7</td>
<td>QtPandas</td>
<td>1278</td>
</tr>
<tr>
<td>29.3</td>
<td>IDE</td>
<td>1278</td>
</tr>
<tr>
<td>29.3.1</td>
<td>IPython</td>
<td>1278</td>
</tr>
<tr>
<td>29.3.2</td>
<td>quantopian/qgrid</td>
<td>1279</td>
</tr>
<tr>
<td>29.3.3</td>
<td>Spyder</td>
<td>1279</td>
</tr>
<tr>
<td>29.4</td>
<td>API</td>
<td>1279</td>
</tr>
<tr>
<td>29.4.1</td>
<td>pandas-datareader</td>
<td>1279</td>
</tr>
<tr>
<td>29.4.2</td>
<td>quandl/Python</td>
<td>1279</td>
</tr>
<tr>
<td>29.4.3</td>
<td>pydatastream</td>
<td>1279</td>
</tr>
<tr>
<td>29.4.4</td>
<td>pandaSDMX</td>
<td>1280</td>
</tr>
<tr>
<td>29.4.5</td>
<td>fredapi</td>
<td>1280</td>
</tr>
<tr>
<td>29.5</td>
<td>Domain Specific</td>
<td>1280</td>
</tr>
<tr>
<td>29.5.1</td>
<td>Geopandas</td>
<td>1280</td>
</tr>
<tr>
<td>29.5.2</td>
<td>xarray</td>
<td>1280</td>
</tr>
<tr>
<td>29.6</td>
<td>Out-of-core</td>
<td>1280</td>
</tr>
<tr>
<td>29.6.1</td>
<td>Dask</td>
<td>1280</td>
</tr>
<tr>
<td>29.6.2</td>
<td>Dask-ML</td>
<td>1280</td>
</tr>
<tr>
<td>29.6.3</td>
<td>Blaze</td>
<td>1280</td>
</tr>
<tr>
<td>29.6.4</td>
<td>Odo</td>
<td>1281</td>
</tr>
<tr>
<td>29.7</td>
<td>Data validation</td>
<td>1281</td>
</tr>
</tbody>
</table>
30 Comparison with R / R libraries 1283

30.1 Quick Reference .................................................................................................................. 1283
  30.1.1 Querying, Filtering, Sampling .......................................................................................... 1283
  30.1.2 Sorting ............................................................................................................................ 1284
  30.1.3 Transforming ................................................................................................................... 1284
  30.1.4 Grouping and Summarizing ............................................................................................ 1284
  30.2 Base R .................................................................................................................................. 1284
    30.2.1 Slicing with R’s c ........................................................................................................... 1284
    30.2.2 aggregate ...................................................................................................................... 1286
    30.2.3 match/%in% ................................................................................................................... 1287
    30.2.4 tapply ............................................................................................................................ 1287
    30.2.5 subset ............................................................................................................................ 1288
    30.2.6 with ................................................................................................................................. 1288
  30.3 plyr ..................................................................................................................................... 1289
    30.3.1 ddply .............................................................................................................................. 1290
  30.4 reshape / reshape2 .............................................................................................................. 1290
    30.4.1 melt.array ...................................................................................................................... 1290
    30.4.2 melt.list ......................................................................................................................... 1291
    30.4.3 melt.data.frame ............................................................................................................ 1291
    30.4.4 cast ............................................................................................................................... 1292
    30.4.5 factor ............................................................................................................................. 1294

31 Comparison with SQL 1295

31.1 SELECT ............................................................................................................................... 1295
31.2 WHERE .................................................................................................................................. 1296
31.3 GROUP BY ............................................................................................................................ 1298
31.4 JOIN .................................................................................................................................... 1300
  31.4.1 INNER JOIN .................................................................................................................... 1300
  31.4.2 LEFT OUTER JOIN ........................................................................................................... 1301
  31.4.3 RIGHT JOIN .................................................................................................................... 1301
  31.4.4 FULL JOIN ...................................................................................................................... 1301
31.5 UNION .................................................................................................................................. 1302
31.6 Pandas equivalents for some SQL analytic and aggregate functions ........................................... 1303
  31.6.1 Top N rows with offset ..................................................................................................... 1303
  31.6.2 Top N rows per group ..................................................................................................... 1303
31.7 UPDATE ................................................................................................................................ 1305
31.8 DELETE ................................................................................................................................ 1305

32 Comparison with SAS 1307

32.1 Data Structures ..................................................................................................................... 1307
  32.1.1 General Terminology Translation ................................................................................... 1307
  32.1.2 DataFrame/Series ............................................................................................................ 1307
  32.1.3 Index ............................................................................................................................... 1308
32.2 Data Input / Output .............................................................................................................. 1308
  32.2.1 Constructing a DataFrame from Values ........................................................................... 1308
  32.2.2 Reading External Data .................................................................................................... 1308
  32.2.3 Exporting Data ............................................................................................................... 1309
32.3 Data Operations ................................................................................................................... 1309
  32.3.1 Operations on Columns ................................................................................................. 1309
| 34.3.13.1 | pandas.Series.dt.week                                      | 1639 |
| 34.3.13.1 | pandas.Series.dt.weekofyear                                 | 1639 |
| 34.3.13.1 | pandas.Series.dt.dayofweek                                 | 1639 |
| 34.3.13.1 | pandas.Series.dt.weekday                                   | 1639 |
| 34.3.13.1 | pandas.Series.dt.dayofyear                                 | 1639 |
| 34.3.13.1 | pandas.Series.dt.quarter                                   | 1640 |
| 34.3.13.1 | pandas.Series.ds.is_month_start                            | 1640 |
| 34.3.13.1 | pandas.Series.ds.is_month_end                              | 1640 |
| 34.3.13.1 | pandas.Series.ds.is_quarter_start                           | 1641 |
| 34.3.13.1 | pandas.Series.ds.is_quarter_end                             | 1641 |
| 34.3.13.1 | pandas.Series.ds.is_year_start                              | 1642 |
| 34.3.13.1 | pandas.Series.ds.is_year_end                                | 1643 |
| 34.3.13.1 | pandas.Series.ds.is_leap_year                               | 1643 |
| 34.3.13.1 | pandas.Series.ds.days_in_month                              | 1644 |
| 34.3.13.1 | pandas.Series.ds.tz                                         | 1644 |
| 34.3.13.1 | pandas.Series.ds.freq                                       | 1644 |
| 34.3.13.1 | pandas.Series.ds.to_period                                  | 1645 |
| 34.3.13.1 | pandas.Series.ds.to_pydatetime                              | 1646 |
| 34.3.13.1 | pandas.Series.ds.tz_localize                                | 1646 |
| 34.3.13.1 | pandas.Series.ds.tz_convert                                 | 1648 |
| 34.3.13.1 | pandas.Series.ds.normalize                                  | 1649 |
| 34.3.13.1 | pandas.Series.ds.strftime                                   | 1649 |
| 34.3.13.1 | pandas.Series.ds.round                                      | 1650 |
| 34.3.13.1 | pandas.Series.dt.floor                                      | 1651 |
| 34.3.13.1 | pandas.Series.dt.ceil                                       | 1652 |
| 34.3.13.1 | pandas.Series.dt.month_name                                 | 1652 |
| 34.3.13.1 | pandas.Series.dt.day_name                                   | 1653 |
| 34.3.13.1 | pandas.Series.dt.days                                       | 1653 |
| 34.3.13.1 | pandas.Series.dt.seconds                                    | 1653 |
| 34.3.13.1 | pandas.Series.dt.microseconds                              | 1653 |
| 34.3.13.1 | pandas.Series.dt.nanoseconds                                | 1653 |
| 34.3.13.1 | pandas.Series.dt.components                                 | 1653 |
| 34.3.13.1 | pandas.Series.dt.to_pytimedelta                             | 1654 |
| 34.3.13.1 | pandas.Series.dt.total_seconds                              | 1654 |

34.3.14  String handling

| 34.3.14.1 | pandas.Series.str.capitalize                              | 1655 |
| 34.3.14.1 | pandas.Series.str.cat                                      | 1657 |
| 34.3.14.1 | pandas.Series.str.center                                   | 1659 |
| 34.3.14.1 | pandas.Series.str.contains                                 | 1661 |
| 34.3.14.1 | pandas.Series.str.count                                    | 1663 |
| 34.3.14.1 | pandas.Series.str.decode                                   | 1664 |
| 34.3.14.1 | pandas.Series.str.encode                                   | 1665 |
| 34.3.14.1 | pandas.Series.str.endswith                                  | 1665 |
| 34.3.14.1 | pandas.Series.str.extract                                   | 1666 |
| 34.3.14.1 | pandas.Series.str.extractall                               | 1667 |
| 34.3.14.1 | pandas.Series.str.find                                     | 1669 |
| 34.3.14.1 | pandas.Series.str.findall                                  | 1669 |
| 34.3.14.1 | pandas.Series.str.get                                      | 1670 |
| 34.3.14.1 | pandas.Series.str.index                                     | 1671 |
| 34.3.14.1 | pandas.Series.str.join                                      | 1672 |
| 34.3.14.1 | pandas.Series.str.len                                       | 1673 |
| 34.3.14.1 | pandas.Series.str.ljust                                    | 1673 |
| 34.3.14.1 | pandas.Series.str.lower                                    | 1673 |
34.3.16 Plotting

34.3.16.1 pandas.Series.plot.area
34.3.16.2 pandas.Series.plot.bar
34.3.16.3 pandas.Series.plot.barh
34.3.16.4 pandas.Series.plot.box
34.3.16.5 pandas.Series.plot.density
34.4 DataFrame ................................................................. 1709
  34.4.1 Constructor ...................................................... 1709
    34.4.1.1 pandas.DataFrame ........................................ 1709
  34.4.2 Attributes and underlying data ................................ 1942
    34.4.2.1 pandas.DataFrame.is_copy ................................ 1943
  34.4.3 Conversion ....................................................... 1943
  34.4.4 Indexing, iteration ............................................. 1943
    34.4.4.1 pandas.DataFrame.__iter__ ................................. 1944
  34.4.5 Binary operator functions ..................................... 1944
  34.4.6 Function application, GroupBy & Window ....................... 1945
  34.4.7 Computations / Descriptive Stats ............................ 1945
  34.4.8 Reindexing / Selection / Label manipulation ................ 1947
  34.4.9 Missing data handling ......................................... 1948
  34.4.10 Reshaping, sorting, transposing ............................. 1948
  34.4.11 Combining / joining / merging ............................... 1949
  34.4.12 Time series-related ......................................... 1949
  34.4.13 Plotting ........................................................ 1949
    34.4.13.1 pandas.DataFrame.plot.area ............................... 1950
    34.4.13.2 pandas.DataFrame.plot.bar ............................... 1950
    34.4.13.3 pandas.DataFrame.plot.barh ............................. 1951
    34.4.13.4 pandas.DataFrame.plot.box ............................... 1953
    34.4.13.5 pandas.DataFrame.plot.density ........................... 1953
    34.4.13.6 pandas.DataFrame.plot.hexbin ........................... 1954
    34.4.13.7 pandas.DataFrame.plot.hist ............................... 1956
    34.4.13.8 pandas.DataFrame.plot.kde ............................... 1956
    34.4.13.9 pandas.DataFrame.plot.line .............................. 1957
    34.4.13.10 pandas.DataFrame.plot.pie .............................. 1958
    34.4.13.11 pandas.DataFrame.plot.scatter ......................... 1959
  34.4.14 Serialization / IO / Conversion ................................ 1960
  34.4.15 Sparse .......................................................... 1961
    34.4.15.1 pandas.SparseDataFrame.to_coo .......................... 1961
  34.4.16 Series .......................................................... 1707
  34.4.17 Timedelta ........................................................ 1707
  34.4.18 Sparse ............................................................ 1707

34.5 Panel ................................................................. 1962
  34.5.1 Constructor ...................................................... 1962
    34.5.1.1 pandas.Panel ............................................... 1962
  34.5.2 Attributes and underlying data ................................ 2096
  34.5.3 Conversion ....................................................... 2096
  34.5.4 Getting and setting ............................................ 2096
    34.5.4.1 pandas.Panel.__iter__ .................................... 2097
  34.5.5 Indexing, iteration, slicing ................................... 2096
  34.5.6 Binary operator functions .................................... 2097
  34.5.7 Function application, GroupBy ................................ 2098
  34.5.8 Computations / Descriptive Stats ............................ 2098
  34.5.9 Reindexing / Selection / Label manipulation ................ 2099
    34.5.9.1 pandas.Panel.drop ......................................... 2099
  34.5.10 Missing data handling ........................................ 2099
  34.5.11 Reshaping, sorting, transposing ............................. 2099
34.5.12 Combining / joining / merging .............................................. 2100
34.5.13 Time series-related .......................................................... 2100
34.5.14 Serialization / IO / Conversion ........................................... 2100

34.6 Index .................................................. 2100

34.6.1 pandas.Index ............................................. 2100

34.6.1.1 pandas.Index.T ........................................... 2102
34.6.1.2 pandas.Index.base ........................................ 2102
34.6.1.3 pandas.Index.data ........................................ 2102
34.6.1.4 pandas.Index.dtype ........................................ 2102
34.6.1.5 pandas.Index.dtype_str ................................... 2102
34.6.1.6 pandas.Index.flags ....................................... 2102
34.6.1.7 pandas.Index.hasnans .................................... 2103
34.6.1.8 pandas.Index.inferred_type ................................. 2103
34.6.1.9 pandas.Index.is_monotonic ................................ 2103
34.6.1.10 pandas.Index.is_monotonic_decreasing ....................... 2103
34.6.1.11 pandas.Index.is_monotonic_increasing ....................... 2103
34.6.1.12 pandas.Index.is_unique .................................. 2103
34.6.1.13 pandas.Index.itemsize ................................... 2104
34.6.1.14 pandas.Index nbytes ....................................... 2104
34.6.1.15 pandas.Index.ndim ....................................... 2104
34.6.1.16 pandas.Index.shape ....................................... 2104
34.6.1.17 pandas.Index.size ........................................ 2104
34.6.1.18 pandas.Index.strides ...................................... 2104
34.6.1.19 pandas.Index.values ...................................... 2104
34.6.1.20 pandas.Index.all ........................................ 2107
34.6.1.21 pandas.Index.any ........................................ 2108
34.6.1.22 pandas.Index.append ..................................... 2108
34.6.1.23 pandas.Index.argmax ..................................... 2108
34.6.1.24 pandas.Index.argmin ..................................... 2109
34.6.1.25 pandas.Index.argsort ..................................... 2109
34.6.1.26 pandas.Index.asof ........................................ 2109
34.6.1.27 pandas.Index.asof_loes .................................. 2110
34.6.1.28 pandas.Index.astype ...................................... 2110
34.6.1.29 pandas.Index.contains ................................... 2110
34.6.1.30 pandas.Index.copy ....................................... 2110
34.6.1.31 pandas.Index.delete ..................................... 2111
34.6.1.32 pandas.Index.difference ................................ 2111
34.6.1.33 pandas.Index.drop ....................................... 2111
34.6.1.34 pandas.Index.drop_duplicates ............................. 2112
34.6.1.35 pandas.Index.dropna ..................................... 2112
34.6.1.36 pandas.Index.duplicated .................................. 2113
34.6.1.37 pandas.Index.equals ...................................... 2113
34.6.1.38 pandas.Index.factorize ................................... 2114
34.6.1.39 pandas.Index.fillna ...................................... 2115
34.6.1.40 pandas.Index.format ...................................... 2115
34.6.1.41 pandas.Index.get_duplicates ............................... 2116
34.6.1.42 pandas.Index.get_indexer .................................. 2116
34.6.1.43 pandas.Index.get_indexer_for .............................. 2117
34.6.1.44 pandas.Index.get_indexer_non_unique ....................... 2117
34.6.1.45 pandas.Index.get_level_values .............................. 2118
34.6.1.46 pandas.Index.get_loc ..................................... 2118
34.6.1.47 pandas.Index.get_slice_bound ................................ 2119
34.6.1.48 pandas.Index.get_value ................................... 2119
34.6.1.49 pandas.Index.get_values ................................... 2119
34.6.1.50 pandas.Index.groupby ........................................... 2120
34.6.1.51 pandas.Index.identical .......................................... 2120
34.6.1.52 pandas.Index.insert ............................................. 2120
34.6.1.53 pandas.Index.intersection ...................................... 2121
34.6.1.54 pandas.Index.is_ .................................................. 2121
34.6.1.55 pandas.Index.is_categorical .................................... 2121
34.6.1.56 pandas.Index.isin ................................................ 2122
34.6.1.57 pandas.Index.isna ............................................... 2123
34.6.1.58 pandas.Index.isnull ............................................. 2124
34.6.1.59 pandas.Index.item ............................................... 2125
34.6.1.60 pandas.Index.join ............................................... 2125
34.6.1.61 pandas.Index.map ............................................... 2126
34.6.1.62 pandas.Index.max ............................................... 2126
34.6.1.63 pandas.Index.memory_usage .................................... 2127
34.6.1.64 pandas.Index.min ............................................... 2127
34.6.1.65 pandas.Index.notna .............................................. 2128
34.6.1.66 pandas.Index.notnull ........................................... 2128
34.6.1.67 pandas.Index.unique ........................................... 2129
34.6.1.68 pandas.Index.putmask ......................................... 2129
34.6.1.69 pandas.Index.ravel ............................................. 2129
34.6.1.70 pandas.Index.reindex .......................................... 2130
34.6.1.71 pandas.Index.rename ........................................... 2130
34.6.1.72 pandas.Index.repeat ............................................ 2130
34.6.1.73 pandas.Index.searchsorted .................................... 2131
34.6.1.74 pandas.Index.set_names ....................................... 2132
34.6.1.75 pandas.Index.set_value ........................................ 2133
34.6.1.76 pandas.Index.shift .............................................. 2133
34.6.1.77 pandas.Index.slice_indexer .................................... 2134
34.6.1.78 pandas.Index.slice_locs ....................................... 2135
34.6.1.79 pandas.Index.sort_values ...................................... 2135
34.6.1.80 pandas.Index.sortlevel ........................................ 2136
34.6.1.81 pandas.Index.str ................................................ 2136
34.6.1.82 pandas.Index.summary ......................................... 2137
34.6.1.83 pandas.Index.symmetric_difference ............................ 2137
34.6.1.84 pandas.Index.take ............................................... 2137
34.6.1.85 pandas.Index.to_frame ......................................... 2138
34.6.1.86 pandas.Index.to_native_types .................................. 2138
34.6.1.87 pandas.Index.to_series ......................................... 2139
34.6.1.88 pandas.Index.tolist ............................................. 2139
34.6.1.89 pandas.Index.transpose ........................................ 2139
34.6.1.90 pandas.Index.union ............................................. 2139
34.6.1.91 pandas.Index.unique ........................................... 2140
34.6.1.92 pandas.Index.value_counts ..................................... 2140
34.6.1.93 pandas.Index.where ............................................. 2141
34.6.2 Attributes ............................................................ 2141
34.6.2.1 pandas.Index.has_duplicates ................................... 2142
34.6.2.2 pandas.Index.is_all_dates ...................................... 2142
34.6.2.3 pandas.Index.name ................................................ 2142
34.6.2.4 pandas.Index.names .............................................. 2142
34.6.2.5 pandas.Index.empty .............................................. 2142
34.6.3 Modifying and Computations ....................................... 2142
34.6.3.1 pandas.Index.is_boolean ......................................... 2143
34.6.3.2 pandas.Index.is_floating ........................................ 2143
34.6.3.3 pandas.Index.is_integer ......................................... 2143
34.6.4 Missing Values ........................................................................... 2143
34.6.5 Conversion .................................................................................. 2143
  34.6.5.1 pandas.Index.view ................................................................. 2144
34.6.6 Sorting ......................................................................................... 2144
34.6.7 Time-specific operations ............................................................. 2144
34.6.8 Combining / joining / set operations ........................................... 2145
34.6.9 Selecting ....................................................................................... 2145
34.7 Numeric Index ................................................................................ 2145
  34.7.1 pandas.RangeIndex ................................................................. 2146
    34.7.1.1 pandas.RangeIndex.from_range ........................................... 2147
  34.7.2 pandas.Int64Index ................................................................. 2147
  34.7.3 pandas.UInt64Index ............................................................... 2147
  34.7.4 pandas.Float64Index .............................................................. 2148
34.8 CategoricalIndex ............................................................................ 2149
  34.8.1 pandas.CategoricalIndex ......................................................... 2149
    34.8.1.1 pandas.CategoricalIndex.rename_categories ......................... 2150
    34.8.1.2 pandas.CategoricalIndex.reorder_categories ......................... 2151
    34.8.1.3 pandas.CategoricalIndex.add_categories ............................... 2151
    34.8.1.4 pandas.CategoricalIndex.remove_categories ......................... 2152
    34.8.1.5 pandas.CategoricalIndex.remove_unused_categories ................. 2152
    34.8.1.6 pandas.CategoricalIndex.set_categories ............................... 2153
    34.8.1.7 pandas.CategoricalIndex.as_unordered .................................. 2153
    34.8.1.8 pandas.CategoricalIndex.as_ordered .................................... 2154
    34.8.1.9 pandas.CategoricalIndex.map ............................................. 2154
  34.8.2 Categorical Components .......................................................... 2155
    34.8.2.1 pandas.CategoricalIndex.codes ........................................... 2155
    34.8.2.2 pandas.CategoricalIndex.categories ..................................... 2155
    34.8.2.3 pandas.CategoricalIndex.ordered ......................................... 2156
34.9 IntervalIndex ................................................................................. 2156
  34.9.1 pandas.IntervalIndex ............................................................. 2156
    34.9.1.1 pandas.IntervalIndex.closed .............................................. 2157
    34.9.1.2 pandas.IntervalIndex.is_non_overlapping_monotonic .............. 2157
    34.9.1.3 pandas.IntervalIndex.left ............................................... 2157
    34.9.1.4 pandas.IntervalIndex.length ............................................ 2158
    34.9.1.5 pandas.IntervalIndex.mid ............................................... 2158
    34.9.1.6 pandas.IntervalIndex.right .............................................. 2158
    34.9.1.7 pandas.IntervalIndex.values ............................................. 2158
    34.9.1.8 pandas.IntervalIndex.contains ......................................... 2158
    34.9.1.9 pandas.IntervalIndex.from_arrays ...................................... 2159
    34.9.1.10 pandas.IntervalIndex.from_breaks .................................... 2160
    34.9.1.11 pandas.IntervalIndex.from_tuples .................................... 2161
    34.9.1.12 pandas.IntervalIndex.get_indexer ..................................... 2161
    34.9.1.13 pandas.IntervalIndex.get_loc ......................................... 2162
  34.9.2 IntervalIndex Components ...................................................... 2163
34.10 MultiIndex .................................................................................... 2164
  34.10.1 pandas.MultiIndex ............................................................... 2164
    34.10.1.1 pandas.MultiIndex.names ............................................... 2165
    34.10.1.2 pandas.MultiIndex.levels .............................................. 2165
    34.10.1.3 pandas.MultiIndex.levshape ........................................... 2165
xxxv
### 34.13 Scalars

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.13.1.1</td>
<td>pandas.PeriodIndex.year</td>
</tr>
<tr>
<td>34.13.1.1</td>
<td>pandas.PeriodIndex.asfreq</td>
</tr>
<tr>
<td>34.13.1.1</td>
<td>pandas.PeriodIndex.strftime</td>
</tr>
<tr>
<td>34.13.1.2</td>
<td>pandas.PeriodIndex.to_timestamp</td>
</tr>
<tr>
<td>34.13.1.2</td>
<td>pandas.PeriodIndex.tz_convert</td>
</tr>
<tr>
<td>34.13.1.2</td>
<td>pandas.PeriodIndex.tz_localize</td>
</tr>
</tbody>
</table>

### 34.14 Scalars

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.14.1</td>
<td>Period</td>
</tr>
<tr>
<td>34.14.2</td>
<td>Attributes</td>
</tr>
<tr>
<td>34.14.3</td>
<td>Methods</td>
</tr>
<tr>
<td>34.14.5</td>
<td>Properties</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.14.5.1</td>
<td>pandas.Timestamp.asm8</td>
</tr>
<tr>
<td>34.14.5.2</td>
<td>pandas.Timestamp.day</td>
</tr>
<tr>
<td>34.14.5.3</td>
<td>pandas.Timestamp.dayofweek</td>
</tr>
<tr>
<td>34.14.5.4</td>
<td>pandas.Timestamp.dayofyear</td>
</tr>
<tr>
<td>34.14.5.5</td>
<td>pandas.Timestamp.days_in_month</td>
</tr>
<tr>
<td>34.14.5.6</td>
<td>pandas.Timestamp.daysinmonth</td>
</tr>
<tr>
<td>34.14.5.7</td>
<td>pandas.Timestamp.fold</td>
</tr>
<tr>
<td>34.14.5.8</td>
<td>pandas.Timestamp.hour</td>
</tr>
<tr>
<td>34.14.5.9</td>
<td>pandas.Timestamp.is_leap_year</td>
</tr>
<tr>
<td>34.14.5.10</td>
<td>pandas.Timestamp.is_month_end</td>
</tr>
<tr>
<td>34.14.5.11</td>
<td>pandas.Timestamp.is_month_start</td>
</tr>
<tr>
<td>34.14.5.12</td>
<td>pandas.Timestamp.is_quarter_end</td>
</tr>
<tr>
<td>34.14.5.13</td>
<td>pandas.Timestamp.is_quarter_start</td>
</tr>
<tr>
<td>34.14.5.14</td>
<td>pandas.Timestamp.is_year_end</td>
</tr>
<tr>
<td>34.14.5.15</td>
<td>pandas.Timestamp.is_year_start</td>
</tr>
<tr>
<td>34.14.5.16</td>
<td>pandas.Timestamp.max</td>
</tr>
<tr>
<td>34.14.5.17</td>
<td>pandas.Timestamp.min</td>
</tr>
<tr>
<td>34.14.5.18</td>
<td>pandas.Timestamp.minute</td>
</tr>
<tr>
<td>34.14.5.19</td>
<td>pandas.Timestamp.month</td>
</tr>
<tr>
<td>34.14.5.20</td>
<td>pandas.Timestamp.nanosecond</td>
</tr>
<tr>
<td>34.14.5.21</td>
<td>pandas.Timestamp.now</td>
</tr>
<tr>
<td>34.14.5.22</td>
<td>pandas.Timestamp.quarter</td>
</tr>
<tr>
<td>34.14.5.23</td>
<td>pandas.Timestamp.resolution</td>
</tr>
<tr>
<td>34.14.5.24</td>
<td>pandas.Timestamp.timestamp</td>
</tr>
<tr>
<td>34.14.5.25</td>
<td>pandas.Timestamp.timezone</td>
</tr>
<tr>
<td>34.14.5.26</td>
<td>pandas.Timestamp.week</td>
</tr>
<tr>
<td>34.14.5.27</td>
<td>pandas.Timestamp.weekofyear</td>
</tr>
<tr>
<td>34.14.5.28</td>
<td>pandas.Timestamp.weekday</td>
</tr>
<tr>
<td>34.14.5.29</td>
<td>pandas.Timestamp.year</td>
</tr>
</tbody>
</table>

### 34.13.2 Attributes

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.13.2.1</td>
<td>pandas.PeriodIndex.end_time</td>
</tr>
<tr>
<td>34.13.2.2</td>
<td>pandas.PeriodIndex.qyear</td>
</tr>
<tr>
<td>34.13.2.3</td>
<td>pandas.PeriodIndex.start_time</td>
</tr>
</tbody>
</table>

### 34.13.3 Methods

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.13.3.1</td>
<td>pandas.Period.now</td>
</tr>
<tr>
<td>34.13.3.2</td>
<td>pandas.PeriodIndex.qyear</td>
</tr>
<tr>
<td>34.13.3.3</td>
<td>pandas.PeriodIndex.start_time</td>
</tr>
</tbody>
</table>

### 34.13.1 Methods

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.13.1.1</td>
<td>pandas.Period</td>
</tr>
<tr>
<td>34.13.1.2</td>
<td>pandas.PeriodIndex.end_time</td>
</tr>
<tr>
<td>34.13.1.3</td>
<td>pandas.PeriodIndex.qyear</td>
</tr>
<tr>
<td>34.13.1.4</td>
<td>pandas.PeriodIndex.start_time</td>
</tr>
</tbody>
</table>

### 34.14.4 Methods

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.14.4.1</td>
<td>pandas.Timestamp.now</td>
</tr>
</tbody>
</table>

### 34.14.5 Methods

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.14.5.1</td>
<td>pandas.Timestamp.asm8</td>
</tr>
<tr>
<td>34.14.5.2</td>
<td>pandas.Timestamp.day</td>
</tr>
<tr>
<td>34.14.5.3</td>
<td>pandas.Timestamp.dayofweek</td>
</tr>
<tr>
<td>34.14.5.4</td>
<td>pandas.Timestamp.dayofyear</td>
</tr>
<tr>
<td>34.14.5.5</td>
<td>pandas.Timestamp.days_in_month</td>
</tr>
<tr>
<td>34.14.5.6</td>
<td>pandas.Timestamp.daysinmonth</td>
</tr>
<tr>
<td>34.14.5.7</td>
<td>pandas.Timestamp.fold</td>
</tr>
<tr>
<td>34.14.5.8</td>
<td>pandas.Timestamp.hour</td>
</tr>
<tr>
<td>34.14.5.9</td>
<td>pandas.Timestamp.is_leap_year</td>
</tr>
<tr>
<td>34.14.5.10</td>
<td>pandas.Timestamp.is_month_end</td>
</tr>
<tr>
<td>34.14.5.11</td>
<td>pandas.Timestamp.is_month_start</td>
</tr>
<tr>
<td>34.14.5.12</td>
<td>pandas.Timestamp.is_quarter_end</td>
</tr>
<tr>
<td>34.14.5.13</td>
<td>pandas.Timestamp.is_quarter_start</td>
</tr>
<tr>
<td>34.14.5.14</td>
<td>pandas.Timestamp.is_year_end</td>
</tr>
<tr>
<td>34.14.5.15</td>
<td>pandas.Timestamp.is_year_start</td>
</tr>
<tr>
<td>34.14.5.16</td>
<td>pandas.Timestamp.max</td>
</tr>
<tr>
<td>34.14.5.17</td>
<td>pandas.Timestamp.min</td>
</tr>
<tr>
<td>34.14.5.18</td>
<td>pandas.Timestamp.minute</td>
</tr>
<tr>
<td>34.14.5.19</td>
<td>pandas.Timestamp.month</td>
</tr>
<tr>
<td>34.14.5.20</td>
<td>pandas.Timestamp.nanosecond</td>
</tr>
<tr>
<td>34.14.5.21</td>
<td>pandas.Timestamp.now</td>
</tr>
<tr>
<td>34.14.5.22</td>
<td>pandas.Timestamp.quarter</td>
</tr>
<tr>
<td>34.14.5.23</td>
<td>pandas.Timestamp.resolution</td>
</tr>
<tr>
<td>34.14.5.24</td>
<td>pandas.Timestamp.timestamp</td>
</tr>
<tr>
<td>34.14.5.25</td>
<td>pandas.Timestamp.timezone</td>
</tr>
<tr>
<td>34.14.5.26</td>
<td>pandas.Timestamp.week</td>
</tr>
<tr>
<td>34.14.5.27</td>
<td>pandas.Timestamp.weekofyear</td>
</tr>
<tr>
<td>34.14.5.28</td>
<td>pandas.Timestamp.weekday</td>
</tr>
<tr>
<td>34.14.5.29</td>
<td>pandas.Timestamp.year</td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>34.16.1.1 pandas.core.window.Expanding.skew</td>
<td>2268</td>
</tr>
<tr>
<td>34.16.1.2 pandas.core.window.Expanding.kurt</td>
<td>2268</td>
</tr>
<tr>
<td>34.16.1.3 pandas.core.window.Expanding.apply</td>
<td>2269</td>
</tr>
<tr>
<td>34.16.1.4 pandas.core.window.Expanding.aggregate</td>
<td>2269</td>
</tr>
<tr>
<td>34.16.1.5 pandas.core.window.Expanding.quantile</td>
<td>2271</td>
</tr>
<tr>
<td>34.16.3 Exponentially-weighted moving window functions</td>
<td>2272</td>
</tr>
<tr>
<td>34.16.3.1 pandas.core.window.EWM.mean</td>
<td>2272</td>
</tr>
<tr>
<td>34.16.3.2 pandas.core.window.EWM.std</td>
<td>2272</td>
</tr>
<tr>
<td>34.16.3.3 pandas.core.window.EWM.var</td>
<td>2272</td>
</tr>
<tr>
<td>34.16.3.4 pandas.core.window.EWM.corr</td>
<td>2273</td>
</tr>
<tr>
<td>34.16.3.5 pandas.core.window.EWM.cov</td>
<td>2273</td>
</tr>
<tr>
<td>34.17 GroupBy</td>
<td>2273</td>
</tr>
<tr>
<td>34.17.1 Indexing, iteration</td>
<td>2274</td>
</tr>
<tr>
<td>34.17.1.1 pandas.core.groupby.GroupBy.<strong>iter</strong></td>
<td>2274</td>
</tr>
<tr>
<td>34.17.1.2 pandas.core.groupby.GroupBy.groups</td>
<td>2274</td>
</tr>
<tr>
<td>34.17.1.3 pandas.core.groupby.GroupBy.indices</td>
<td>2274</td>
</tr>
<tr>
<td>34.17.1.4 pandas.core.groupby.GroupBy.get_group</td>
<td>2274</td>
</tr>
<tr>
<td>34.17.1.5 pandas.Grouper</td>
<td>2274</td>
</tr>
<tr>
<td>34.17.2 Function application</td>
<td>2276</td>
</tr>
<tr>
<td>34.17.2.1 pandas.core.groupby.GroupBy.apply</td>
<td>2276</td>
</tr>
<tr>
<td>34.17.2.2 pandas.core.groupby.GroupBy.aggregate</td>
<td>2277</td>
</tr>
<tr>
<td>34.17.2.3 pandas.core.groupby.GroupBy.transform</td>
<td>2277</td>
</tr>
<tr>
<td>34.17.2.4 pandas.core.groupby.GroupBy.pipe</td>
<td>2277</td>
</tr>
<tr>
<td>34.17.3 Computations / Descriptive Stats</td>
<td>2279</td>
</tr>
<tr>
<td>34.17.3.1 pandas.core.groupby.GroupBy.all</td>
<td>2279</td>
</tr>
<tr>
<td>34.17.3.2 pandas.core.groupby.GroupBy.any</td>
<td>2279</td>
</tr>
<tr>
<td>34.17.3.3 pandas.core.groupby.GroupBy.bfill</td>
<td>2280</td>
</tr>
<tr>
<td>34.17.3.4 pandas.core.groupby.GroupBy.count</td>
<td>2280</td>
</tr>
<tr>
<td>34.17.3.5 pandas.core.groupby.GroupBy.cumcount</td>
<td>2280</td>
</tr>
<tr>
<td>34.17.3.6 pandas.core.groupby.GroupBy.fill</td>
<td>2281</td>
</tr>
<tr>
<td>34.17.3.7 pandas.core.groupby.GroupBy.first</td>
<td>2281</td>
</tr>
<tr>
<td>34.17.3.8 pandas.core.groupby.GroupBy.head</td>
<td>2281</td>
</tr>
<tr>
<td>34.17.3.9 pandas.core.groupby.GroupBy.last</td>
<td>2282</td>
</tr>
<tr>
<td>34.17.3.10 pandas.core.groupby.GroupBy.max</td>
<td>2282</td>
</tr>
<tr>
<td>34.17.3.11 pandas.core.groupby.GroupBy.mean</td>
<td>2282</td>
</tr>
<tr>
<td>34.17.3.12 pandas.core.groupby.GroupBy.median</td>
<td>2282</td>
</tr>
<tr>
<td>34.17.3.13 pandas.core.groupby.GroupBy.min</td>
<td>2283</td>
</tr>
<tr>
<td>34.17.3.14 pandas.core.groupby.GroupBy.ngroup</td>
<td>2283</td>
</tr>
<tr>
<td>34.17.3.15 pandas.core.groupby.GroupBy.nth</td>
<td>2284</td>
</tr>
<tr>
<td>34.17.3.16 pandas.core.groupby.GroupBy.ohlc</td>
<td>2285</td>
</tr>
<tr>
<td>34.17.3.17 pandas.core.groupby.GroupBy.prod</td>
<td>2285</td>
</tr>
<tr>
<td>34.17.3.18 pandas.core.groupby.GroupBy.rank</td>
<td>2285</td>
</tr>
<tr>
<td>34.17.3.19 pandas.core.groupby.GroupBy.pct_change</td>
<td>2286</td>
</tr>
<tr>
<td>34.17.3.20 pandas.core.groupby.GroupBy.size</td>
<td>2286</td>
</tr>
<tr>
<td>34.17.3.21 pandas.core.groupby.GroupBy.sem</td>
<td>2286</td>
</tr>
<tr>
<td>34.17.3.22 pandas.core.groupby.GroupBy.std</td>
<td>2287</td>
</tr>
<tr>
<td>34.17.3.23 pandas.core.groupby.GroupBy.sum</td>
<td>2287</td>
</tr>
<tr>
<td>34.17.3.24 pandas.core.groupby.GroupBy.var</td>
<td>2287</td>
</tr>
<tr>
<td>34.17.3.25 pandas.core.groupby.GroupBy.tail</td>
<td>2287</td>
</tr>
<tr>
<td>34.17.3.26 pandas.core.groupby.DataFrameGroupBy.agg</td>
<td>2289</td>
</tr>
<tr>
<td>34.17.3.27 pandas.core.groupby.DataFrameGroupBy.all</td>
<td>2290</td>
</tr>
<tr>
<td>34.17.3.28 pandas.core.groupby.DataFrameGroupBy.any</td>
<td>2291</td>
</tr>
<tr>
<td>34.17.3.29 pandas.core.groupby.DataFrameGroupBy.bfill</td>
<td>2291</td>
</tr>
<tr>
<td>34.17.3.30 pandas.core.groupby.DataFrameGroupBy.corr</td>
<td>2291</td>
</tr>
<tr>
<td>Function</td>
<td>Page</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.count</td>
<td>2291</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.cov</td>
<td>2291</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.cummax</td>
<td>2293</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.cummin</td>
<td>2293</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.cumprod</td>
<td>2293</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.cumsum</td>
<td>2293</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.diff</td>
<td>2297</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.fill</td>
<td>2299</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.filter</td>
<td>2301</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.hist</td>
<td>2301</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.idxmax</td>
<td>2303</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.idxmin</td>
<td>2303</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.mad</td>
<td>2304</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.pct_change</td>
<td>2304</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.plot</td>
<td>2304</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.quantile</td>
<td>2304</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.rank</td>
<td>2306</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.resample</td>
<td>2306</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.shift</td>
<td>2307</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.size</td>
<td>2307</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.skew</td>
<td>2307</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.take</td>
<td>2307</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.tshift</td>
<td>2309</td>
</tr>
<tr>
<td>pandas.core.groupby.SeriesGroupBy.nlargest</td>
<td>2310</td>
</tr>
<tr>
<td>pandas.core.groupby.SeriesGroupBy.nsmallest</td>
<td>2310</td>
</tr>
<tr>
<td>pandas.core.groupby.SeriesGroupBy.nunique</td>
<td>2311</td>
</tr>
<tr>
<td>pandas.core.groupby.SeriesGroupBy.unique</td>
<td>2311</td>
</tr>
<tr>
<td>pandas.core.groupby.SeriesGroupBy.value_counts</td>
<td>2312</td>
</tr>
<tr>
<td>pandas.core.groupby.SeriesGroupBy.is_monotonic_increasing</td>
<td>2312</td>
</tr>
<tr>
<td>pandas.core.groupby.SeriesGroupBy.is_monotonic_decreasing</td>
<td>2312</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.corrwith</td>
<td>2313</td>
</tr>
<tr>
<td>pandas.core.groupby.DataFrameGroupBy.boxplot</td>
<td>2313</td>
</tr>
</tbody>
</table>

34.18 Resampling

34.18.1 Indexing, iteration

34.18.2 Function application

34.18.3 Upsampling

34.18.3.1 pandas.core.resample.Resampler.fill   | 2320 |
34.18.3.2 pandas.core.resample.Resampler.backfill | 2320 |
34.18.3.3 pandas.core.resample.Resampler.bfill   | 2322 |
34.18.3.4 pandas.core.resample.Resampler.pad     | 2324 |
34.18.3.5 pandas.core.resample.Resampler.nearest | 2324 |
34.18.3.6 pandas.core.resample.Resampler.fillna  | 2324 |
34.18.3.7 pandas.core.resample.Resampler.asfreq  | 2327 |
34.18.3.8 pandas.core.resample.Resampler.interpolate | 2327 |
34.18.4 Computations / Descriptive Stats .................................................. 2329
  34.18.4.1 pandas.core.resample.Resampler.count ................................. 2329
  34.18.4.2 pandas.core.resample.Resampler.nunique .............................. 2329
  34.18.4.3 pandas.core.resample.Resampler.first ............................... 2329
  34.18.4.4 pandas.core.resample.Resampler.last .................................. 2330
  34.18.4.5 pandas.core.resample.Resampler.max .................................. 2330
  34.18.4.6 pandas.core.resample.Resampler.mean ................................ 2330
  34.18.4.7 pandas.core.resample.Resampler.median ............................. 2330
  34.18.4.8 pandas.core.resample.Resampler.min .................................. 2330
  34.18.4.9 pandas.core.resample.Resampler.ohlc .................................. 2331
  34.18.4.10 pandas.core.resample.Resampler.prod .................................. 2331
  34.18.4.11 pandas.core.resample.Resampler.size .................................. 2331
  34.18.4.12 pandas.core.resample.Resampler.sem .................................. 2331
  34.18.4.13 pandas.core.resample.Resampler.std .................................. 2331
  34.18.4.14 pandas.core.resample.Resampler.sum .................................. 2331
  34.18.4.15 pandas.core.resample.Resampler.var .................................. 2332

34.19 Style .......................................................... 2332
  34.19.1 Styler Constructor ......................................................... 2332
  34.19.1.1 pandas.io.formats.style.Styler ........................................ 2332
  34.19.2 Styler Attributes .......................................................... 2344
  34.19.2.1 pandas.io.formats.style.Styler.env .................................. 2344
  34.19.2.2 pandas.io.formats.style.Styler.template ............................. 2344
  34.19.2.3 pandas.io.formats.style.Styler.loader ................................ 2344
  34.19.3 Style Application ......................................................... 2344
  34.19.4 Builtin Styles .............................................................. 2345
  34.19.5 Style Export and Import ................................................... 2345

34.20 Plotting .......................................................... 2345
  34.20.1 pandas.plotting.andrews_curves .......................................... 2345
  34.20.2 pandas.plotting.bootstrap_plot ......................................... 2346
  34.20.3 pandas.plotting.deregister_matplotlib_converters .................... 2347
  34.20.4 pandas.plotting.lag_plot .................................................. 2347
  34.20.5 pandas.plotting.parallel_coordinates ................................... 2347
  34.20.6 pandas.plotting.radviz .................................................... 2348
  34.20.7 pandas.plotting.register_matplotlib_converters ....................... 2349
  34.20.8 pandas.plotting.scatter_matrix ......................................... 2350

34.21 General utility functions ............................................... 2351
  34.21.1 Working with options ...................................................... 2351
    34.21.1.1 pandas.describe_option .............................................. 2351
    34.21.1.2 pandas.reset_option .................................................. 2355
    34.21.1.3 pandas.get_option ..................................................... 2358
    34.21.1.4 pandas.set_option ..................................................... 2362
    34.21.1.5 pandas.option_context ............................................... 2366
  34.21.2 Testing functions .......................................................... 2366
    34.21.2.1 pandas.testing.assert_frame_equal .................................. 2366
    34.21.2.2 pandas.testing.assert_series_equal ................................ 2367
    34.21.2.3 pandas.testing.assert_index_equal .................................. 2368
  34.21.3 Exceptions and warnings .................................................. 2368
    34.21.3.1 pandas.errors.DtypeWarning ........................................ 2369
    34.21.3.2 pandas.errors.EmptyDataError ...................................... 2370
    34.21.3.3 pandas.errorsOutOfBoundsDateTime .................................. 2370
    34.21.3.4 pandas.errors.ParserError .......................................... 2370
    34.21.3.5 pandas.errors.ParserWarning ....................................... 2371
    34.21.3.6 pandas.errors.PerformanceWarning .................................. 2371
    34.21.3.7 pandas.errors.UnsortedIndexError .................................. 2371
34.21.3.8 pandas.errors.UnsupportedFunctionCall .......................... 2371
34.21.4 Data types related functionality .................................. 2371
34.21.4.1 pandas.api.types.union_categoricals ........................... 2372
34.21.4.2 pandas.api.types.infer_dtype ................................. 2373
34.21.4.3 pandas.api.types.pandas_dtype ............................... 2376
34.21.4.4 pandas.api.types.is_bool_dtype ............................. 2377
34.21.4.5 pandas.api.types.is_categorical_dtype ....................... 2377
34.21.4.6 pandas.api.types.is_complex_dtype .......................... 2378
34.21.4.7 pandas.api.types.is_datetime64_any_dtype ................. 2378
34.21.4.8 pandas.api.types.is_datetime64_dtype ....................... 2379
34.21.4.9 pandas.api.types.is_datetime64_ns_dtype ..................... 2379
34.21.4.10 pandas.api.types.is_datetime64tz_dtype ..................... 2380
34.21.4.11 pandas.api.types.is_extension_type ....................... 2381
34.21.4.12 pandas.api.types.is_float_dtype ......................... 2381
34.21.4.13 pandas.api.types.is_int64_dtype ........................... 2382
34.21.4.14 pandas.api.types.is_integer_dtype ........................ 2383
34.21.4.15 pandas.api.types.is_interval_dtype ....................... 2383
34.21.4.16 pandas.api.types.is_int64_dtype ........................... 2383
34.21.4.17 pandas.api.types.is_integer_dtype ........................ 2383
34.21.4.18 pandas.api.types.is_period_dtype ......................... 2384
34.21.4.19 pandas.api.types.is_period_dtype ......................... 2384
34.21.4.20 pandas.api.types.is_object_dtype ......................... 2385
34.21.4.21 pandas.api.types.is_object_dtype ......................... 2385
34.21.4.22 pandas.api.types.is_extension_type ....................... 2386
34.21.4.23 pandas.api.types.is_extension_type ....................... 2386
34.21.4.24 pandas.api.types.is_extension_type ....................... 2387
34.21.4.25 pandas.api.types.is_extension_type ....................... 2387
34.21.4.26 pandas.api.types.is_extension_type ....................... 2388
34.21.4.27 pandas.api.types.is_extension_type ....................... 2388
34.21.4.28 pandas.api.types.is_extension_type ....................... 2389
34.21.4.29 pandas.api.types.is_extension_type ....................... 2389
34.21.4.30 pandas.api.types.is_extension_type ....................... 2390
34.21.4.31 pandas.api.types.is_extension_type ....................... 2390
34.21.4.32 pandas.api.types.is_extension_type ....................... 2391
34.21.4.33 pandas.api.types.is_extension_type ....................... 2391
34.21.4.34 pandas.api.types.is_extension_type ....................... 2392
34.21.4.35 pandas.api.types.is_extension_type ....................... 2392
34.21.4.36 pandas.api.types.is_extension_type ....................... 2392
34.21.4.37 pandas.api.types.is_extension_type ....................... 2392
34.21.4.38 pandas.api.types.is_extension_type ....................... 2393
34.21.4.39 pandas.api.types.is_extension_type ....................... 2393
34.21.4.40 pandas.api.types.is_extension_type ....................... 2393
34.21.4.41 pandas.api.types.is_extension_type ....................... 2393
34.21.4.42 pandas.api.types.is_extension_type ....................... 2393
34.21.4.43 pandas.api.types.is_extension_type ....................... 2393
34.21.4.44 pandas.api.types.is_extension_type ....................... 2394
34.21.4.45 pandas.api.types.is_extension_type ....................... 2394
34.21.4.46 pandas.api.types.is_extension_type ....................... 2395
34.21.4.47 pandas.api.types.is_extension_type ....................... 2395
34.21.4.48 pandas.api.types.is_extension_type ....................... 2395
34.21.4.49 pandas.api.types.is_extension_type ....................... 2395
34.21.4.50 pandas.api.types.is_extension_type ....................... 2395
34.21.4.51 pandas.api.types.is_extension_type ....................... 2395
34.21.4.52 pandas.api.types.is_extension_type ....................... 2395
34.21.4.53 pandas.api.types.is_extension_type ....................... 2395
34.21.4.54 pandas.api.types.is_extension_type ....................... 2395
34.21.4.55 pandas.api.types.is_extension_type ....................... 2395
34.22 Extensions .......................................................... 2395
34.22.1 pandas.api.extensions.register_dataframe_accessor ........... 2396
34.22.2 pandas.api.extensions.register_series_accessor ............. 2397
34.22.3 pandas.api.extensions.register_index_accessor .............. 2398
34.22.4 pandas.api.extensions.ExtensionDtype ....................... 2399
34.22.4.1 pandas.api.extensions.ExtensionDtype.kind ................ 2400
34.22.4.2 pandas.api.extensions.ExtensionDtype.name ............... 2400
34.22.4.3 pandas.api.extensions.ExtensionDtype.names .............. 2400
34.22.4.4 pandas.api.extensions.ExtensionDtype.type ............... 2400
34.22.4.5 pandas.api.extensions.ExtensionDtype.construct_from_string 2400
38.27 pandas 0.10.1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2512
  38.27.1 New Features
  38.27.2 API Changes
  38.27.3 Improvements to existing features
  38.27.4 Bug Fixes

38.28 pandas 0.10.0 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2514
  38.28.1 New Features
  38.28.2 Experimental Features
  38.28.3 API Changes
  38.28.4 Improvements to existing features
  38.28.5 Bug Fixes

38.29 pandas 0.9.1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2519
  38.29.1 New Features
  38.29.2 API Changes
  38.29.3 Improvements to existing features
  38.29.4 Bug Fixes

38.30 pandas 0.9.0 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2521
  38.30.1 New Features
  38.30.2 Improvements to existing features
  38.30.3 API Changes
  38.30.4 Bug Fixes

38.31 pandas 0.8.1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2526
  38.31.1 New Features
  38.31.2 Improvements to existing features
  38.31.3 Bug Fixes

38.32 pandas 0.8.0 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2528
  38.32.1 New Features
  38.32.2 Improvements to existing features
  38.32.3 API Changes
  38.32.4 Bug Fixes

38.33 pandas 0.7.3 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2533
  38.33.1 New Features
  38.33.2 API Changes
  38.33.3 Bug Fixes

38.34 pandas 0.7.2 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2534
  38.34.1 New Features
  38.34.2 API Changes
  38.34.3 Improvements to existing features
  38.34.4 Bug Fixes

38.35 pandas 0.7.1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2536
  38.35.1 New Features
  38.35.2 Improvements to existing features
  38.35.3 Bug Fixes

38.36 pandas 0.7.0 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2537
  38.36.1 New Features
  38.36.2 API Changes
  38.36.3 Improvements to existing features
  38.36.4 Bug Fixes
  38.36.5 Thanks

38.37 pandas 0.6.1 . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2543
38.38 pandas 0.6.0 ................................................. 2545
  38.38.1 API Changes ........................................ 2546
  38.38.2 New Features ...................................... 2546
  38.38.3 Improvements to existing features .............. 2547
  38.38.4 Bug Fixes .......................................... 2547
  38.38.5 Thanks ............................................. 2549

38.39 pandas 0.5.0 ................................................. 2549
  38.39.1 API Changes ........................................ 2549
  38.39.2 Deprecations Removed ............................ 2551
  38.39.3 New Features ...................................... 2551
  38.39.4 Improvements to existing features .............. 2551
  38.39.5 Bug Fixes .......................................... 2552
  38.39.6 Thanks ............................................. 2553

38.40 pandas 0.4.3 ................................................. 2553
  38.40.1 New Features ...................................... 2553
  38.40.2 Improvements to existing features .............. 2553
  38.40.3 API Changes ........................................ 2554
  38.40.4 Bug Fixes .......................................... 2554
  38.40.5 Thanks ............................................. 2554

38.41 pandas 0.4.2 ................................................. 2554
  38.41.1 New Features ...................................... 2554
  38.41.2 Improvements to existing features .............. 2555
  38.41.3 API Changes ........................................ 2555
  38.41.4 Bug Fixes .......................................... 2555
  38.41.5 Thanks ............................................. 2555

38.42 pandas 0.4.1 ................................................. 2555
  38.42.1 New Features ...................................... 2556
  38.42.2 Improvements to existing features .............. 2556
  38.42.3 API Changes ........................................ 2556
  38.42.4 Bug Fixes .......................................... 2556
  38.42.5 Thanks ............................................. 2557

38.43 pandas 0.4.0 ................................................. 2557
  38.43.1 New Features ...................................... 2557
  38.43.2 Improvements to existing features .............. 2558
  38.43.3 API Changes ........................................ 2559
  38.43.4 Bug Fixes .......................................... 2560
  38.43.5 Thanks ............................................. 2561

38.44 pandas 0.3.0 ................................................. 2562
  38.44.1 New features ...................................... 2562
  38.44.2 Improvements to existing features .............. 2562
  38.44.3 API Changes ........................................ 2562
  38.44.4 Bug Fixes .......................................... 2563

Bibliography .................................................. 2565

Python Module Index ......................................... 2567
pandas is a Python package providing fast, flexible, and expressive data structures designed to make working with “relational” or “labeled” data both easy and intuitive. It aims to be the fundamental high-level building block for doing practical, real world data analysis in Python. Additionally, it has the broader goal of becoming the most powerful and flexible open source data analysis / manipulation tool available in any language. It is already well on its way toward this goal.

pandas is well suited for many different kinds of data:

- Tabular data with heterogeneously-typed columns, as in an SQL table or Excel spreadsheet
- Ordered and unordered (not necessarily fixed-frequency) time series data.
- Arbitrary matrix data (homogeneously typed or heterogeneous) with row and column labels
- Any other form of observational / statistical data sets. The data actually need not be labeled at all to be placed into a pandas data structure

The two primary data structures of pandas, Series (1-dimensional) and DataFrame (2-dimensional), handle the vast majority of typical use cases in finance, statistics, social science, and many areas of engineering. For R users, DataFrame provides everything that R’s data.frame provides and much more. pandas is built on top of NumPy and is intended to integrate well within a scientific computing environment with many other 3rd party libraries.

Here are just a few of the things that pandas does well:

- Easy handling of missing data (represented as NaN) in floating point as well as non-floating point data
- Size mutability: columns can be inserted and deleted from DataFrame and higher dimensional objects
- Automatic and explicit data alignment: objects can be explicitly aligned to a set of labels, or the user can simply ignore the labels and let Series, DataFrame, etc. automatically align the data for you in computations
- Powerful, flexible group by functionality to perform split-apply-combine operations on data sets, for both aggregating and transforming data
- Make it easy to convert ragged, differently-indexed data in other Python and NumPy data structures into DataFrame objects
- Intelligent label-based slicing, fancy indexing, and subsetting of large data sets
- Intuitive merging and joining data sets
- Flexible reshaping and pivoting of data sets
- Hierarchical labeling of axes (possible to have multiple labels per tick)
- Robust IO tools for loading data from flat files (CSV and delimited), Excel files, databases, and saving / loading data from the ultrafast HDF5 format
- Time series-specific functionality: date range generation and frequency conversion, moving window statistics, moving window linear regressions, date shifting and lagging, etc.
Many of these principles are here to address the shortcomings frequently experienced using other languages / scientific research environments. For data scientists, working with data is typically divided into multiple stages: munging and cleaning data, analyzing / modeling it, then organizing the results of the analysis into a form suitable for plotting or tabular display. pandas is the ideal tool for all of these tasks.

Some other notes

- **pandas is fast.** Many of the low-level algorithmic bits have been extensively tweaked in Cython code. However, as with anything else generalization usually sacrifices performance. So if you focus on one feature for your application you may be able to create a faster specialized tool.

- **pandas is a dependency of statsmodels,** making it an important part of the statistical computing ecosystem in Python.

- **pandas has been used extensively in production in financial applications.**

---

**Note:** This documentation assumes general familiarity with NumPy. If you haven’t used NumPy much or at all, do invest some time in learning about NumPy first.

See the package overview for more detail about what’s in the library.
WHAT'S NEW

These are new features and improvements of note in each release.

1.1 v0.23.2

This is a minor bug-fix release in the 0.23.x series and includes some small regression fixes and bug fixes. We recommend that all users upgrade to this version.

Note:  Pandas 0.23.2 is first pandas release that’s compatible with Python 3.7 (GH20552)

What's new in v0.23.2

- Logical Reductions over Entire DataFrame
  - DataFrame.all() and DataFrame.any() now accept axis=None to reduce over all axes to a scalar (GH19976)

```python
In [1]: df = pd.DataFrame({"A": [1, 2], "B": [True, False]})
In [2]: df.all(axis=None)
Out[2]: False
```

This also provides compatibility with NumPy 1.15, which now dispatches to DataFrame.all. With NumPy 1.15 and pandas 0.23.1 or earlier, numpy.all() will no longer reduce over every axis:

```python
>>> # NumPy 1.15, pandas 0.23.1
>>> np.any(pd.DataFrame({"A": [False], "B": [False]}))
A  False
B  False
dtype: bool
```
With pandas 0.23.2, that will correctly return False, as it did with NumPy < 1.15.

```
In [3]: np.any(pd.DataFrame({"A": [False], "B": [False]}))
Out[3]: False
```

### 1.1.2 Fixed Regressions

- Fixed regression in `to_csv()` when handling file-like object incorrectly (GH21471)
- Re-allowed duplicate level names of a MultiIndex. Accessing a level that has a duplicate name by name still raises an error (GH19029).
- Bug in both `DataFrame.first_valid_index()` and `Series.first_valid_index()` raised for a row index having duplicate values (GH21441)
- Fixed printing of DataFrames with hierarchical columns with long names (GH21180)
- Fixed regression in `reindex()` and `groupby()` with a MultiIndex or multiple keys that contains categorical datetime-like values (GH21390).
- Fixed regression in unary negative operations with object dtype (GH21380)
- Bug in `Timestamp.ceil()` and `Timestamp.floor()` when timestamp is a multiple of the rounding frequency (GH21262)
- Fixed regression in `to_clipboard()` that defaulted to copying dataframes with space delimited instead of tab delimited (GH21104)

### 1.1.3 Build Changes

- The source and binary distributions no longer include test data files, resulting in smaller download sizes. Tests relying on these data files will be skipped when using `pandas.test()` (GH19320)

### 1.1.4 Bug Fixes

#### Conversion

- Bug in constructing `Index` with an iterator or generator (GH21470)
- Bug in `Series.nlargest()` for signed and unsigned integer dtypes when the minimum value is present (GH21426)

#### Indexing

- Bug in `Index.get_indexer_non_unique()` with categorical key (GH21448)
- Bug in comparison operations for `MultiIndex` where error was raised on equality / inequality comparison involving a MultiIndex with `nlevels == 1` (GH21149)
- Bug in `DataFrame.drop()` behaviour is not consistent for unique and non-unique indexes (GH21494)
- Bug in `DataFrame.duplicated()` with a large number of columns causing a ‘maximum recursion depth exceeded’ (GH21524).

#### I/O

- Bug in `read_csv()` that caused it to incorrectly raise an error when `nrows=0`, `low_memory=True`, and `index_col` was not `None` (GH21414)
- Bug in `json_normalize()` when formatting the `record_prefix` with integer columns (GH21536)
Categorical

- Bug in rendering Series with Categorical dtype in rare conditions under Python 2.7 (GH21002)

Timezones

- Bug in Timestamp and DatetimeIndex where passing a Timestamp localized after a DST transition would return a datetime before the DST transition (GH20854)
- Bug in comparing DataFrame's with tz-aware :class:`DatetimeIndex` columns with a DST transition that raised a KeyError (GH19970)

Timedelta

- Bug in Timedelta where non-zero timedeltas shorter than 1 microsecond were considered False (GH21484)

1.2 v0.23.1

This is a minor bug-fix release in the 0.23.x series and includes some small regression fixes and bug fixes. We recommend that all users upgrade to this version.

What's new in v0.23.1

- Fixed Regressions
- Performance Improvements
- Bug Fixes

1.2.1 Fixed Regressions

Comparing Series with datetime.date

We've reverted a 0.23.0 change to comparing a Series holding datetimes and a datetime.date object (GH21152). In pandas 0.22 and earlier, comparing a Series holding datetimes and datetime.date objects would coerce the datetime.date to a datetime before comparing. This was inconsistent with Python, NumPy, and DatetimeIndex, which never consider a datetime and datetime.date equal.

In 0.23.0, we unified operations between DatetimeIndex and Series, and in the process changed comparisons between a Series of datetimes and datetime.date without warning.

We've temporarily restored the 0.22.0 behavior, so datetimes and dates may again compare equal, but restore the 0.23.0 behavior in a future release.

To summarize, here's the behavior in 0.22.0, 0.23.0, 0.23.1:

```python
# 0.22.0... Silently coerce the datetime.date
>>> Series(pd.date_range('2017', periods=2)) == datetime.date(2017, 1, 1)
0  True
1  False
dtype: bool

# 0.23.0... Do not coerce the datetime.date
>>> Series(pd.date_range('2017', periods=2)) == datetime.date(2017, 1, 1)
0  False
1  False
```

(continues on next page)
dtype: bool

# 0.23.1... Coerce the datetime.date with a warning
>>> Series(pd.date_range('2017', periods=2)) == datetime.date(2017, 1, 1)
/bin/python:1: FutureWarning: Comparing Series of datetimes with 'datetime.date'.
Currently, the 'datetime.date' is coerced to a datetime. In the future pandas will not coerce, and the values not compare equal to the 'datetime.date'. To retain the current behavior, convert the 'datetime.date' to a datetime with 'pd.Timestamp'.
   #!/bin/python3
   0  True
   1  False
dtype: bool

In addition, ordering comparisons will raise a TypeError in the future.

Other Fixes

- Reverted the ability of to_sql() to perform multivalue inserts as this caused regression in certain cases (GH21103). In the future this will be made configurable.
- Fixed regression in the DatetimeIndex.date and DatetimeIndex.time attributes in case of timezone-aware data: DatetimeIndex.time returned a tz-aware time instead of tz-naive (GH21267) and DatetimeIndex.date returned incorrect date when the input date has a non-UTC timezone (GH21230).
- Fixed regression in pandas.io.json.json_normalize() when called with None values in nested levels in JSON, and to not drop keys with value as None (GH21158, GH21356).
- Bug in to_csv() causes encoding error when compression and encoding are specified (GH21241, GH21118)
- Bug preventing pandas from being importable with -OO optimization (GH21071)
- Bug in Categorical.fillna() incorrectly raising a TypeError when value the individual categories are iterable and value is an iterable (GH21097, GH19788)
- Fixed regression in constructors coercing NA values like None to strings when passing dtype=str (GH21083)
- Regression in pivot_table() where an ordered Categorical with missing values for the pivot's index would give a mis-aligned result (GH21133)
- Fixed regression in merging on boolean index/columns (GH21119).

1.2.2 Performance Improvements

- Improved performance of CategoricalIndex.is_monotonic_increasing(), CategoricalIndex.is_monotonic_decreasing() and CategoricalIndex.is_monotonic() (GH21025)
- Improved performance of CategoricalIndex.is_unique() (GH21107)

1.2.3 Bug Fixes

Groupby/Resample/Rolling

- Bug in DataFrame.agg() where applying multiple aggregation functions to a DataFrame with duplicated column names would cause a stack overflow (GH21063)
• Bug in `pandas.core.groupby.GroupBy.ffill()` and `pandas.core.groupby.GroupBy.bfill()` where the fill within a grouping would not always be applied as intended due to the implementations' use of a non-stable sort (GH21207)

• Bug in `pandas.core.groupby.GroupBy.rank()` where results did not scale to 100% when specifying method='dense' and pct=True

• Bug in `pandas.DataFrame.rolling()` and `pandas.Series.rolling()` which incorrectly accepted a 0 window size rather than raising (GH21286)

Data-type specific

• Bug in `Series.str.replace()` where the method throws `TypeError` on Python 3.5.2 (GH21078)

• Bug in `Timedelta`: where passing a float with a unit would prematurely round the float precision (GH14156)

• Bug in `pandas.testing.assert_index_equal()` which raised `AssertionError` incorrectly, when comparing two `CategoricalIndex` objects with param `check_categorical=False` (GH19776)

Sparse

• Bug in `SparseArray.shape` which previously only returned the shape `SparseArray.sp_values` (GH21126)

Indexing

• Bug in `Series.reset_index()` where appropriate error was not raised with an invalid level name (GH20925)

• Bug in `interval_range()` when start/periods or end/periods are specified with float start or end (GH21161)

• Bug in `MultiIndex.set_names()` where error raised for a `MultiIndex` with nlevels == 1 (GH21149)

• Bug in `IntervalIndex` constructors where creating an `IntervalIndex` from categorical data was not fully supported (GH21243, GH21253)

• Bug in `MultiIndex.sort_index()` which was not guaranteed to sort correctly with level=1; this was also causing data misalignment in particular `DataFrame.stack()` operations (GH20994, GH20945, GH21052)

Plotting

• New keywords (sharex, sharey) to turn on/off sharing of x/y-axis by subplots generated with pandas.DataFrame().groupby().boxplot() (GH20968)

I/O

• Bug in IO methods specifying `compression='zip'` which produced uncompressed zip archives (GH17778, GH21144)

• Bug in `DataFrame.to_stata()` which prevented exporting DataFrames to buffers and most file-like objects (GH21041)

• Bug in `read_stata()` and `StataReader` which did not correctly decode utf-8 strings on Python 3 from Stata 14 files (dta version 118) (GH21244)

• Bug in IO JSON `read_json()` reading empty JSON schema with `orient='table'` back to `DataFrame` caused an error (GH21287)

Reshaping
• Bug in `concat()` where error was raised in concatenating `Series` with numpy scalar and tuple names (GH21015)
• Bug in `concat()` warning message providing the wrong guidance for future behavior (GH21101)

Other
• Tab completion on `Index` in IPython no longer outputs deprecation warnings (GH21125)
• Bug preventing pandas being used on Windows without C++ redistributable installed (GH21106)

1.3 v0.23.0 (May 15, 2018)

This is a major release from 0.22.0 and includes a number of API changes, deprecations, new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:
• Round-trippable JSON format with ‘table’ orient.
• Instantiation from dicts respects order for Python 3.6+.
• Dependent column arguments for `assign`.
• Merging / sorting on a combination of columns and index levels.
• Extending Pandas with custom types.
• Excluding unobserved categories from `groupby`.
• Changes to make output shape of `DataFrame.apply` consistent.

Check the API Changes and deprecations before updating.

Warning: Starting January 1, 2019, pandas feature releases will support Python 3 only. See Plan for dropping Python 2.7 for more.

What’s new in v0.23.0

• New features
  – JSON read/write round-trippable with `orient='table'`
  – `.assign()` accepts dependent arguments
  – Merging on a combination of columns and index levels
  – Sorting by a combination of columns and index levels
  – Extending Pandas with Custom Types (Experimental)
  – New `observed` keyword for excluding unobserved categories in `groupby`
  – `Rolling/Expanding.apply()` accepts `raw=False` to pass a `Series` to the function
  – `DataFrame.interpolate` has gained the `limit_area` kwarg
  – `get_dummies` now supports `dtype` argument
  – `Timedelta mod method`
pandas: powerful Python data analysis toolkit, Release 0.23.2

- `Series.rank()` handles inf values when NaN are present
- `Series.str.cat` has gained the `join` kwarg
- `DataFrame.astype` performs column-wise conversion to `Categorical`
- Other Enhancements

- **Backwards incompatible API changes**
  - Dependencies have increased minimum versions
  - Instantiation from dicts preserves dict insertion order for python 3.6+
  - Deprecate Panel
  - `pandas.core.common` removals
  - Changes to make output of `DataFrame.apply` consistent
  - Concatenation will no longer sort
  - Build Changes
  - `Index Division By Zero Fills Correctly`
  - Extraction of matching patterns from strings
  - Default value for the `ordered` parameter of `CategoricalDtype`
  - Better pretty-printing of DataFrames in a terminal
  - Datetimelike API Changes
  - Other API Changes

- **Deprecations**
- **Removal of prior version deprecations/changes**
- **Performance Improvements**
- **Documentation Changes**
- **Bug Fixes**
  - Categorical
  - Datetimelike
  - `Timedelta`
  - `Timezones`
  - `Offsets`
  - `Numeric`
  - `Strings`
  - `Indexing`
  - `MultiIndex`
  - `I/O`
  - `Plotting`
  - `Groupby/Resample/Rolling`

1.3. v0.23.0 (May 15, 2018)
1.3.1 New features

1.3.1.1 JSON read/write round-trippable with `orient='table'`

A DataFrame can now be written to and subsequently read back via JSON while preserving metadata through usage of the `orient='table'` argument (see GH18912 and GH9146). Previously, none of the available `orient` values guaranteed the preservation of dtypes and index names, amongst other metadata.

```
In [1]: df = pd.DataFrame({'foo': [1, 2, 3, 4],
                       'bar': ['a', 'b', 'c', 'd'],
                       'baz': pd.date_range('2018-01-01', freq='d', periods=4),
                       'qux': pd.Categorical(['a', 'b', 'c', 'c'])}, index=pd.Index(range(4), name='idx'))

In [2]: df
Out[2]:
       foo  bar    baz        qux
    idx
0  1    a  2018-01-01 a
1  2    b  2018-01-02 b
2  3    c  2018-01-03 c
3  4    d  2018-01-04 c

In [3]: df.dtypes
   →
       foo       int64
bar       object
baz  datetime64[ns]
qux      category
dtype: object

In [4]: df.to_json('test.json', orient='table')

In [5]: new_df = pd.read_json('test.json', orient='table')

In [6]: new_df
Out[6]:
       foo  bar    baz        qux
    idx
0  1    a  2018-01-01 a
1  2    b  2018-01-02 b
2  3    c  2018-01-03 c
3  4    d  2018-01-04 c

In [7]: new_df.dtypes
   →
       foo       int64
```
Please note that the string index is not supported with the round trip format, as it is used by default in write_json to indicate a missing index name.

```python
In [8]: df.index.name = 'index'
In [9]: df.to_json('test.json', orient='table')
In [10]: new_df = pd.read_json('test.json', orient='table')
In [11]: new_df
Out[11]:
   foo  bar   baz  qux
0    1    a 2018-01-01  a
1    2    b 2018-01-02  b
2    3    c 2018-01-03  c
3    4    d 2018-01-04  c
```

### 1.3.1.2 .assign() accepts dependent arguments

The DataFrame.assign() now accepts dependent keyword arguments for python version later than 3.6 (see also PEP 468). Later keyword arguments may now refer to earlier ones if the argument is a callable. See the documentation here (GH14207)

```python
In [13]: df = pd.DataFrame({'A': [1, 2, 3]})
In [14]: df
Out[14]:
   A
0  1
1  2
2  3
In [15]: df.assign(B=df.A, C=lambda x:x['A']+ x['B'])
   A  B  C
0  1  1  2
1  2  2  4
2  3  3  6
```
Warning: This may subtly change the behavior of your code when you’re using .assign() to update an existing column. Previously, callables referring to other variables being updated would get the “old” values.

Previous Behavior:

```
In [2]: df = pd.DataFrame({"A": [1, 2, 3]})
In [3]: df.assign(A=lambda df: df.A + 1, C=lambda df: df.A * -1)
```

```
Out[3]:
   A  C
0  2 -1
1  3 -2
2  4 -3
```

New Behavior:

```
In [16]: df.assign(A=df.A+1, C=lambda df: df.A* -1)
Out[16]:
   A    C
0  2   -2
1  3   -3
2  4   -4
```

1.3.1.3 Merging on a combination of columns and index levels

Strings passed to DataFrame.merge() as the on, left_on, and right_on parameters may now refer to either column names or index level names. This enables merging DataFrame instances on a combination of index levels and columns without resetting indexes. See the Merge on columns and levels documentation section. (GH14355)

```
In [17]: left_index = pd.Index(['K0', 'K0', 'K1', 'K2'], name='key1')
In [18]: left = pd.DataFrame({'A': ['A0', 'A1', 'A2', 'A3'],
                          'B': ['B0', 'B1', 'B2', 'B3'],
                          'key2': ['K0', 'K1', 'K0', 'K1']},
                          index=left_index)
In [19]: right_index = pd.Index(['K0', 'K1', 'K2', 'K2'], name='key1')
In [20]: right = pd.DataFrame({'C': ['C0', 'C1', 'C2', 'C3'],
                          'D': ['D0', 'D1', 'D2', 'D3'],
                          'key2': ['K0', 'K0', 'K0', 'K1']},
                          index=right_index)
In [21]: left.merge(right, on=['key1', 'key2'])
```

```
Out[21]:
   A  B   key2  C  D
key1
K0  A0  B0  K0  C0  D0
K1  A2  B2  K0  C1  D1
K2  A3  B3  K1  C3  D3
```
1.3.1.4 Sorting by a combination of columns and index levels

Strings passed to DataFrame.sort_values() as the by parameter may now refer to either column names or index level names. This enables sorting DataFrame instances by a combination of index levels and columns without resetting indexes. See the Sorting by Indexes and Values documentation section. (GH14353)

```
# Build MultiIndex
In [22]: idx = pd.MultiIndex.from_tuples([('a', 1), ('a', 2), ('a', 2),
                                            ('b', 2), ('b', 1), ('b', 1)])

In [23]: idx.names = ['first', 'second']

# Build DataFrame
In [24]: df_multi = pd.DataFrame({'A': np.arange(6, 0, -1),
                                  index=idx})

In [25]: df_multi
Out [25]:
       A
    first second
     a 1  6
     2 5
     2 4
     b 2  3
     1 2
     1 1

# Sort by 'second' (index) and 'A' (column)
In [26]: df_multi.sort_values(by=['second', 'A'])
```

1.3.1.5 Extending Pandas with Custom Types (Experimental)

Pandas now supports storing array-like objects that aren’t necessarily 1-D NumPy arrays as columns in a DataFrame or values in a Series. This allows third-party libraries to implement extensions to NumPy’s types, similar to how pandas implemented categoricals, datetimes with timezones, periods, and intervals.

As a demonstration, we’ll use cyberpandas, which provides an IPArray type for storing ip addresses.

```
In [1]: from cyberpandas import IPArray

In [2]: values = IPArray([
    ...:    0,
    ...:    3232235777,
    ...:    42540766452641154071740215577757643572
    ...])
```
IPArray isn’t a normal 1-D NumPy array, but because it’s a pandas ~pandas.api.extension.ExtensionArray, it can be stored properly inside pandas’ containers.

```python
In [3]: ser = pd.Series(values)
In [4]: ser
Out[4]:
       0  0.0.0.0
        1  192.168.1.1
        2  2001:db8:85a3::8a2e:370:7334
dtype: ip
```

Notice that the dtype is `ip`. The missing value semantics of the underlying array are respected:

```python
In [5]: ser.isna()
Out[5]:
       0   True
       1  False
       2  False
dtype: bool
```

For more, see the extension types documentation. If you build an extension array, publicize it on our ecosystem page.

### 1.3.1.6 New observed keyword for excluding unobserved categories in groupby

Grouping by a categorical includes the unobserved categories in the output. When grouping by multiple categorical columns, this means you get the cartesian product of all the categories, including combinations where there are no observations, which can result in a large number of groups. We have added a keyword `observed` to control this behavior, it defaults to `observed=False` for backward-compatibility. (GH14942, GH8138, GH15217, GH17594, GH8669, GH20583, GH20902)

```python
In [27]: cat1 = pd.Categorical(
               ["a", "a", "b", "b"],
               categories=["a", "b", "z"], ordered=True)
In [28]: cat2 = pd.Categorical(
               ["c", "d", "c", "d"],
               categories=["c", "d", "y"], ordered=True)
In [29]: df = pd.DataFrame({"A": cat1, "B": cat2, "values": [1, 2, 3, 4]})
In [30]: df['C'] = ['foo', 'bar'] * 2
In [31]: df
Out[31]:
       A    B  values  C
    0  a   c    1  foo
    1  a   d    2  bar
    2  b   c    3  foo
    3  b   d    4  bar
```

To show all values, the previous behavior:
In [32]: df.groupby(['A', 'B', 'C'], observed=False).count()

Out[32]:

<table>
<thead>
<tr>
<th>values</th>
</tr>
</thead>
<tbody>
<tr>
<td>A B C</td>
</tr>
<tr>
<td>a c bar NaN</td>
</tr>
<tr>
<td>foo 1.0</td>
</tr>
<tr>
<td>d bar 1.0</td>
</tr>
<tr>
<td>foo NaN</td>
</tr>
<tr>
<td>y bar NaN</td>
</tr>
<tr>
<td>foo NaN</td>
</tr>
<tr>
<td>b c bar NaN</td>
</tr>
</tbody>
</table>
| ... ...
| y foo NaN |
| z c bar NaN |
| foo NaN |
| d bar NaN |
| foo NaN |
| y bar NaN |
| foo NaN |

[18 rows x 1 columns]

To show only observed values:

In [33]: df.groupby(['A', 'B', 'C'], observed=True).count()

Out[33]:

<table>
<thead>
<tr>
<th>values</th>
</tr>
</thead>
<tbody>
<tr>
<td>A B C</td>
</tr>
<tr>
<td>a c foo 1</td>
</tr>
<tr>
<td>d bar 1</td>
</tr>
<tr>
<td>b c foo 1</td>
</tr>
<tr>
<td>d bar 1</td>
</tr>
</tbody>
</table>

For pivoting operations, this behavior is already controlled by the dropna keyword:

In [34]: cat1 = pd.Categorical(['a', 'a', 'b', 'b'], categories=['a', 'b', 'z'], ordered=True)

In [35]: cat2 = pd.Categorical(['c', 'd', 'c', 'd'], categories=['c', 'd', 'y'], ordered=True)

In [36]: df = DataFrame({'A': cat1, 'B': cat2, 'values': [1, 2, 3, 4]})

In [37]: df

Out[37]:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>values</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>a</td>
<td>c 1</td>
</tr>
<tr>
<td>1</td>
<td>a</td>
<td>d 2</td>
</tr>
<tr>
<td>2</td>
<td>b</td>
<td>c 3</td>
</tr>
<tr>
<td>3</td>
<td>b</td>
<td>d 4</td>
</tr>
</tbody>
</table>

In [38]: pd.pivot_table(df, values='values', index=['A', 'B'], dropna=True)

Out[38]:

(continues on next page)
values
A  B
a  1
d  2
b  3
d  4

In [39]: pd.pivot_table(df, values='values', index=['A', 'B'],
....:   dropna=False)

Out[39]:

   values
  A  B
a  1  0.0
   d  2.0
   y  NaN
b  3  0.0
   d  4.0
   y  NaN
z  4  0.0
   y  NaN

1.3.1.7 Rolling/Expanding.apply() accepts raw=False to pass a Series to the function

Series.rolling().apply(), DataFrame.rolling().apply(), Series.expanding().apply(), and DataFrame.expanding().apply() have gained a `raw=None` parameter. This is similar to DataFrame.apply(). This parameter, if True allows one to send a np.ndarray to the applied function. If False a Series will be passed. The default is None, which preserves backward compatibility, so this will default to True, sending an np.ndarray. In a future version the default will be changed to False, sending a Series. (GH5071, GH20584)

In [40]: s = pd.Series(np.arange(5), np.arange(5) + 1)

In [41]: s
Out[41]:
   0  1  2  3  4
Index: 0 1 2 3 4
dtype: int64

Pass a Series:

In [42]: s.rolling(2, min_periods=1).apply(lambda x: x.iloc[-1], raw=False)
Out[42]:
   0  1  2  3  4
Index: 0 1 2 3 4
   0  0  1  2  3  4
dtype: float64
Mimic the original behavior of passing a ndarray:

```python
In [43]: s.rolling(2, min_periods=1).apply(lambda x: x[-1], raw=True)
Out[43]:
    1    0.0
    2    1.0
    3    2.0
    4    3.0
    5    4.0
 dtype: float64
```

### 1.3.1.8 DataFrame.interpolate has gained the `limit_area` kwarg

`DataFrame.interpolate()` has gained a `limit_area` parameter to allow further control of which NaNs are replaced. Use `limit_area='inside'` to fill only NaNs surrounded by valid values or use `limit_area='outside'` to fill only NaNs outside the existing valid values while preserving those inside. (GH16284) See the full documentation here.

```python
In [44]: ser = pd.Series([np.nan, np.nan, 5, np.nan, np.nan, np.nan, 13, np.nan, np.nan])
In [45]: ser
Out[45]:
0      NaN
1      NaN
2      5.0
3      NaN
4      NaN
5      NaN
6     13.0
7      NaN
8      NaN
dtype: float64
```

Fill one consecutive inside value in both directions

```python
In [46]: ser.interpolate(limit_direction='both', limit_area='inside', limit=1)
Out[46]:
0      NaN
1      NaN
2      5.0
3      7.0
4      NaN
5     11.0
6     13.0
7      NaN
8      NaN
dtype: float64
```

Fill all consecutive outside values backward

```python
In [47]: ser.interpolate(limit_direction='backward', limit_area='outside')
Out[47]:
0     5.0
1     5.0
2     5.0
```

(continues on next page)
Fill all consecutive outside values in both directions

```
In [48]: ser.interpolate(limit_direction='both', limit_area='outside')
Out[48]:
0  5.0
1  5.0
2  5.0
3  NaN
4  NaN
5  NaN
6  13.0
7  13.0
8  13.0
dtype: float64
```

1.3.1.9 get_dummies now supports dtype argument

The `get_dummies()` now accepts a `dtype` argument, which specifies a dtype for the new columns. The default remains uint8. (GH18330)

```
In [49]: df = pd.DataFrame({'a': [1, 2], 'b': [3, 4], 'c': [5, 6]})
In [50]: pd.get_dummies(df, columns=['c']).dtypes
Out[50]:
a  int64
b  int64
c_5  uint8
c_6  uint8
dtype: object
In [51]: pd.get_dummies(df, columns=['c'], dtype=bool).dtypes
```

1.3.1.10 Timedelta mod method

The `mod (%)` and `divmod` operations are now defined on `Timedelta` objects when operating with either timedelta-like or with numeric arguments. See the documentation here. (GH19365)

```
In [52]: td = pd.Timedelta(hours=37)
```

(continues on next page)
In [53]: td % pd.Timedelta(minutes=45)
Out[53]: Timedelta('0 days 00:15:00')

1.3.1.11 .rank() handles inf values when NaN are present

In previous versions, .rank() would assign inf elements NaN as their ranks. Now ranks are calculated properly. (GH6945)

In [54]: s = pd.Series([-np.inf, 0, 1, np.nan, np.inf])
In [55]: s
Out[55]:
0   -inf
1    0
2    1
3   NaN
4    inf
Name: 0, dtype: float64

Previous Behavior:

In [11]: s.rank()
Out[11]:
0   1.0
1   2.0
2   3.0
3   NaN
4   NaN
Name: 0, dtype: float64

Current Behavior:

In [56]: s.rank()
Out[56]:
0   1.0
1   2.0
2   3.0
3   NaN
4   4.0
Name: 0, dtype: float64

Furthermore, previously if you rank inf or -inf values together with NaN values, the calculation won’t distinguish NaN from infinity when using ‘top’ or ‘bottom’ argument.

In [57]: s = pd.Series([np.nan, np.nan, -np.inf, -np.inf])
In [58]: s
Out[58]:
0   NaN
1   NaN
2   -inf
3   -inf
Name: 0, dtype: float64

Previous Behavior:
In [15]: s.rank(na_option='top')
Out[15]:
0   2.5
1   2.5
2   2.5
3   2.5
dtype: float64

Current Behavior:

In [59]: s.rank(na_option='top')
Out[59]:
0   1.5
1   1.5
2   3.5
3   3.5
dtype: float64

These bugs were squashed:

- Bug in `DataFrame.rank()` and `Series.rank()` when `method='dense'` and `pct=True` in which percentile ranks were not being used with the number of distinct observations (GH15630)
- Bug in `Series.rank()` and `DataFrame.rank()` when `ascending='False'` failed to return correct ranks for infinity if NaN were present (GH19538)
- Bug in `DataFrameGroupBy.rank()` where ranks were incorrect when both infinity and NaN were present (GH20561)

1.3.1.12 Series.str.cat has gained the join kwarg

Previously, `Series.str.cat()` did not – in contrast to most of pandas – align `Series` on their index before concatenation (see GH18657). The method has now gained a keyword `join` to control the manner of alignment, see examples below and here.

In v.0.23 `join` will default to None (meaning no alignment), but this default will change to 'left' in a future version of pandas.

In [60]: s = pd.Series(['a', 'b', 'c', 'd'])
In [61]: t = pd.Series(['b', 'd', 'e', 'c'], index=[1, 3, 4, 2])
In [62]: s.str.cat(t)
Out[62]:
0   ab
1   bd
2   ce
3   dc
dtype: object

In [63]: s.str.cat(t, join='left', na_rep='-')
Out[63]:
0   a-
1   bb
2   cc
3   dd
dtype: object
Furthermore, `Series.str.cat()` now works for `CategoricalIndex` as well (previously raised a `ValueError`; see GH20842).

### 1.3.1.13 DataFrame.astype performs column-wise conversion to Categorical

`DataFrame.astype()` can now perform column-wise conversion to Categorical by supplying the string 'category' or a `CategoricalDtype`. Previously, attempting this would raise a `NotImplementedError`. See the [Object Creation](#) section of the documentation for more details and examples. (GH12860, GH18099)

Supplying the string 'category' performs column-wise conversion, with only labels appearing in a given column set as categories:

```python
In [64]: df = pd.DataFrame({'A': list('abca'), 'B': list('bccd')})
In [65]: df = df.astype('category')
In [66]: df['A'].dtype
Out[66]: CategoricalDtype(categories=['a', 'b', 'c'], ordered=False)
In [67]: df['B'].dtype
Out[67]: CategoricalDtype(categories=['b', 'c', 'd'], ordered=False)
```

Supplying a `CategoricalDtype` will make the categories in each column consistent with the supplied dtype:

```python
In [68]: from pandas.api.types import CategoricalDtype
In [69]: df = pd.DataFrame({'A': list('abca'), 'B': list('bccd')})
In [70]: cdt = CategoricalDtype(categories=list('abcd'), ordered=True)
In [71]: df = df.astype(cdt)
In [72]: df['A'].dtype
Out[72]: CategoricalDtype(categories=['a', 'b', 'c', 'd'], ordered=True)
In [73]: df['B'].dtype
Out[73]: CategoricalDtype(categories=['a', 'b', 'c', 'd'], ordered=True)
```

### 1.3.1.14 Other Enhancements

- Unary + now permitted for `Series` and `DataFrame` as numeric operator (GH16073)
- Better support for `to_excel()` output with the `xlsxwriter` engine. (GH16149)
- `pandas.tseries.frequencies.to_offset()` now accepts leading ‘+’ signs e.g. ‘+1h’. (GH18171)
- `MultiIndex.unique()` now supports the `level` argument, to get unique values from a specific index level (GH17896)
- `pandas.io.formats.style.Styler` now has method `hide_index()` to determine whether the index will be rendered in output (GH14194)
- `pandas.io.formats.style.Styler` now has method `hide_columns()` to determine whether columns will be hidden in output (GH14194)
\begin{itemize}
\item Improved wording of \texttt{ValueError} raised in \texttt{to_datetime()} when \texttt{unit=} is passed with a non-convertible value (GH14350)
\item \texttt{Series.fillna()} now accepts a Series or a dict as a value for a categorical dtype (GH17033)
\item \texttt{pandas.read_clipboard()} updated to use qtpy, falling back to PyQt5 and then PyQt4, adding compatibility with Python3 and multiple python-qt bindings (GH17722)
\item Improved wording of \texttt{ValueError} raised in \texttt{read_csv()} when the \texttt{usecols} argument cannot match all columns. (GH17301)
\item \texttt{DataFrame.corrwith()} now silently drops non-numeric columns when passed a Series. Before, an exception was raised (GH18570).
\item \texttt{IntervalIndex} now supports time zone aware \texttt{Interval} objects (GH18537, GH18538)
\item \texttt{Series()} / \texttt{DataFrame()} tab completion also returns identifiers in the first level of a \texttt{MultiIndex()}. (GH16326)
\item \texttt{read_excel()} has gained the \texttt{nrows} parameter (GH16645)
\item \texttt{DataFrame.append()} can now in more cases preserve the type of the calling dataframe’s columns (e.g. if both are \texttt{CategoricalIndex}) (GH18359)
\item \texttt{DataFrame.to_json()} and \texttt{Series.to_json()} now accept an index argument which allows the user to exclude the index from the JSON output (GH17394)
\item \texttt{IntervalIndex.to_tuples()} has gained the \texttt{na_tuple} parameter to control whether NA is returned as a tuple of NA, or NA itself (GH18756)
\item \texttt{Categorical.rename_categories}, \texttt{CategoricalIndex.rename_categories} and \texttt{Series.cat.rename_categories} can now take a callable as their argument (GH18862)
\item \texttt{Interval} and \texttt{IntervalIndex} have gained a \texttt{length} attribute (GH18789)
\item \texttt{Resampler} objects now have a functioning \texttt{pipe} method. Previously, calls to \texttt{pipe} were diverted to the mean method (GH17905).
\item \texttt{is_scalar()} now returns \texttt{True} for \texttt{DateOffset} objects (GH18943).
\item \texttt{DataFrame.pivot()} now accepts a list for the \texttt{values=} kwarg (GH17160).
\item Added \texttt{pandas.api.extensions.register_dataframe_accessor()}, \texttt{pandas.api.extensions.register_series_accessor()}, and \texttt{pandas.api.extensions.register_index_accessor()}, accessor for libraries downstream of pandas to register custom accessors like \texttt{.cat} on pandas objects. See \texttt{Registering Custom Accessors} for more (GH14781).
\item \texttt{IntervalIndex.astype} now supports conversions between subtypes when passed an \texttt{IntervalDtype} (GH19197)
\item \texttt{IntervalIndex} and its associated constructor methods (\texttt{from_arrays}, \texttt{from_breaks}, \texttt{from_tuples}) have gained a \texttt{dtype} parameter (GH19262)
\item Added \texttt{pandas.core.groupby.SeriesGroupBy.is_monotonic_increasing()} and \texttt{pandas.core.groupby.SeriesGroupBy.is_monotonic_decreasing()} (GH17015)
\item For subclassed \texttt{DataFrames}, \texttt{DataFrame.apply()} will now preserve the \texttt{Series} subclass (if defined) when passing the data to the applied function (GH19822)
\item \texttt{DataFrame.from_dict()} now accepts a \texttt{columns} argument that can be used to specify the column names when \texttt{orient='index'} is used (GH18529)
\item Added option \texttt{display.html.use_mathjax} so MathJax can be disabled when rendering tables in Jupyter notebooks (GH19856, GH19824)
\end{itemize}
- `DataFrame.replace()` now supports the `method` parameter, which can be used to specify the replacement method when `to_replace` is a scalar, list or tuple and `value` is `None` (GH19632)

- `Timestamp.month_name()`, `DatetimeIndex.month_name()`, and `Series.dt.month_name()` are now available (GH12805)

- `Timestamp.day_name()` and `DatetimeIndex.day_name()` are now available to return day names with a specified locale (GH12806)

- `DataFrame.to_sql()` now performs a multivalue insert if the underlying connection supports `itk` rather than inserting row by row. SQLAlchemy dialects supporting multivalue inserts include: `mysql`, `postgresql`, `sqlite` and any dialect with `supports_multivalues_insert`. (GH14315, GH8953)

- `read_html()` now accepts a `displayed_only` keyword argument to controls whether or not hidden elements are parsed (True by default) (GH20027)

- `read_html()` now reads all `<tbody>` elements in a `<table>`, not just the first. (GH20690)

- `quantile()` and `quantile()` now accept the `interpolation` keyword, `linear` by default (GH20497)

- `zip` compression is supported via `compression=zip` in `DataFrame.to_pickle()`, `Series.to_pickle()`, `DataFrame.to_csv()`, `Series.to_csv()`, `DataFrame.to_json()`, `Series.to_json()`. (GH17778)

- `WeekOfMonth` constructor now supports `n=0` (GH20517).

- `DataFrame` and `Series` now support matrix multiplication (`@`) operator (GH10259) for Python>3.5

- Updated `DataFrame.to_gbq()` and `pandas.read_gbq()` signature and documentation to reflect changes from the Pandas-GBQ library version 0.4.0. Adds intersphinx mapping to Pandas-GBQ library. (GH20564)

- Added new writer for exporting Stata dta files in version 117, `StataWriter117`. This format supports exporting strings with lengths up to 2,000,000 characters (GH16450)

- `to_hdf()` and `read_hdf()` now accept an `errors` keyword argument to control encoding error handling (GH20835)

- `cut()` has gained the `duplicates='raise'`|'drop' option to control whether to raise on duplicated edges (GH20947)

- `date_range()`, `timedelta_range()`, and `interval_range()` now return a linearly spaced index if `start`, `stop`, and `periods` are specified, but `freq` is not. (GH20808, GH20983, GH20976)

### 1.3.2 Backwards incompatible API changes

#### 1.3.2.1 Dependencies have increased minimum versions

We have updated our minimum supported versions of dependencies (GH15184). If installed, we now require:

<table>
<thead>
<tr>
<th>Package</th>
<th>Minimum Version</th>
<th>Required</th>
<th>Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>python-dateutil</td>
<td>2.5.0</td>
<td>X</td>
<td>GH15184</td>
</tr>
<tr>
<td>openpyxl</td>
<td>2.4.0</td>
<td></td>
<td>GH15184</td>
</tr>
<tr>
<td>beautifulsoup4</td>
<td>4.2.1</td>
<td></td>
<td>GH20082</td>
</tr>
<tr>
<td>setuptools</td>
<td>24.2.0</td>
<td></td>
<td>GH20698</td>
</tr>
</tbody>
</table>
1.3.2.2 Instantiation from dicts preserves dict insertion order for python 3.6+

Until Python 3.6, dicts in Python had no formally defined ordering. For Python version 3.6 and later, dicts are ordered by insertion order, see PEP 468. Pandas will use the dict’s insertion order, when creating a Series or DataFrame from a dict and you’re using Python version 3.6 or higher. (GH19884)

Previous Behavior (and current behavior if on Python < 3.6):

```python
```

Expenses -1500
Income 2000
Net result 300
Taxes -200
dtype: int64

Note the Series above is ordered alphabetically by the index values.

New Behavior (for Python >= 3.6):

```python
In [74]: pd.Series({'Income': 2000, 'Expenses': -1500, 'Taxes': -200, 'Net result': 300})
```

```output
Out[74]:
Income 2000
Expenses -1500
Taxes -200
Net result 300
dtype: int64
```

Notice that the Series is now ordered by insertion order. This new behavior is used for all relevant pandas types (Series, DataFrame, SparseSeries and SparseDataFrame).

If you wish to retain the old behavior while using Python >= 3.6, you can use .sort_index():

```python
In [75]: pd.Series({'Income': 2000, 'Expenses': -1500, 'Taxes': -200, 'Net result': 300}).sort_index()
```

```output
Out[75]:
Expenses -1500
Income 2000
Net result 300
Taxes -200
dtype: int64
```

1.3.2.3 Deprecate Panel

Panel was deprecated in the 0.20.x release, showing as a DeprecationWarning. Using Panel will now show a FutureWarning. The recommended way to represent 3-D data are with a MultiIndex on a DataFrame via the to_frame() or with the xarray package. Pandas provides a to_xarray() method to automate this conversion. For more details see Deprecate Panel documentation. (GH13563, GH18324).
In [76]: p = tm.makePanel()

In [77]: p
Out[77]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 3 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-05 00:00:00
Minor_axis axis: A to D

Convert to a MultiIndex DataFrame

In [78]: p.to_frame()
Out[78]:
<table>
<thead>
<tr>
<th></th>
<th>ItemA</th>
<th>ItemB</th>
<th>ItemC</th>
</tr>
</thead>
<tbody>
<tr>
<td>major</td>
<td>minor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000-01-03</td>
<td>A</td>
<td>-0.964980</td>
<td>-1.197071</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.781836</td>
<td>1.846883</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>2.353925</td>
<td>-1.717693</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>-0.744471</td>
<td>0.901805</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>A</td>
<td>-0.064034</td>
<td>-0.845696</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>-1.071357</td>
<td>-1.328865</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0.583787</td>
<td>0.888782</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>0.758527</td>
<td>1.171216</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>A</td>
<td>-1.282782</td>
<td>-1.340896</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.441153</td>
<td>1.682706</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0.221471</td>
<td>0.228440</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>1.729689</td>
<td>0.520260</td>
</tr>
</tbody>
</table>

Convert to an xarray DataArray

In [79]: p.to_xarray()
Out[79]:
xarray.DataArray (items: 3, major_axis: 3, minor_axis: 4)
array([[-1.474071, 0.781836, 2.353925, -0.858447],  # 2000-01-03
        [-0.064034, -1.071357, 0.583787, 0.758527],
        [-1.282782, 0.441153, 0.221471, 1.729689]],
       [[-0.964980, 1.846883, -1.717693, 0.901805],
        [-0.845696, -1.328865, 0.888782, 1.171216],
        [-1.340896, 1.682706, 0.228444, 0.520264]],
       [[-1.197071, -0.858447, 0.384316, 0.476720],
        [-1.066969, 0.306996, 1.574159, 0.473424],
        [-0.303421, -0.028665, 1.588931, -0.242861]])
Coordinates:
* items (items) object 'ItemA' 'ItemB' 'ItemC'
* major_axis (major_axis) datetime64[ns] 2000-01-03 2000-01-04 2000-01-05
* minor_axis (minor_axis) object 'A' 'B' 'C' 'D'

1.3.2.4 pandas.core.common removals

The following error & warning messages are removed from pandas.core.common (GH13634, GH19769):

- PerformanceWarning
- UnsupportedFunctionCall
• `UnsortedIndexError`
• `AbstractMethodError`

These are available from import from `pandas.errors` (since 0.19.0).

### 1.3.2.5 Changes to make output of `DataFrame.apply` consistent

`DataFrame.apply()` was inconsistent when applying an arbitrary user-defined-function that returned a list-like with `axis=1`. Several bugs and inconsistencies are resolved. If the applied function returns a Series, then pandas will return a DataFrame; otherwise a Series will be returned, this includes the case where a list-like (e.g. tuple or list is returned) (GH16353, GH17437, GH17970, GH17348, GH17892, GH18573, GH17602, GH18775, GH18901, GH18919).

```python
In [80]: df = pd.DataFrame(np.tile(np.arange(3), 6).reshape(6, -1) + 1, columns=['A', 'B', 'C'])

In [81]: df
Out[81]:
   A  B  C
0  1  2  3
1  1  2  3
2  1  2  3
3  1  2  3
4  1  2  3
5  1  2  3

Previous Behavior: if the returned shape happened to match the length of original columns, this would return a DataFrame. If the return shape did not match, a Series with lists was returned.

```python
In [3]: df.apply(lambda x: [1, 2, 3], axis=1)
Out[3]:
   A  B  C
0  1  2  3
1  1  2  3
2  1  2  3
3  1  2  3
4  1  2  3
5  1  2  3
```

New Behavior: When the applied function returns a list-like, this will now _always_ return a Series.

```python
In [82]: df.apply(lambda x: [1, 2, 3], axis=1)
Out[82]:
   0  1  2  3
   1  1  2  3
   2  1  2  3
```

(continues on next page)
To have expanded columns, you can use `result_type='expand'`

```
In [84]: df.apply(lambda x: [1, 2, 3], axis=1, result_type='expand')
```

```
   A   B   C
0  1   2   3
1  1   2   3
2  1   2   3
3  1   2   3
4  1   2   3
5  1   2   3
```

To broadcast the result across the original columns (the old behaviour for list-likes of the correct length), you can use `result_type='broadcast'`. The shape must match the original columns.

```
In [85]: df.apply(lambda x: [1, 2, 3], axis=1, result_type='broadcast')
```

```
   A   B   C
0  1   2   3
1  1   2   3
2  1   2   3
3  1   2   3
4  1   2   3
5  1   2   3
```

Returning a `Series` allows one to control the exact return structure and column names:

```
In [86]: df.apply(lambda x: Series([1, 2, 3], index=['D', 'E', 'F']), axis=1)
```

```
   D   E   F
0  1   2   3
1  1   2   3
2  1   2   3
3  1   2   3
4  1   2   3
5  1   2   3
```
1.3.2.6 Concatenation will no longer sort

In a future version of pandas `pandas.concat()` will no longer sort the non-concatenation axis when it is not already aligned. The current behavior is the same as the previous (sorting), but now a warning is issued when `sort` is not specified and the non-concatenation axis is not aligned (GH4588).

```python
In [87]: df1 = pd.DataFrame({"a": [1, 2], "b": [1, 2]}, columns=['b', 'a'])
In [88]: df2 = pd.DataFrame({"a": [4, 5]})
In [89]: pd.concat([df1, df2])
Out[89]:
   a   b
0  1  1.0
1  2  2.0
0  4  NaN
1  5  NaN
```

To keep the previous behavior (sorting) and silence the warning, pass `sort=True`

```python
In [90]: pd.concat([df1, df2], sort=True)
Out[90]:
   a   b
0  1  1.0
1  2  2.0
0  4  NaN
1  5  NaN
```

To accept the future behavior (no sorting), pass `sort=False`

Note that this change also applies to `DataFrame.append()`, which has also received a `sort` keyword for controlling this behavior.

1.3.2.7 Build Changes

- Building pandas for development now requires `cython >= 0.24` (GH18613)
- Building from source now explicitly requires `setuptools` in `setup.py` (GH18113)
- Updated conda recipe to be in compliance with conda-build 3.0+ (GH18002)

1.3.2.8 Index Division By Zero Fills Correctly

Division operations on `Index` and subclasses will now fill division of positive numbers by zero with `np.inf`, division of negative numbers by zero with `-np.inf` and `0 / 0` with `np.nan`. This matches existing `Series` behavior. (GH19322, GH19347)

Previous Behavior:

```python
In [6]: index = pd.Int64Index([-1, 0, 1])
In [7]: index / 0
Out[7]: Int64Index([0, 0, 0], dtype='int64')
```

# Previous behavior yielded different results depending on the type of zero in the divisor

(continues on next page)
1.3.2.9 Extraction of matching patterns from strings

By default, extracting matching patterns from strings with `str.extract()` used to return a `Series` if a single group was being extracted (a `DataFrame` if more than one group was extracted). As of Pandas 0.23.0 `str.extract()` always returns a `DataFrame`, unless `expand` is set to `False`. Finally, `None` was an accepted value for the `expand` parameter (which was equivalent to `False`), but now raises a `ValueError`. (GH11386)

Previous Behavior:

```python
In [1]: s = pd.Series(['number 10', '12 eggs'])
In [2]: extracted = s.str.extract('.*\d.*')
In [3]: extracted
Out [3]:
         0    1
0   10   12

In [4]: type(extracted)
Out [4]:
```
```
New Behavior:

```python
In [97]: s = pd.Series(['number 10', '12 eggs'])
In [98]: extracted = s.str.extract('.*(\d\d).*')
In [99]: extracted
Out[99]:
    0 10
   1 12

In [100]: type(extracted)
Out[100]: pandas.core.frame.DataFrame
```

To restore previous behavior, simply set `expand` to `False`:

```python
In [101]: s = pd.Series(['number 10', '12 eggs'])
In [102]: extracted = s.str.extract('.*(\d\d).*', expand=False)
In [103]: extracted
Out[103]:
    0 10
   1 12
dtype: object

In [104]: type(extracted)
Out[104]: pandas.core.series.Series
```

### 1.3.2.10 Default value for the `ordered` parameter of CategoricalDtype

The default value of the `ordered` parameter for `CategoricalDtype` has changed from `False` to `None` to allow updating of categories without impacting `ordered`. Behavior should remain consistent for downstream objects, such as `Categorical` (GH18790)

In previous versions, the default value for the `ordered` parameter was `False`. This could potentially lead to the `ordered` parameter unintentionally being changed from `True` to `False` when users attempt to update categories if `ordered` is not explicitly specified, as it would silently default to `False`. The new behavior for `ordered=None` is to retain the existing value of `ordered`.

New Behavior:

```python
In [105]: from pandas.api.types import CategoricalDtype

In [106]: cat = pd.Categorical(list('abcaba'), ordered=True, categories=list('cba'))
In [107]: cat
Out[107]:
    [a, b, c, a, b, a]
Categories (3, object): [c < b < a]

In [108]: cdt = CategoricalDtype(categories=list('cbad'))

In [109]: cat.astype(cdt)
Out[109]:
    [a, b, c, a, b, a]
Categories (3, object): [c < b < a]
```

(continues on next page)
Notice in the example above that the converted Categorical has retained ordered=True. Had the default value for ordered remained as False, the converted Categorical would have become unordered, despite ordered=False never being explicitly specified. To change the value of ordered, explicitly pass it to the new dtype, e.g. `CategoricalDtype(categories=list('cbad'), ordered=False)`.

Note that the unintentional conversion of ordered discussed above did not arise in previous versions due to separate bugs that prevented astype from doing any type of category to category conversion (GH10696, GH18593). These bugs have been fixed in this release, and motivated changing the default value of ordered.

### 1.3.2.11 Better pretty-printing of DataFrames in a terminal

Previously, the default value for the maximum number of columns was `pd.options.display.max_columns=20`. This meant that relatively wide data frames would not fit within the terminal width, and pandas would introduce line breaks to display these 20 columns. This resulted in an output that was relatively difficult to read:

If Python runs in a terminal, the maximum number of columns is now determined automatically so that the printed data frame fits within the current terminal width (`pd.options.display.max_columns=0`) (GH17023). If Python runs as a Jupyter kernel (such as the Jupyter QtConsole or a Jupyter notebook, as well as in many IDEs), this value cannot be inferred automatically and is thus set to 20 as in previous versions. In a terminal, this results in a much nicer output:
Note that if you don’t like the new default, you can always set this option yourself. To revert to the old setting, you can run this line:

```
pd.options.display.max_columns = 20
```

### 1.3.2.12 Datetimelike API Changes

- The default `Timedelta` constructor now accepts an ISO 8601 Duration string as an argument (GH19040)
- Subtracting `NaT` from a `Series` with `dtype='datetime64[ns]'` returns a `Series` with `dtype='timedelta64[ns]'` instead of `dtype='datetime64[ns]'` (GH18808)
- Addition or subtraction of `NaT` from `TimedeltaIndex` will return `TimedeltaIndex` instead of `DatetimeIndex` (GH19124)
- `DatetimeIndex.shift()` and `TimedeltaIndex.shift()` will now raise `NullFrequencyError` (which subclasses `ValueError`, which was raised in older versions) when the index object frequency is `None` (GH19147)
- Addition and subtraction of `NaN` from a `Series` with `dtype='timedelta64[ns]'` will raise a `TypeError` instead of treating the `NaN` as `NaT` (GH19274)
- `NaT` division with `datetime.timedelta` will now return `NaN` instead of raising (GH17876)
- Operations between a `Series` with `dtype='datetime64[ns]'` and a `PeriodIndex` will correctly raise `TypeError` (GH18850)
- Subtraction of `Series` with timezone-aware `dtype='datetime64[ns]'` with mis-matched timezones will raise `TypeError` instead of `ValueError` (GH18817)
- `Timestamp` will no longer silently ignore unused or invalid `tz` or `tzinfo` keyword arguments (GH17690)
- `Timestamp` will no longer silently ignore invalid `freq` arguments (GH5168)
- `CacheableOffset` and `WeekDay` are no longer available in the `pandas.tseries.offsets` module (GH17830)
- `pandas.tseries.frequencies.get_freq_group()` and `pandas.tseries.frequencies.DAYS` are removed from the public API (GH18034)
- `Series.truncate()` and `DataFrame.truncate()` will raise a `ValueError` if the index is not sorted instead of an unhelpful `KeyError` (GH17935)
- `Series.first` and `DataFrame.first` will now raise a `TypeError` rather than `NotImplementedError` when index is not a `DatetimeIndex` (GH20725).
- `Series.last` and `DataFrame.last` will now raise a `TypeError` rather than `NotImplementedError` when index is not a `DatetimeIndex` (GH20725).
- Restricted `DateOffset` keyword arguments. Previously, `DateOffset` subclasses allowed arbitrary keyword arguments which could lead to unexpected behavior. Now, only valid arguments will be accepted. (GH17176, GH18226).
- `pandas.merge()` provides a more informative error message when trying to merge on timezone-aware and timezone-naive columns (GH15800)
- For `DatetimeIndex` and `TimedeltaIndex` with `freq=None`, addition or subtraction of integer-dtyped array or `Index` will raise `NullFrequencyError` instead of `TypeError` (GH19895)
- `Timestamp` constructor now accepts a `nanosecond` keyword or positional argument (GH18898)
- `DatetimeIndex` will now raise an `AttributeError` when the `tz` attribute is set after instantiation (GH3746)
- `DatetimeIndex` with a `pytz` timezone will now return a consistent `pytz` timezone (GH18595)

### 1.3.2.13 Other API Changes

- `Series.astype()` and `Index.astype()` with an incompatible dtype will now raise a `TypeError` rather than a `ValueError` (GH18231)
- Series construction with an object dtyped tz-aware datetime and `dtype=object` specified, will now return an object dtyped `Series`, previously this would infer the datetime dtype (GH18231)
- A `Series` of `dtype=category` constructed from an empty `dict` will now have categories of `dtype=object` rather than `dtype=float64`, consistently with the case in which an empty list is passed (GH18515)
- All NaN levels in a MultiIndex are now assigned `float` rather than `object` dtype, promoting consistency with `Index` (GH17929).
- Levels names of a MultiIndex (when not None) are now required to be unique: trying to create a MultiIndex with repeated names will raise a `ValueError` (GH18872)
- Both construction and renaming of `Index/MultiIndex` with non-hashable name/`names` will now raise `TypeError` (GH20527)
Index.map() can now accept Series and dictionary input objects (GH12756, GH18482, GH18509).

DataFrame.unstack() will now default to filling with np.nan for object columns. (GH12815)

IntervalIndex constructor will raise if the closed parameter conflicts with how the input data is inferred to be closed (GH18421)

Inserting missing values into indexes will work for all types of indexes and automatically insert the correct type of missing value (NaN, NaT, etc.) regardless of the type passed in (GH18295)

When created with duplicate labels, MultiIndex now raises a ValueError. (GH17464)

Series.fillna() now raises a TypeError instead of a ValueError when passed a list, tuple or DataFrame as a value (GH18293)

pandas.DataFrame.merge() no longer casts a float column to object when merging on int and float columns (GH16572)

pandas.merge() now raises a ValueError when trying to merge on incompatible data types (GH9780)

The default NA value for UInt64Index has changed from 0 to NaN, which impacts methods that mask with NA, such as UInt64Index.where() (GH18398)

Refactored setup.py to use find_packages instead of explicitly listing out all subpackages (GH18535)

Rearranged the order of keyword arguments in read_excel() to align with read_csv() (GH16672)

wide_to_long() previously kept numeric-like suffixes as object dtype. Now they are cast to numeric if possible (GH17627)

In read_excel(), the comment argument is now exposed as a named parameter (GH18735)

Rearranged the order of keyword arguments in read_excel() to align with read_csv() (GH16672)

The options html.border and mode.use_inf_as_null were deprecated in prior versions, these will now show FutureWarning rather than a DeprecationWarning (GH19003)

IntervalIndex and IntervalDtype no longer support categorical, object, and string subtypes (GH19016)

IntervalDtype now returns True when compared against 'interval' regardless of subtype, and IntervalDtype.name now returns 'interval' regardless of subtype (GH18980)

KeyError now raises instead of ValueError in drop(), drop(), drop(), drop() when dropping a non-existent element in an axis with duplicates (GH19186)

Series.to_csv() now accepts a compression argument that works in the same way as the compression argument in DataFrame.to_csv() (GH18958)

Set operations (union, difference...) on IntervalIndex with incompatible index types will now raise a TypeError rather than a ValueError (GH19329)

DateOffset objects render more simply, e.g. <DateOffset: days=1> instead of <DateOffset: kwds={'days': 1}> (GH19403)

Categorical.fillna now validates its value and method keyword arguments. It now raises when both or none are specified, matching the behavior of Series.fillna() (GH19682)

pd.to_datetime('today') now returns a datetime, consistent with pd.Timestamp('today'); previously pd.to_datetime('today') returned a .normalized() datetime (GH19935)

Series.str.replace() now takes an optional regex keyword which, when set to False, uses literal string replacement rather than regex replacement (GH16808)

DatetimeIndex.strftime() and PeriodIndex.strftime() now return an Index instead of a numpy array to be consistent with similar accessors (GH20127)
• Constructing a Series from a list of length 1 no longer broadcasts this list when a longer index is specified (GH19714, GH20391).

  DataFrame.to_dict() with orient='index' no longer casts int columns to float for a DataFrame with only int and float columns (GH18580)

• A user-defined-function that is passed to Series.rolling().aggregate(), DataFrame.rolling().aggregate(), or its expanding cousins, will now always be passed a Series, rather than a np.array; .apply() only has the raw keyword, see here. This is consistent with the signatures of .aggregate() across pandas (GH20584)

• Rolling and Expanding types raise NotImplementedError upon iteration (GH11704).

1.3.3 Deprecations

• Series.from_array and SparseSeries.from_array are deprecated. Use the normal constructor Series(..) and SparseSeries(..) instead (GH18213).

• DataFrame.as_matrix is deprecated. Use DataFrame.values instead (GH18458).

• Series.asobject, DatetimeIndex.asobject, PeriodIndex.asobject and TimeDeltaIndex.asobject have been deprecated. Use .astype(object) instead (GH18572)

• Grouping by a tuple of keys now emits a FutureWarning and is deprecated. In the future, a tuple passed to 'by' will always refer to a single key that is the actual tuple, instead of treating the tuple as multiple keys. To retain the previous behavior, use a list instead of a tuple (GH18314)

• Series.valid is deprecated. Use Series.dropna() instead (GH18800).

• read_excel() has deprecated the skip_footer parameter. Use skipfooter instead (GH18836)

• ExcelFile.parse() has deprecated sheetname in favor of sheet_name for consistency with read_excel() (GH20920).

• The is_copy attribute is deprecated and will be removed in a future version (GH18801).

• IntervalIndex.from_intervals is deprecated in favor of the IntervalIndex constructor (GH19263)

• DataFrame.from_items is deprecated. Use DataFrame.from_dict() instead, or DataFrame.from_dict(OrderedDict()) if you wish to preserve the key order (GH17320, GH17312)

• Indexing a MultiIndex or a FloatIndex with a list containing some missing keys will now show a FutureWarning, which is consistent with other types of indexes (GH17758).

• The broadcast parameter of .apply() is deprecated in favor of result_type='broadcast' (GH18577)

• The reduce parameter of .apply() is deprecated in favor of result_type='reduce' (GH18577)

• The order parameter of factorize() is deprecated and will be removed in a future release (GH19727)

• Timestamp.weekday_name, DatetimeIndex.weekday_name, and Series.dt.weekday_name are deprecated in favor of Timestamp.day_name(), DatetimeIndex.day_name(), and Series.dt.day_name() (GH12806)

• pandas.tseries.plotting.tsplot is deprecated. Use Series.plot() instead (GH18627)

• Index.summary() is deprecated and will be removed in a future version (GH18217)

• NDFrame.get_ftype_counts() is deprecated and will be removed in a future version (GH18243)
• The `convert_datetime64` parameter in `DataFrame.to_records()` has been deprecated and will be removed in a future version. The NumPy bug motivating this parameter has been resolved. The default value for this parameter has also changed from `True` to `None` (GH18160).

• `Series.rolling().apply()`, `DataFrame.rolling().apply()`, `Series.expanding().apply()` and `DataFrame.expanding().apply()` have deprecated passing an `np.array` by default. One will need to pass the new `raw` parameter to be explicit about what is passed (GH20584).

• The `data`, `base`, `strides`, `flags` and `itemsize` properties of the `Series` and `Index` classes have been deprecated and will be removed in a future version (GH20419).

• `DatetimeIndex.offset` is deprecated. Use `DatetimeIndex.freq` instead (GH20716).

• Floor division between an integer ndarray and a `Timedelta` is deprecated. Divide by `Timedelta.value` instead (GH19761).

• Setting `PeriodIndex.freq` (which was not guaranteed to work correctly) is deprecated. Use `PeriodIndex.asfreq()` instead (GH20678).

• `Index.get_duplicates()` is deprecated and will be removed in a future version (GH20239).

• The previous default behavior of negative indices in `Categorical.take` is deprecated. In a future version it will change from meaning missing values to meaning positional indices from the right. The future behavior is consistent with `Series.take()` (GH20664).

• Passing multiple axes to the `axis` parameter in `DataFrame.dropna()` has been deprecated and will be removed in a future version (GH20987).

### 1.3.4 Removal of prior version deprecations/changes

• Warnings against the obsolete usage `Categorical(codes, categories)`, which were emitted for instance when the first two arguments to `Categorical()` had different dtypes, and recommended the use of `Categorical.from_codes`, have now been removed (GH8074).

• The `levels` and `labels` attributes of a `MultiIndex` can no longer be set directly (GH4039).

• `pd.tseries.util.pivot_annual` has been removed (deprecated since v0.19). Use `pivot_table` instead (GH18370).

• `pd.tseries.util.isleapyear` has been removed (deprecated since v0.19). Use `.is_leap_year` property in Datetime-likes instead (GH18370).

• `pd.ordered_merge` has been removed (deprecated since v0.19). Use `pd.merge_ordered` instead (GH18459).

• The `SparseList` class has been removed (GH14007).

• The `pandas.io.wb` and `pandas.io.data` stub modules have been removed (GH13735).

• `Categorical.from_array` has been removed (GH13854).

• The `freq` and `how` parameters have been removed from the `rolling/expandng/ewm` methods of `DataFrame` and `Series` (deprecated since v0.18). Instead, resample before calling the methods. (GH18601 & GH18668).

• `DatetimeIndex.to_datetime`, `Timestamp.to_datetime`, `PeriodIndex.to_datetime`, and `Index.to_datetime` have been removed (GH8254, GH14096, GH14113).

• `read_csv()` has dropped the `skip_footer` parameter (GH13386).

• `read_csv()` has dropped the `as_recarray` parameter (GH13373).

• `read_csv()` has dropped the `buffer_lines` parameter (GH13360).
• **read_csv()** has dropped the compact_ints and use_unsigned parameters (GH13323)

• The Timestamp class has dropped the offset attribute in favor of freq (GH13593)

• The Series, Categorical, and Index classes have dropped the reshape method (GH13012)

• pandas.tseries.frequencies.get_standard_freq has been removed in favor of pandas.tseries.frequencies.to_offset(freq).rule_code (GH13874)

• The freqstr keyword has been removed from pandas.tseries.frequencies.to_offset in favor of freq (GH13874)

• The Panel4D and PanelND classes have been removed (GH13776)

• The Panel class has dropped the to_long and toLong methods (GH19077)

• The options display.line_with and display.height are removed in favor of display.width and display.max_rows respectively (GH4391, GH19107)

• The labels attribute of the Categorical class has been removed in favor of Categorical.codes (GH7768)

• The flavor parameter have been removed from func:to_sql method (GH13611)

• The modules pandas.tools.hashing and pandas.util.hashing have been removed (GH16223)

• The top-level functions pd.rolling_*, pd.expanding_* and pd.ewm* have been removed (Deprecated since v0.18). Instead, use the DataFrame/Series methods rolling, expanding and ewm (GH18723)

• Imports from pandas.core.common for functions such as is_datetime64_dtype are now removed. These are located in pandas.api.types (GH13634, GH19769)

• The infer_dst keyword in Series.tz_localize(), DatetimeIndex.tz_localize() and DatetimeIndex have been removed. infer_dst=True is equivalent to ambiguous='infer', and infer_dst=False to ambiguous='raise' (GH7963).

• When .resample() was changed from an eager to a lazy operation, like .groupby() in v0.18.0, we put in place compatibility (with a FutureWarning), so operations would continue to work. This is now fully removed, so a Resampler will no longer forward compat operations (GH20554)

• Remove long deprecated axis=None parameter from .replace() (GH20271)

### 1.3.5 Performance Improvements

• Indexers on Series or DataFrame no longer create a reference cycle (GH17956)

• Added a keyword argument, cache, to to_datetime() that improved the performance of converting duplicate datetime arguments (GH11665)

• DateOffset arithmetic performance is improved (GH18218)

• Converting a Series of Timedelta objects to days, seconds, etc... sped up through vectorization of underlying methods (GH18092)

• Improved performance of .map() with a Series/dict input (GH15081)

• The overridden Timedelta properties of days, seconds and microseconds have been removed, leveraging their built-in Python versions instead (GH18242)

• Series construction will reduce the number of copies made of the input data in certain cases (GH17449)

• Improved performance of Series.dt.date() and DatetimeIndex.date() (GH18058)

• Improved performance of Series.dt.time() and DatetimeIndex.time() (GH18461)
• Improved performance of `IntervalIndex.symmetric_difference()` (GH18475)
• Improved performance of `DatetimeIndex` and `Series` arithmetic operations with Business-Month and Business-Quarter frequencies (GH18489)
• `Series() / DataFrame()` tab completion limits to 100 values, for better performance. (GH18587)
• Improved performance of `DataFrame.median()` with `axis=1` when bottleneck is not installed (GH16468)
• Improved performance of `MultiIndex.get_loc()` for large indexes, at the cost of a reduction in performance for small ones (GH18519)
• Improved performance of `MultiIndex.remove_unused_levels()` when there are no unused levels, at the cost of a reduction in performance when there are (GH19289)
• Improved performance of `Index.get_loc()` for non-unique indexes (GH19478)
• Improved performance of pairwise `.rolling()` and `.expanding()` with `.cov()` and `.corr()` operations (GH17917)
• Improved performance of `pandas.core.groupby.GroupBy.rank()` (GH15779)
• Improved performance of variable `.rolling()` on `.min()` and `.max()` (GH19521)
• Improved performance of `pandas.core.groupby.GroupBy.ffill()` and `pandas.core.groupby.GroupBy.bfill()` (GH11296)
• Improved performance of `pandas.core.groupby.GroupBy.any()` and `pandas.core.groupby.GroupBy.all()` (GH15435)
• Improved performance of `pandas.core.groupby.GroupBy.pct_change()` (GH19165)
• Improved performance of `Series.isin()` in the case of categorical dtypes (GH20003)
• Improved performance of `getattr(Series, attr)` when the Series has certain index types. This manifested in slow printing of large Series with a `DatetimeIndex` (GH19764)
• Fixed a performance regression for `GroupBy.nth()` and `GroupBy.last()` with some object columns (GH19283)
• Improved performance of `pandas.core.arrays.Categorical.from_codes()` (GH18501)

### 1.3.6 Documentation Changes

Thanks to all of the contributors who participated in the Pandas Documentation Sprint, which took place on March 10th. We had about 500 participants from over 30 locations across the world. You should notice that many of the `API` docstrings have greatly improved.

There were too many simultaneous contributions to include a release note for each improvement, but this GitHub search should give you an idea of how many docstrings were improved.

Special thanks to Marc Garcia for organizing the sprint. For more information, read the NumFOCUS blogpost recapping the sprint.

• Changed spelling of “numpy” to “NumPy”, and “python” to “Python”. (GH19017)
• Consistency when introducing code samples, using either colon or period. Rewrote some sentences for greater clarity, added more dynamic references to functions, methods and classes. (GH18941, GH18948, GH18973, GH19017)
• Added a reference to `DataFrame.assign()` in the concatenate section of the merging documentation (GH18665)
1.3.7 Bug Fixes

1.3.7.1 Categorical

**Warning:** A class of bugs were introduced in pandas 0.21 with `CategoricalDtype` that affects the correctness of operations like `merge`, `concat`, and indexing when comparing multiple unordered `Categorical` arrays that have the same categories, but in a different order. We highly recommend upgrading or manually aligning your categories before doing these operations.

- Bug in `Categorical.equals` returning the wrong result when comparing two unordered `Categorical` arrays with the same categories, but in a different order (GH16603)
- Bug in `pandas.api.types.union_categoricals()` returning the wrong result when for unordered categoricals with the categories in a different order. This affected `pandas.concat()` with Categorical data (GH19096).
- Bug in `pandas.merge()` returning the wrong result when joining on an unordered `Categorical` that had the same categories but in a different order (GH19551)
- Bug in `CategoricalIndex.get_indexer()` returning the wrong result when `target` was an unordered `Categorical` that had the same categories as `self` but in a different order (GH19551)
- Bug in `Index.astype()` with a categorical dtype where the resultant index is not converted to a `CategoricalIndex` for all types of index (GH18630)
- Bug in `Series.astype()` and `Categorical.astype()` where an existing categorical data does not get updated (GH10696, GH18593)
- Bug in `Series.str.split()` with `expand=True` incorrectly raising an `IndexError` on empty strings (GH20002).
- Bug in `Index` constructor with `dtype=CategoricalDtype(...)` where categories and ordered are not maintained (GH19032)
- Bug in `Series` constructor with scalar and `dtype=CategoricalDtype(...)` where categories and ordered are not maintained (GH19565)
- Bug in `Categorical.__iter__` not converting to Python types (GH19909)
- Bug in `pandas.factorize()` returning the unique codes for the uniques. This now returns a `Categorical` with the same dtype as the input (GH19721)
- Bug in `pandas.factorize()` including an item for missing values in the uniques return value (GH19721)
- Bug in `Series.take()` with categorical data interpreting `-1` in `indices` as missing value markers, rather than the last element of the Series (GH20664)

1.3.7.2 Datetimelike

- Bug in `Series.__sub__()` subtracting a non-nanosecond `np.datetime64` object from a `Series` gave incorrect results (GH7996)
- Bug in `DatetimeIndex`, `TimedeltaIndex` addition and subtraction of zero-dimensional integer arrays gave incorrect results (GH19012)
• Bug in `DatetimeIndex` and `TimedeltaIndex` where adding or subtracting an array-like of `DateOffset` objects either raised (np.array, pd.Index) or broadcast incorrectly (pd.Series) (GH18849)

• Bug in `Series.__add__()` adding Series with dtype `timedelta64[ns]` to a timezone-aware `DatetimeIndex` incorrectly dropped timezone information (GH13905)

• Adding a `Period` object to a `datetime` or `Timestamp` object will now correctly raise a `TypeError` (GH17983)

• Bug in `Timestamp` where comparison with an array of `Timestamp` objects would result in a `RecursionError` (GH15183)

• Bug in `Series.floor-division` where operating on a scalar `timedelta` raises an exception (GH18846)

• Bug in `DatetimeIndex` where the repr was not showing high-precision time values at the end of a day (e.g., 23:59:59.999999999) (GH19030)

• Bug in `astype()` to non-ns timedelta units would hold the incorrect dtype (GH19176, GH19223, GH12425)

• Bug in subtracting `Series` from `NaT` incorrectly returning `NaT` (GH19158)

• Bug in `Series.truncate()` which raises `TypeError` with a monotonic `PeriodIndex` (GH17717)

• Bug in `pct_change()` using periods and freq returned different length outputs (GH7292)

• Bug in comparison of `DatetimeIndex` against None or `datetime.date` objects raising `TypeError` for `==` and `!=` comparisons instead of all-False and all-True, respectively (GH19301)

• Bug in `Timestamp` and `to_datetime()` where a string representing a barely out-of-bounds timestamp would be incorrectly rounded down instead of raising `OutOfBoundsDatetime` (GH19382)

• Bug in `Timestamp.floor()` `DatetimeIndex.floor()` where time stamps far in the future and past were not rounded correctly (GH19206)

• Bug in `to_datetime()` where passing an out-of-bounds datetime with `errors='coerce'` and `utc=True` would raise `OutOfBoundsDatetime` instead of parsing to `NaT` (GH19612)

• Bug in `DatetimeIndex` and `TimedeltaIndex` addition and subtraction where name of the returned object was not always set consistently. (GH19744)

• Bug in `DatetimeIndex` and `TimedeltaIndex` addition and subtraction where operations with numpy arrays raised `TypeError` (GH19847)

• Bug in `DatetimeIndex` and `TimedeltaIndex` where setting the freq attribute was not fully supported (GH20678)

1.3.7.3 Timedelta

• Bug in `Timedelta.__mul__()` where multiplying by `NaT` returned `NaT` instead of raising a `TypeError` (GH19819)

• Bug in `Series` with dtype='timedelta64[ns]' where addition or subtraction of `TimedeltaIndex` had results cast to dtype='int64' (GH17250)

• Bug in `Series` with dtype='timedelta64[ns]' where addition or subtraction of `TimedeltaIndex` could return a `Series` with an incorrect name (GH19043)

• Bug in `Timedelta.__floordiv__()` and `Timedelta.__rfloordiv__()` dividing by many incompatible numpy objects was incorrectly allowed (GH18846)

• Bug where dividing a scalar timedelta-like object with `TimedeltaIndex` performed the reciprocal operation (GH19125)
• Bug in `TimedeltaIndex` where division by a `Series` would return a `TimedeltaIndex` instead of a `Series` (GH19042)

• Bug in `Timedelta.__add__()`, `Timedelta.__sub__()` where adding or subtracting a `np.timedelta64` object would return another `np.timedelta64` instead of a `Timedelta` (GH19738)

• Bug in `Timedelta.__floordiv__(), Timedelta.__rfloordiv__()` where operating with a `Tick` object would raise a `TypeError` instead of returning a numeric value (GH19738)

• Bug in `Period.asfreq()` where periods near datetime(1, 1, 1) could be converted incorrectly (GH19643, GH19834)

• Bug in `Timedelta.total_seconds()` causing precision errors, for example `Timedelta('30S').total_seconds() == 30.000000000000004` (GH19458)

• Bug in `Timedelta.__rmod__()` where operating with a `numpy.timedelta64` returned a `timedelta64` object instead of a `Timedelta` (GH19820)

• Multiplication of `TimedeltaIndex` by `TimedeltaIndex` will now raise `TypeError` instead of raising `ValueError` in cases of length mis-match (GH19333)

• Bug in indexing a `TimedeltaIndex` with a `np.timedelta64` object which was raising a `TypeError` (GH20393)

1.3.7.4 Timezones

• Bug in creating a `Series` from an array that contains both tz-naive and tz-aware values will result in a `Series` whose dtype is tz-aware instead of object (GH16406)

• Bug in comparison of timezone-aware `DatetimeIndex` against `NaT` incorrectly raising `TypeError` (GH19276)

• Bug in `DatetimeIndex.astype()` when converting between timezone aware dtypes, and converting from timezone aware to naive (GH18951)

• Bug in comparing `DatetimeIndex`, which failed to raise `TypeError` when attempting to compare timezone-aware and timezone-naive datetimelike objects (GH18162)

• Bug in localization of a naive, datetime string in a `Series` constructor with a `datetime64[ns, tz]` dtype (GH174151)

• `Timestamp.replace()` will now handle Daylight Savings transitions gracefully (GH18319)

• Bug in tz-aware `DatetimeIndex` where addition/subtraction with a `TimedeltaIndex` or array with dtype='timedelta64[ns]' was incorrect (GH17558)

• Bug in `DatetimeIndex.insert()` where inserting `NaT` into a time-zone-aware index incorrectly raised (GH16357)

• Bug in `DataFrame` constructor, where tz-aware Datetimeindex and a given column name will result in an empty `DataFrame` (GH19157)

• Bug in `Timestamp.tz_localize()` where localizing a timestamp near the minimum or maximum valid values could overflow and return a timestamp with an incorrect nanosecond value (GH12677)

• Bug when iterating over `DatetimeIndex` that was localized with fixed timezone offset that rounded nanosecond precision to microseconds (GH19603)

• Bug in `DataFrame.diff()` that raised an `IndexError` with tz-aware values (GH18578)

• Bug in `melt()` that converted tz-aware dtypes to tz-naive (GH15785)
• Bug in `Dataframe.count()` that raised a `ValueError`, if `Dataframe.dropna()` was called for a single column with timezone-aware values. (GH13407)

### 1.3.7.5 Offsets

• Bug in `WeekOfMonth` and `Week` where addition and subtraction did not roll correctly (GH18510, GH18672, GH18864)

• Bug in `WeekOfMonth` and `LastWeekOfMonth` where default keyword arguments for constructor raised `ValueError` (GH19142)

• Bug in `FY5253Quarter`, `LastWeekOfMonth` where rollback and rollforward behavior was inconsistent with addition and subtraction behavior (GH18854)

• Bug in `FY5253` where datetime addition and subtraction incremented incorrectly for dates on the year-end but not normalized to midnight (GH18854)

• Bug in `FY5253` where date offsets could incorrectly raise an `AssertionError` in arithmetic operations (GH14774)

### 1.3.7.6 Numeric

• Bug in `Series` constructor with an int or float list where specifying `dtype=str`, `dtype='str'` or `dtype='U'` failed to convert the data elements to strings (GH16605)

• Bug in `Index` multiplication and division methods where operating with a `Series` would return an `Index` object instead of a `Series` object (GH19042)

• Bug in the `DataFrame` constructor in which data containing very large positive or very large negative numbers was causing `OverflowError` (GH18584)

• Bug in `Index` constructor with `dtype='uint64'` where int-like floats were not coerced to `UInt64Index` (GH18400)

• Bug in `DataFrame` flex arithmetic (e.g. `df.add(other, fill_value=foo)`) with a `fill_value` other than `None` failed to raise `NotImplementedError` in corner cases where either the frame or other has length zero (GH19522)

• Multiplication and division of numeric-dtyped `Index` objects with timedelta-like scalars returns `TimedeltaIndex` instead of raising `TypeError` (GH19333)

• Bug where NaN was returned instead of 0 by `Series.pct_change()` and `DataFrame.pct_change()` when `fill_method` is not `None` (GH19873)

### 1.3.7.7 Strings

• Bug in `Series.str.get()` with a dictionary in the values and the index not in the keys, raising `KeyError` (GH20671)

### 1.3.7.8 Indexing

• Bug in `Index` construction from list of mixed type tuples (GH18505)

• Bug in `Index.drop()` when passing a list of both tuples and non-tuples (GH18304)

• Bug in `DataFrame.drop()`, `Panel.drop()`, `Series.drop()`, `Index.drop()` where no `KeyError` is raised when dropping a non-existent element from an axis that contains duplicates (GH19186)
• Bug in indexing a datetimelike Index that raised ValueError instead of IndexError (GH18386).
• Index.to_series() now accepts index and name kwargs (GH18699)
• DatetimeIndex.to_series() now accepts index and name kwargs (GH18699)
• Bug in indexing non-scalar value from Series having non-unique Index will return value flattened (GH17610)
• Bug in indexing with iterator containing only missing keys, which raised no error (GH20748)
• Fixed inconsistency in .ix between list and scalar keys when the index has integer dtype and does not include the desired keys (GH20753)
• Bug in __setitem__ when indexing a DataFrame with a 2-d boolean ndarray (GH18582)
• Bug in str.extractall when there were no matches empty Index was returned instead of appropriate MultiIndex (GH19034)
• Bug in IntervalIndex where empty and purely NA data was constructed inconsistently depending on the construction method (GH18421)
• Bug in IntervalIndex.symmetric_difference() where the symmetric difference with a non-IntervalIndex did not raise (GH18475)
• Bug in IntervalIndex where set operations that returned an empty IntervalIndex had the wrong dtype (GH19101)
• Bug in DataFrame.drop_duplicates() where no KeyError is raised when passing in columns that don’t exist on the DataFrame (GH19726)
• Bug in Index subclasses constructors that ignore unexpected keyword arguments (GH19348)
• Bug in Index.difference() when taking difference of an Index with itself (GH20040)
• Bug in DataFrame.first_valid_index() and DataFrame.last_valid_index() in presence of entire rows of NaNs in the middle of values (GH20499).
• Bug in IntervalIndex where some indexing operations were not supported for overlapping or non-monotonic uint64 data (GH20636)
• Bug in Series.is_unique where extraneous output in stderr is shown if Series contains objects with __ne__ defined (GH20661)
• Bug in .loc assignment with a single-element list-like incorrectly assigns as a list (GH19474)
• Bug in partial string indexing on a Series/DataFrame with a monotonic decreasing DatetimeIndex (GH19362)
• Bug in performing in-place operations on a DataFrame with a duplicate Index (GH17105)
• Bug in IntervalIndex.get_loc() and IntervalIndex.get_indexer() when used with an IntervalIndex containing a single interval (GH17284, GH20921)
• Bug in .loc with a uint64 indexer (GH20722)

1.3.7.9 MultiIndex

• Bug in MultiIndex.__contains__() where non-tuple keys would return True even if they had been dropped (GH19027)
• Bug in MultiIndex.set_labels() which would cause casting (and potentially clipping) of the new labels if the level argument is not 0 or a list like [0, 1, ...] (GH19057)
• Bug in `MultiIndex.get_level_values()` which would return an invalid index on level of ints with missing values (GH17924)
• Bug in `MultiIndex.unique()` when called on empty `MultiIndex` (GH20568)
• Bug in `MultiIndex.unique()` which would not preserve level names (GH20570)
• Bug in `MultiIndex.remove_unused_levels()` which would fill nan values (GH18417)
• Bug in `MultiIndex.from_tuples()` which would fail to take zipped tuples in python3 (GH18434)
• Bug in `MultiIndex.get_loc()` which would fail to automatically cast values between float and int (GH18818, GH15994)
• Bug in `MultiIndex.get_loc()` which would cast boolean to integer labels (GH19086)
• Bug in `MultiIndex.get_loc()` which would fail to locate keys containing NaN (GH18485)
• Bug in `MultiIndex.get_loc()` in large `MultiIndex`, would fail when levels had different dtypes (GH18520)
• Bug in indexing where nested indexers having only numpy arrays are handled incorrectly (GH19686)

1.3.7.10 I/O

• `read_html()` now rewinds seekable IO objects after parse failure, before attempting to parse with a new parser. If a parser errors and the object is non-seekable, an informative error is raised suggesting the use of a different parser (GH17975)
• `DataFrame.to_html()` now has an option to add an id to the leading `<table>` tag (GH8496)
• Bug in `read_msgpack()` with a non existent file is passed in Python 2 (GH15296)
• Bug in `read_csv()` where a `MultiIndex` with duplicate columns was not being mangled appropriately (GH18062)
• Bug in `read_csv()` where missing values were not being handled properly when `keep_default_na=False` with dictionary `na_values` (GH19227)
• Bug in `read_csv()` causing heap corruption on 32-bit, big-endian architectures (GH20785)
• Bug in `read_sas()` where a file with 0 variables gave an `AttributeError` incorrectly. Now it gives an `EmptyDataError` (GH18184)
• Bug in `DataFrame.to_latex()` where pairs of braces meant to serve as invisible placeholders were escaped (GH18667)
• Bug in `DataFrame.to_latex()` where a NaN in a MultiIndex would cause an `IndexError` or incorrect output (GH14249)
• Bug in `DataFrame.to_latex()` where a non-string index-level name would result in an `AttributeError` (GH19981)
• Bug in `DataFrame.to_latex()` where the combination of an index name and the `index_names=False` option would result in incorrect output (GH18326)
• Bug in `DataFrame.to_latex()` where a MultiIndex with an empty string as its name would result in incorrect output (GH18669)
• Bug in `DataFrame.to_parquet()` where missing space characters caused wrong escaping and produced non-valid latex in some cases (GH20859)
• Bug in `read_json()` where large numeric values were causing an `OverflowError` (GH18842)
• Bug in `DataFrame.to_parquet()` where an exception was raised if the write destination is S3 (GH19134)
• Interval now supported in DataFrame.to_excel() for all Excel file types (GH19242)
• Timedelta now supported in DataFrame.to_excel() for all Excel file types (GH19242, GH9155, GH19900)
• Bug in pandas.io.stata.StataReader.value_labels() raising an AttributeError when called on very old files. Now returns an empty dict (GH19417)
• Bug in read_pickle() when unpickling objects with TimedeltaIndex or Float64Index created with pandas prior to version 0.20 (GH19939)
• Bug in usecols parameter in read_csv() where error is not raised correctly when passing a string. (GH20529)
• Bug in HDFStore.keys() when reading a file with a softlink causes exception (GH20523)
• Bug in HDFStore.select_column() where a key which is not a valid store raised an AttributeError instead of a KeyError (GH17912)

1.3.7.11 Plotting

• Better error message when attempting to plot but matplotlib is not installed (GH19810).
• DataFrame.plot() now raises a ValueError when the x or y argument is improperly formed (GH18671)
• Bug in DataFrame.plot() when x and y arguments given as positions caused incorrect referenced columns for line, bar and area plots (GH20056)
• Fixing error message when using datetime.time() and fractional seconds (GH18478).
• Series.plot.kde() has exposed the args ind and bw_method in the docstring (GH18461). The argument ind may now also be an integer (number of sample points).
• DataFrame.plot() now supports multiple columns to the y argument (GH19699)

1.3.7.12 Groupby/Resample/Rolling

• Bug when grouping by a single column and aggregating with a class like list or tuple (GH18079)
• Fixed regression in DataFrame.groupby() which would not emit an error when called with a tuple key not in the index (GH18798)
• Bug in DataFrame.resample() which silently ignored unsupported (or mistyped) options for label, closed and convention (GH19303)
• Bug in DataFrame.groupby() where tuples were interpreted as lists of keys rather than as keys (GH17979, GH18249)
• Bug in DataFrame.groupby() where aggregation by first/last/min/max was causing timestamps to lose precision (GH19526)
• Bug in DataFrame.transform() where particular aggregation functions were being incorrectly cast to match the dtype(s) of the grouped data (GH19200)
• Bug in DataFrame.groupby() passing the on= kwarg, and subsequently using .apply() (GH17813)
• Bug in DataFrame.resample().aggregate not raising a KeyError when aggregating a non-existent column (GH16766, GH19566)
• Bug in `DataFrameGroupBy.cumsum()` and `DataFrameGroupBy.cumprod()` when `skipna` was passed (GH19806)

• Bug in `DataFrame.resample()` that dropped timezone information (GH13238)

• Bug in `DataFrame.groupby()` where transformations using `np.all` and `np.any` were raising a `ValueError` (GH20653)

• Bug in `DataFrame.resample()` where `ffill`, `bfill`, `pad`, `backfill`, `fillna`, `interpolate`, and `asfreq` were ignoring `loffset`. (GH20744)

• Bug in `DataFrame.groupby()` when applying a function that has mixed data types and the user supplied function can fail on the grouping column (GH20949)

• Bug in `DataFrameGroupBy.rolling().apply()` where operations performed against the associated `DataFrameGroupBy` object could impact the inclusion of the grouped item(s) in the result (GH14013)

1.3.7.13 Sparse

• Bug in which creating a `SparseDataFrame` from a dense `Series` or an unsupported type raised an uncontrolled exception (GH19374)

• Bug in `SparseDataFrame.to_csv` causing exception (GH19384)

• Bug in `SparseSeries.memory_usage` which caused segfault by accessing non sparse elements (GH19368)

• Bug in constructing a `SparseArray`: if `data` is a scalar and `index` is defined it will coerce to `float64` regardless of scalar’s dtype. (GH19163)

1.3.7.14 Reshaping

• Bug in `DataFrame.merge()` where referencing a `CategoricalIndex` by name, where the `by` kwarg would `KeyError` (GH20777)

• Bug in `DataFrame.stack()` which fails trying to sort mixed type levels under Python 3 (GH18310)

• Bug in `DataFrame.unstack()` which casts int to float if `columns` is a `MultiIndex` with unused levels (GH17845)

• Bug in `DataFrame.unstack()` which raises an error if `index` is a `MultiIndex` with unused labels on the unstacked level (GH18562)

• Fixed construction of a `Series` from a `dict` containing `NaN` as key (GH18480)

• Fixed construction of a `DataFrame` from a `dict` containing `NaN` as key (GH18455)

• Disabled construction of a `Series` where `len(index) > len(data) = 1`, which previously would broadcast the data item, and now raises a `ValueError` (GH18819)

• Suppressed error in the construction of a `DataFrame` from a `dict` containing scalar values when the corresponding keys are not included in the passed index (GH18600)

• Fixed (changed from `object` to `float64`) dtype of `DataFrame` initialized with axes, no data, and `dtype=int` (GH19646)

• Bug in `Series.rank()` where `Series` containing `NaT` modifies the `Series` inplace (GH18521)

• Bug in `cut()` which fails when using readonly arrays (GH18773)

• Bug in `DataFrame.pivot_table()` which fails when the `aggfunc` arg is of type string. The behavior is now consistent with other methods like `agg` and `apply` (GH18713)
• Bug in `DataFrame.merge()` in which merging using `Index` objects as vectors raised an Exception (GH19038)

• Bug in `DataFrame.stack()`, `DataFrame.unstack()`, `Series.unstack()` which were not returning subclasses (GH15563)

• Bug in timezone comparisons, manifesting as a conversion of the index to UTC in `.concat()` (GH18523)

• Bug in `concat()` when concatting sparse and dense series it returns only a `SparseDataFrame`. Should be a `DataFrame`. (GH18914, GH18686, and GH16874)

• Improved error message for `DataFrame.merge()` when there is no common merge key (GH19427)

• Bug in `DataFrame.join()` which does an `outer` instead of a `left` join when being called with multiple DataFrames and some have non-unique indices (GH19624)

• `Series.rename()` now accepts `axis` as a kwarg (GH18589)

• Bug in `rename()` where an Index of same-length tuples was converted to a MultiIndex (GH19497)

• Comparisons between `Series` and `Index` would return a `Series` with an incorrect name, ignoring the Index’s name attribute (GH19582)

• Bug in `qcut()` where datetime and timedelta data with NaT present raised a `ValueError` (GH19768)

• Bug in `DataFrame.iterrows()`, which would infer strings not compliant to ISO8601 to datetimes (GH19671)

• Bug in `Series` constructor with `Categorical` where a `ValueError` is not raised when an index of different length is given (GH19342)

• Bug in `DataFrame.astype()` where column metadata is lost when converting to categorical or a dictionary of dtypes (GH19920)

• Bug in `cut()` and `qcut()` where timezone information was dropped (GH19872)

• Bug in `Series` constructor with a `dtype=str`, previously raised in some cases (GH19853)

• Bug in `get_dummies()`, and `select_dtypes()`, where duplicate column names caused incorrect behavior (GH20848)

• Bug in `isna()`, which cannot handle ambiguous typed lists (GH20675)

• Bug in `concat()` which raises an error when concatenating TZ-aware dataframes and all-NaT dataframes (GH12396)

• Bug in `concat()` which raises an error when concatenating empty TZ-aware series (GH18447)

1.3.7.15 Other

• Improved error message when attempting to use a Python keyword as an identifier in a `numexpr` backed query (GH18221)

• Bug in accessing a `pandas.get_option()`, which raised `KeyError` rather than `OptionError` when looking up a non-existant option key in some cases (GH19789)

• Bug in `testing.assert_series_equal()` and `testing.assert_frame_equal()` for Series or DataFrames with differing unicode data (GH20503)
1.4 v0.22.0 (December 29, 2017)

This is a major release from 0.21.1 and includes a single, API-breaking change. We recommend that all users upgrade to this version after carefully reading the release note (singular!).

1.4.1 Backwards incompatible API changes

Pandas 0.22.0 changes the handling of empty and all-NA sums and products. The summary is that

- The sum of an empty or all-NA Series is now 0
- The product of an empty or all-NA Series is now 1
- We’ve added a min_count parameter to .sum() and .prod() controlling the minimum number of valid values for the result to be valid. If fewer than min_count non-NA values are present, the result is NA. The default is 0. To return NaN, the 0.21 behavior, use min_count=1.

Some background: In pandas 0.21, we fixed a long-standing inconsistency in the return value of all-NA series depending on whether or not bottleneck was installed. See *Sum/Prod of all-NaN or empty Series/DataFrames is now consistently NaN*. At the same time, we changed the sum and prod of an empty Series to also be NaN.

Based on feedback, we’ve partially reverted those changes.

1.4.1.1 Arithmetic Operations

The default sum for empty or all-NA Series is now 0.

**pandas 0.21.x**

```
In [1]: pd.Series([]).sum()
Out[1]: nan

In [2]: pd.Series([np.nan]).sum()
Out[2]: nan
```

**pandas 0.22.0**

```
In [1]: pd.Series([]).sum()
Out[1]: 0.0

In [2]: pd.Series([np.nan]).sum()  
\n\n\n\n\n\nOut[2]: 0.0
```

The default behavior is the same as pandas 0.20.3 with bottleneck installed. It also matches the behavior of NumPy’s `np.nansum` on empty and all-NA arrays.

To have the sum of an empty series return NaN (the default behavior of pandas 0.20.3 without bottleneck, or pandas 0.21.x), use the `min_count` keyword.

```
In [3]: pd.Series([]).sum(min_count=1)
Out[3]: nan
```

Thanks to the `skipna` parameter, the `.sum` on an all-NA series is conceptually the same as the `.sum` of an empty one with `skipna=True` (the default).

```
In [4]: pd.Series([np.nan]).sum(min_count=1)  # skipna=True by default
Out[4]: nan
```
The `min_count` parameter refers to the minimum number of *non-null* values required for a non-NA sum or product. `Series.prod()` has been updated to behave the same as `Series.sum()`, returning 1 instead.

```
In [5]: pd.Series([]).prod()
Out[5]: 1.0

In [6]: pd.Series([np.nan]).prod()
Out[6]: 1.0

In [7]: pd.Series([]).prod(min_count=1)
Out[7]: nan
```

These changes affect `DataFrame.sum()` and `DataFrame.prod()` as well. Finally, a few less obvious places in pandas are affected by this change.

### 1.4.1.2 Grouping by a Categorical

Grouping by a `Categorical` and summing now returns 0 instead of NaN for categories with no observations. The product now returns 1 instead of NaN.

*pandas 0.21.x*

```
In [8]: grouper = pd.Categorical(['a', 'a'], categories=['a', 'b'])

In [9]: pd.Series([1, 2]).groupby(grouper).sum()
Out[9]:
   a  3.0
   b  NaN
dtype: float64
```

*pandas 0.22*

```
In [8]: grouper = pd.Categorical(['a', 'a'], categories=['a', 'b'])

In [9]: pd.Series([1, 2]).groupby(grouper).sum()
Out[9]:
   a  3
   b  0
dtype: int64
```

To restore the 0.21 behavior of returning NaN for unobserved groups, use `min_count>=1`.

```
In [10]: pd.Series([1, 2]).groupby(grouper).sum(min_count=1)
Out[10]:
   a  3.0
   b  NaN
dtype: float64
```

### 1.4.1.3 Resample

The sum and product of all-NA bins has changed from NaN to 0 for sum and 1 for product.

*pandas 0.21.x*
In [11]: s = pd.Series([1, 1, np.nan, np.nan],
                  index=pd.date_range('2017', periods=4))
In [11]: s
Out[11]:
2017-01-01 1.0
2017-01-02 1.0
2017-01-03 NaN
2017-01-04 NaN
Freq: D, dtype: float64

In [12]: s.resample('2d').sum()
Out[12]:
2017-01-01 2.0
2017-01-03 NaN
Freq: 2D, dtype: float64

To restore the 0.21 behavior of returning NaN, use min_count>=1.

In [13]: s.resample('2d').sum(min_count=1)
Out[13]:
2017-01-01 2.0
2017-01-03 NaN
dtype: float64

In particular, upsampling and taking the sum or product is affected, as upsampling introduces missing values even if the original series was entirely valid.

pandas 0.21.x

In [14]: idx = pd.DatetimeIndex(['2017-01-01', '2017-01-02'])
In [15]: pd.Series([1, 2], index=idx).resample('12H').sum()
Out[15]:
2017-01-01 00:00:00 1.0
2017-01-01 12:00:00 NaN
2017-01-02 00:00:00 2.0
Freq: 12H, dtype: float64

pandas 0.22.0

In [14]: idx = pd.DatetimeIndex(['2017-01-01', '2017-01-02'])
In [15]: pd.Series([1, 2], index=idx).resample("12H").sum()
Out[15]:
2017-01-01 00:00:00 1
(continues on next page)
Once again, the `min_count` keyword is available to restore the 0.21 behavior.

```python
In [16]: pd.Series([1, 2], index=idx).resample("12H").sum(min_count=1)
Out[16]:
2017-01-01 00:00:00 1.0
2017-01-01 12:00:00 NaN
2017-01-02 00:00:00 2.0
Freq: 12H, dtype: float64
```

### 1.4.1.4 Rolling and Expanding

Rolling and expanding already have a `min_periods` keyword that behaves similar to `min_count`. The only case that changes is when doing a rolling or expanding sum with `min_periods=0`. Previously this returned `NaN`, when fewer than `min_periods` non-NA values were in the window. Now it returns 0.

**pandas 0.21.1**

```python
In [17]: s = pd.Series([np.nan, np.nan])
In [18]: s.rolling(2, min_periods=0).sum()
Out[18]:
0 NaN
1 NaN
dtype: float64
```

**pandas 0.22.0**

```python
In [17]: s = pd.Series([np.nan, np.nan])
In [18]: s.rolling(2, min_periods=0).sum()
Out[18]:
0 0.0
1 0.0
dtype: float64
```

The default behavior of `min_periods=None`, implying that `min_periods` equals the window size, is unchanged.

### 1.4.2 Compatibility

If you maintain a library that should work across pandas versions, it may be easiest to exclude pandas 0.21 from your requirements. Otherwise, all your `sum()` calls would need to check if the `Series` is empty before summing.

With setuptools, in your `setup.py` use:

```
install_requires=['pandas!=0.21.*', ...]
```

With conda, use

```
requirements:
  run:
    - pandas !=0.21.0,!=0.21.1
```

1.4. v0.22.0 (December 29, 2017)
Note that the inconsistency in the return value for all-NA series is still there for pandas 0.20.3 and earlier. Avoiding pandas 0.21 will only help with the empty case.

1.5 v0.21.1 (December 12, 2017)

This is a minor bug-fix release in the 0.21.x series and includes some small regression fixes, bug fixes and performance improvements. We recommend that all users upgrade to this version.

Highlights include:

- Temporarily restore matplotlib datetime plotting functionality. This should resolve issues for users who implicitly relied on pandas to plot datetimes with matplotlib. See here.
- Improvements to the Parquet IO functions introduced in 0.21.0. See here.

What’s new in v0.21.1

- Restore Matplotlib datetime Converter Registration
- New features
  - Improvements to the Parquet IO functionality
  - Other Enhancements
- Deprecations
- Performance Improvements
- Bug Fixes
  - Conversion
  - Indexing
  - I/O
  - Plotting
  - Groupby/Resample/Rolling
  - Reshaping
  - Numeric
  - Categorical
  - String

1.5.1 Restore Matplotlib datetime Converter Registration

Pandas implements some matplotlib converters for nicely formatting the axis labels on plots with datetime or Period values. Prior to pandas 0.21.0, these were implicitly registered with matplotlib, as a side effect of import pandas.

In pandas 0.21.0, we required users to explicitly register the converter. This caused problems for some users who relied on those converters being present for regular matplotlib.pyplot plotting methods, so we’re temporarily reverting that change; pandas 0.21.1 again registers the converters on import, just like before 0.21.0.
We’ve added a new option to control the converters: `pd.options.plotting.matplotlib.register_converters`. By default, they are registered. Toggling this to `False` removes pandas’ formatters and restore any converters we overwrote when registering them (GH18301).

We’re working with the matplotlib developers to make this easier. We’re trying to balance user convenience (automatically registering the converters) with import performance and best practices (importing pandas shouldn’t have the side effect of overwriting any custom converters you’ve already set). In the future we hope to have most of the date-time formatting functionality in matplotlib, with just the pandas-specific converters in pandas. We’ll then gracefully deprecate the automatic registration of converters in favor of users explicitly registering them when they want them.

1.5.2 New features

1.5.2.1 Improvements to the Parquet IO functionality

- `DataFrame.to_parquet()` will now write non-default indexes when the underlying engine supports it. The indexes will be preserved when reading back in with `read_parquet()` (GH18581).
- `read_parquet()` now allows to specify the columns to read from a parquet file (GH18154)
- `read_parquet()` now allows to specify kwargs which are passed to the respective engine (GH18216)

1.5.2.2 Other Enhancements

- `Timestamp.timestamp()` is now available in Python 2.7. (GH17329)
- `Grouper` and `TimeGrouper` now have a friendly repr output (GH18203).

1.5.3 Deprecations

- `pandas.tseries.register` has been renamed to `pandas.plotting.register_matplotlib_converters()` (GH18301)

1.5.4 Performance Improvements

- Improved performance of plotting large series/dataframes (GH18236).

1.5.5 Bug Fixes

1.5.5.1 Conversion

- Bug in `TimedeltaIndex` subtraction could incorrectly overflow when NaT is present (GH17791)
- Bug in `DatetimeIndex` subtracting datetimelike from DatetimeIndex could fail to overflow (GH18020)
- Bug in `IntervalIndex.copy()` when copying and `IntervalIndex` with non-default `closed` (GH18339)
- Bug in `DataFrame.to_dict()` where columns of datetime that are tz-aware were not converted to required arrays when used with `orient='records'`, raising `TypeError` (GH18372)
- Bug in `DateTimeIndex` and `date_range()` where mismatching tz-aware start and end timezones would not raise an err if `end.tzinfo` is None (GH18431)
- Bug in `Series.fillna()` which raised when passed a long integer on Python 2 (GH18159).
1.5.5.2 Indexing

- Bug in a boolean comparison of a `datetime.datetime` and a `datetime64[ns]` dtype Series (GH17965)
- Bug where a `MultiIndex` with more than a million records was not raising `AttributeError` when trying to access a missing attribute (GH18165)
- Bug in `IntervalIndex` constructor when a list of intervals is passed with non-default `closed` (GH18334)
- Bug in `Index.putmask` when an invalid mask passed (GH18368)
- Bug in masked assignment of a `timedelta64[ns]` dtype Series, incorrectly coerced to float (GH18493)

1.5.5.3 I/O

- Bug in class: `pandas.io.stata.StataReader` not converting date/time columns with display formatting addressed (GH17990). Previously columns with display formatting were normally left as ordinal numbers and not converted to datetime objects.
- Bug in `read_csv()` when reading a compressed UTF-16 encoded file (GH18071)
- Bug in `read_csv()` for handling null values in index columns when specifying `na_filter=False` (GH5239)
- Bug in `read_csv()` when reading numeric category fields with high cardinality (GH18186)
- Bug in `DataFrame.to_csv()` when the table had `MultiIndex` columns, and a list of strings was passed in for `header` (GH5539)
- Bug in parsing integer datetime-like columns with specified format in `read_sql` (GH17855).
- Bug in `DataFrame.to_msgpack()` when serializing data of the `numpy.bool_` datatype (GH18390)
- Bug in `read_json()` not decoding when reading line delimited JSON from S3 (GH17200)
- Bug in `pandas.io.json.json_normalize()` to avoid modification of `meta` (GH18610)
- Bug in `to_latex()` where repeated multi-index values were not printed even though a higher level index differed from the previous row (GH14484)
- Bug when reading NaN-only categorical columns in `HDFStore` (GH18413)
- Bug in `DataFrame.to_latex()` with longtable=True where a latex multicolumn always spanned over three columns (GH17959)

1.5.5.4 Plotting

- Bug in `DataFrame.plot()` and `Series.plot()` with `DatetimeIndex` where a figure generated by them is not pickleable in Python 3 (GH18439)

1.5.5.5 Groupby/Resample/Rolling

- Bug in `DataFrame.resample(...) .apply(...)` when there is a callable that returns different columns (GH15169)
- Bug in `DataFrame.resample(...) when there is a time change (DST) and resampling frequency is 12h or higher (GH15549)
- Bug in `pd.DataFrameGroupBy.count()` when counting over a datetimelike column (GH13393)
- Bug in `rolling.var` where calculation is inaccurate with a zero-valued array (GH18430)
1.5.5.6 Reshaping

- Error message in `pd.merge_asof()` for key datatype mismatch now includes datatype of left and right key (GH18068)
- Bug in `pd.concat` when empty and non-empty DataFrames or Series are concatenated (GH18178 GH18187)
- Bug in `DataFrame.filter(...)` when unicode is passed as a condition in Python 2 (GH13101)
- Bug when merging empty DataFrames when `np.seterr(divide='raise')` is set (GH17776)

1.5.5.7 Numeric

- Bug in `pd.Series.rolling.skew()` and `rolling.kurt()` with all equal values has floating issue (GH18044)

1.5.5.8 Categorical

- Bug in `DataFrame.astype()` where casting to 'category' on an empty `DataFrame` causes a segmentation fault (GH18004)
- Error messages in the testing module have been improved when items have different `CategoricalDtype` (GH18069)
- `CategoricalIndex` can now correctly take a `pd.api.types.CategoricalDtype` as its dtype (GH18116)
- Bug in `Categorical.unique()` returning read-only codes array when all categories were NaN (GH18051)
- Bug in `DataFrame.groupby(axis=1)` with a `CategoricalIndex` (GH18432)

1.5.5.9 String

- `Series.str.split()` will now propagate NaN values across all expanded columns instead of None (GH18450)

1.6 v0.21.0 (October 27, 2017)

This is a major release from 0.20.3 and includes a number of API changes, deprecations, new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- Integration with Apache Parquet, including a new top-level `read_parquet()` function and `DataFrame.to_parquet()` method, see here.
- New user-facing `pandas.api.types.CategoricalDtype` for specifying categoricals independent of the data, see here.
- The behavior of `sum` and `prod` on all-NaN Series/DataFrames is now consistent and no longer depends on whether `bottleneck` is installed, and `sum` and `prod` on empty Series now return NaN instead of 0, see here.
- Compatibility fixes for pypy, see here.
- Additions to the `drop`, `reindex` and `rename` API to make them more consistent, see here.
pandas: powerful Python data analysis toolkit, Release 0.23.2

- Addition of the new methods `DataFrame.infer_objects` (see here) and `GroupBy.pipe` (see here).
- Indexing with a list of labels, where one or more of the labels is missing, is deprecated and will raise a KeyError in a future version, see here.

Check the API Changes and deprecations before updating.

What’s new in v0.21.0

- **New features**
  - Integration with Apache Parquet file format
  - `infer_objects` type conversion
  - Improved warnings when attempting to create columns
  - `drop` now also accepts index/columns keywords
  - `rename`, `reindex` now also accept axis keyword
  - `CategoricalDtype` for specifying categoricals
  - `GroupBy` objects now have a `pipe` method
  - `Categorical.rename_categories` accepts a dict-like
  - **Other Enhancements**
- **Backwards incompatible API changes**
  - Dependencies have increased minimum versions
  - Sum/Prod of all-NaN or empty Series/DataFrames is now consistently NaN
  - Indexing with a list with missing labels is Deprecated
  - NA naming Changes
  - Iteration of Series/Index will now return Python scalars
  - Indexing with a Boolean Index
  - `PeriodIndex` resampling
  - Improved error handling during item assignment in `pd.eval`
  - Dtype Conversions
  - `MultiIndex` Constructor with a Single Level
  - UTC Localization with Series
  - Consistency of Range Functions
  - No Automatic Matplotlib Converters
  - **Other API Changes**
- **Deprecations**
  - `Series.select` and `DataFrame.select`
  - `Series.argmax` and `Series.argmin`
- **Removal of prior version deprecations/changes**
- **Performance Improvements**
1.6.1 New features

1.6.1.1 Integration with Apache Parquet file format

Integration with Apache Parquet, including a new top-level `read_parquet()` and `DataFrame.to_parquet()` method, see [here](GH15838, GH17438).

Apache Parquet provides a cross-language, binary file format for reading and writing data frames efficiently. Parquet is designed to faithfully serialize and de-serialize `DataFrame`s, supporting all of the pandas dtypes, including extension dtypes such as datetime with timezones.

This functionality depends on either the `pyarrow` or `fastparquet` library. For more details, see the [IO docs on Parquet](103).

1.6.1.2 `infer_objects` type conversion

The `DataFrame.infer_objects()` and `Series.infer_objects()` methods have been added to perform dtype inference on object columns, replacing some of the functionality of the deprecated `convert_objects` method. See the documentation [here](201) for more details. (GH11221)

This method only performs soft conversions on object columns, converting Python objects to native types, but not any coercive conversions. For example:

```python
In [1]: df = pd.DataFrame({'A': [1, 2, 3],
                       'B': np.array([1, 2, 3], dtype='object'),
                       'C': ['1', '2', '3']})

In [2]: df.dtypes
Out[2]:
A    int64
B    object
C    object
```
Note that column 'C' was not converted - only scalar numeric types will be converted to a new type. Other types of conversion should be accomplished using the `to_numeric()` function (or `to_datetime()`, `to_timedelta()`).

```
In [4]: df = df.infer_objects()
In [5]: df['C'] = pd.to_numeric(df['C'], errors='coerce')
In [6]: df.dtypes
Out[6]:
    A  int64
    B  int64
    C  int64
dtype: object
```

1.6.1.3 Improved warnings when attempting to create columns

New users are often puzzled by the relationship between column operations and attribute access on `DataFrame` instances (GH7175). One specific instance of this confusion is attempting to create a new column by setting an attribute on the `DataFrame`:

```
In[1]: df = pd.DataFrame({'one': [1., 2., 3.]})
In[2]: df.two = [4, 5, 6]
```

This does not raise any obvious exceptions, but also does not create a new column:

```
In[3]: df
Out[3]:
    one
  0   1.0
  1   2.0
  2   3.0
```

Setting a list-like data structure into a new attribute now raises a `UserWarning` about the potential for unexpected behavior. See `Attribute Access`.

1.6.1.4 `drop` now also accepts index/columns keywords

The `drop()` method has gained `index/columns` keywords as an alternative to specifying the `axis`. This is similar to the behavior of `reindex` (GH12392).

For example:
In [7]: df = pd.DataFrame(np.arange(8).reshape(2,4),
    ...:                     columns=['A', 'B', 'C', 'D'])
    ...

In [8]: df
Out[8]:
   A  B  C  D
0  0  1  2  3
1  4  5  6  7

In [9]: df.drop(['B', 'C'], axis=1)
Out[9]:
   A  D
0  0  3
1  4  7

# the following is now equivalent
In [10]: df.drop(columns=['B', 'C'])
Out[10]:
   A  D
0  0  3
1  4  7

1.6.1.5 rename, reindex now also accept axis keyword

The DataFrame.rename() and DataFrame.reindex() methods have gained the axis keyword to specify the axis to target with the operation (GH12392).

Here's rename:

In [11]: df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})

In [12]: df.rename(str.lower, axis='columns')
Out[12]:
   a  b
0  1  4
1  2  5
2  3  6

In [13]: df.rename(id, axis='index')
   A  B
4458898752 1  4
4458898784 2  5
4458898816 3  6

And reindex:

In [14]: df.reindex(['A', 'B', 'C'], axis='columns')
Out[14]:
   A  B  C
0  1  4 NaN
1  2  5 NaN
2  3  6 NaN

(continues on next page)
In [15]: df.reindex([0, 1, 3], axis='index')

Out[15]:
A  B
0 1.0 4.0
1 2.0 5.0
3 NaN NaN

The “index, columns” style continues to work as before.

In [16]: df.rename(index=id, columns=str.lower)

Out[16]:
a  b
4458898752 1 4
4458898784 2 5
4458898816 3 6

In [17]: df.reindex(index=[0, 1, 3], columns=['A', 'B', 'C'])

Out[17]:
A  B  C
0 1.0 4.0 NaN
1 2.0 5.0 NaN
3 NaN NaN NaN

We highly encourage using named arguments to avoid confusion when using either style.

### 1.6.1.6 CategoricalDtype for specifying categoricals

`pandas.api.types.CategoricalDtype` has been added to the public API and expanded to include the categories and ordered attributes. A `CategoricalDtype` can be used to specify the set of categories and orderedness of an array, independent of the data. This can be useful for example, when converting string data to a `Categorical` (GH14711, GH15078, GH16015, GH17643):

In [18]: from pandas.api.types import CategoricalDtype
In [19]: s = pd.Series(['a', 'b', 'c', 'a']) # strings
In [20]: dtype = CategoricalDtype(categories=['a', 'b', 'c', 'd'], ordered=True)
In [21]: s.astype(dtype)

Out[21]:
0 a
1 b
2 c
3 a
dtype: category
Categories (4, object): [a < b < c < d]

One place that deserves special mention is in `read_csv()`. Previously, with `dtype={'col': 'category'}`, the returned values and categories would always be strings.

In [22]: data = 'A,B
   ...: a,1
   ...: b,2
   ...: c,3'
In [23]: pd.read_csv(StringIO(data), dtype={'B': 'category'}).B.cat.categories

Out[23]: Index(['1', '2', '3'], dtype='object')
Notice the “object” dtype.

With a `CategoricalDtype` of all numerics, datetimes, or timedeltas, we can automatically convert to the correct type

```python
In [24]: dtype = {'B': CategoricalDtype([1, 2, 3])}
In [25]: pd.read_csv(StringIO(data), dtype=dtype).B.cat.categories
Out[25]: Int64Index([1, 2, 3], dtype='int64')
```

The values have been correctly interpreted as integers.

The `.dtype` property of a `Categorical`, `CategoricalIndex`, or a `Series` with categorical type will now return an instance of `CategoricalDtype`. While the repr has changed, `str(CategoricalDtype())` is still the string 'category'. We’ll take this moment to remind users that the preferred way to detect categorical data is to use `pandas.api.types.is_categorical_dtype()`, and not `str(dtype) == 'category'`.

See the `CategoricalDtype docs` for more.

### 1.6.1.7 GroupBy objects now have a pipe method

GroupBy objects now have a `pipe` method, similar to the one on DataFrame and Series, that allow for functions that take a GroupBy to be composed in a clean, readable syntax. (GH17871)

For a concrete example on combining `.groupby` and `.pipe`, imagine having a DataFrame with columns for stores, products, revenue and sold quantity. We’d like to do a groupwise calculation of `prices` (i.e. revenue/quantity) per store and per product. We could do this in a multi-step operation, but expressing it in terms of piping can make the code more readable.

First we set the data:

```python
In [26]: import numpy as np
In [27]: n = 1000
In [28]: df = pd.DataFrame({'Store': np.random.choice(['Store_1', 'Store_2'], n),
                     'Product': np.random.choice(['Product_1', 'Product_2', 'Product_3'], n),
                     'Revenue': (np.random.random(n)*50+10).round(2),
                     'Quantity': np.random.randint(1, 10, size=n)})
In [29]: df.head(2)
```

```
Store  Product  Revenue  Quantity
0  Store_1  Product_3   54.28       3
1  Store_2  Product_2   30.91       1
```

Now, to find prices per store/product, we can simply do:

```python
In [30]: (df.groupby(['Store', 'Product'])
            .pipe(lambda grp: grp.Revenue.sum()/grp.Quantity.sum())
            .unstack().round(2))
```

```
Product    Product_1   Product_2   Product_3
Store
```

(continues on next page)
See the documentation for more.

### 1.6.1.8 Categorical.rename_categories accepts a dict-like

`rename_categories()` now accepts a dict-like argument for `new_categories`. The previous categories are looked up in the dictionary’s keys and replaced if found. The behavior of missing and extra keys is the same as in `DataFrame.rename()`.

```python
In [31]: c = pd.Categorical(['a', 'a', 'b'])

In [32]: c.rename_categories({'a': 'eh', 'b': 'bee'})
Out[32]:
[eh, eh, bee]
Categories (2, object): [eh, bee]
```

**Warning:** To assist with upgrading pandas, `rename_categories` treats `Series` as list-like. Typically, `Series` are considered to be dict-like (e.g. in `.rename`, `.map`). In a future version of pandas `rename_categories` will change to treat them as dict-like. Follow the warning message’s recommendations for writing future-proof code.

```python
In [33]: c.rename_categories(pd.Series([0, 1], index=['a', 'c']))
```

```
FutureWarning: Treating Series 'new_categories' as a list-like and using the values. In a future version, 'rename_categories' will treat Series like a dictionary.
For dict-like, use 'new_categories.to_dict()'  
For list-like, use 'new_categories.values'.
```

```
Out[33]:
[0, 0, 1]
Categories (2, int64): [0, 1]
```

### 1.6.1.9 Other Enhancements

**New functions or methods**

- `nearest()` is added to support nearest-neighbor upsampling (GH17496).
- `Index` has added support for a `to_frame` method (GH15230).

**New keywords**

- Added a `skipna` parameter to `infer_dtype()` to support type inference in the presence of missing values (GH17059).
- `Series.to_dict()` and `DataFrame.to_dict()` now support an `into` keyword which allows you to specify the `collections.Mapping` subclass that you would like returned. The default is `dict`, which is backwards compatible. (GH16122)
- `Series.set_axis()` and `DataFrame.set_axis()` now support the `inplace` parameter. (GH14636)
• Series.to_pickle() and DataFrame.to_pickle() have gained a protocol parameter (GH16252). By default, this parameter is set to HIGHEST_PROTOCOL.
• read_feather() has gained the nthreads parameter for multi-threaded operations (GH16359).
• DataFrame.clip() and Series.clip() have gained an inplace argument. (GH15388)
• crosstab() has gained a margins_name parameter to define the name of the row/column that will contain the totals when margins=True. (GH15972)
• read_json() now accepts a chunksize parameter that can be used when lines=True. If chunksize is passed, read_json now returns an iterator which reads in chunksize lines with each iteration. (GH17048)
• read_json() and to_json() now accept a compression argument which allows them to transparently handle compressed files. (GH17798)

Various enhancements

• Improved the import time of pandas by about 2.25x. (GH16764)
• Support for PEP 519 – Adding a file system path protocol on most readers (e.g. read_csv()) and writers (e.g. DataFrame.to_csv()) (GH13823).
• Added a __fspath__ method to pd.HDFStore, pd.ExcelFile, and pd.ExcelWriter to work properly with the file system path protocol (GH13823).
• The validate argument for merge() now checks whether a merge is one-to-one, one-to-many, many-to-one, or many-to-many. If a merge is found to not be an example of specified merge type, an exception of type MergeError will be raised. For more, see here (GH16270)
• Added support for PEP 518 (pyproject.toml) to the build system (GH16745)
• RangeIndex.append() now returns a RangeIndex object when possible (GH16212)
• Series.rename_axis() and DataFrame.rename_axis() with inplace=True now return None while renaming the axis inplace. (GH15704)
• api.types.infer_dtype() now infers decimals. (GH15690)
• DataFrame.select_dtypes() now accepts scalar values for include/exclude as well as list-like. (GH16855)
• date_range() now accepts ‘YS’ in addition to ‘AS’ as an alias for start of year. (GH9313)
• date_range() now accepts ‘Y’ in addition to ‘A’ as an alias for end of year. (GH9313)
• DataFrame.add_prefix() and DataFrame.add_suffix() now accept strings containing the ‘%’ character. (GH17151)
• Read/write methods that infer compression (read_csv(), read_table(), read_pickle(), and to_pickle()) can now infer from path-like objects, such as pathlib.Path. (GH17206)
• read_sas() now recognizes much more of the most frequently used date (datetime) formats in SAS7BDAT files. (GH15871)
• DataFrame.items() and Series.items() are now present in both Python 2 and 3 and is lazy in all cases. (GH13918, GH17213)
• pandas.io.formats.style.Styler.where() has been implemented as a convenience for pandas.io.formats.style.Styler.applymap(). (GH17474)
• MultiIndex.is_monotonic_decreasing() has been implemented. Previously returned False in all cases. (GH16554)
pandas: powerful Python data analysis toolkit, Release 0.23.2

- `read_excel()` raises `ImportError` with a better message if `xlrd` is not installed. (GH17613)
- `DataFrame.assign()` will preserve the original order of **kwargs for Python 3.6+ users instead of sorting the column names. (GH14207)
- `Series.reindex(),DataFrame.reindex(),Index.get_indexer()` now support list-like argument for tolerance. (GH17367)

1.6.2 Backwards incompatible API changes

1.6.2.1 Dependencies have increased minimum versions

We have updated our minimum supported versions of dependencies (GH15206, GH15543, GH15214). If installed, we now require:

<table>
<thead>
<tr>
<th>Package</th>
<th>Minimum Version</th>
<th>Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numpy</td>
<td>1.9.0</td>
<td>X</td>
</tr>
<tr>
<td>Matplotlib</td>
<td>1.4.3</td>
<td></td>
</tr>
<tr>
<td>Scipy</td>
<td>0.14.0</td>
<td></td>
</tr>
<tr>
<td>Bottleneck</td>
<td>1.0.0</td>
<td></td>
</tr>
</tbody>
</table>

Additionally, support has been dropped for Python 3.4 (GH15251).

1.6.2.2 Sum/Prod of all-NaN or empty Series/DataFrames is now consistently NaN

**Note:** The changes described here have been partially reverted. See the v0.22.0 Whatsnew for more.

The behavior of `sum` and `prod` on all-NaN Series/DataFrames no longer depends on whether `bottleneck` is installed, and return value of `sum` and `prod` on an empty Series has changed (GH9422, GH15507).

Calling `sum` or `prod` on an empty or all-NaN Series, or columns of a DataFrame, will result in NaN. See the docs.

```
In [33]: s = Series([np.nan])
```

Previously WITHOUT `bottleneck` installed:
```
In [2]: s.sum()
Out[2]: np.nan
```

Previously WITH `bottleneck`:
```
In [2]: s.sum()
Out[2]: 0.0
```

New Behavior, without regard to the bottleneck installation:
```
In [34]: s.sum()
Out[34]: 0.0
```

Note that this also changes the sum of an empty Series. Previously this always returned 0 regardless of a bottleneck installation:
but for consistency with the all-NaN case, this was changed to return NaN as well:

```
In [35]: pd.Series([]).sum()
Out[35]: 0.0
```

### 1.6.2.3 Indexing with a list with missing labels is Deprecated

Previously, selecting with a list of labels, where one or more labels were missing would always succeed, returning NaN for missing labels. This will now show a `FutureWarning`. In the future this will raise a `KeyError` (GH15747). This warning will trigger on a `DataFrame` or a `Series` for using `.loc[]` or `[[ ]]` when passing a list-of-labels with at least 1 missing label. See the deprecation docs.

```
In [36]: s = pd.Series([1, 2, 3])
In [37]: s
Out[37]:
0 1
1 2
2 3
dtype: int64
```

**Previous Behavior**

```
In [4]: s.loc[[1, 2, 3]]
Out[4]:
1 2.0
2 3.0
3 NaN
dtype: float64
```

**Current Behavior**

```
In [4]: s.loc[[1, 2, 3]]
```

Passing list-likes to `.loc` or `[]` with any missing label will raise `KeyError` in the future, you can use `.reindex()` as an alternative.

See the documentation here:
http://pandas.pydata.org/pandas-docs/stable/indexing.html#deprecate-loc-reindex-˓
listlike

```
Out[4]:
1 2.0
2 3.0
3 NaN
dtype: float64
```

The idiomatic way to achieve selecting potentially not-found elements is via `.reindex()`

```
In [38]: s.reindex([1, 2, 3])
Out[38]:
1 2.0
2 3.0
```

(continues on next page)
Selection with all keys found is unchanged.

```
In [39]: s.loc[[1, 2]]
Out[39]:
1  2
2  3
dtype: int64
```

### 1.6.2.4 NA naming Changes

In order to promote more consistency among the pandas API, we have added additional top-level functions `isna()` and `notna()` that are aliases for `isnull()` and `notnull()`. The naming scheme is now more consistent with methods like `.dropna()` and `.fillna()`. Furthermore in all cases where `.isnull()` and `.notnull()` methods are defined, these have additional methods named `.isna()` and `.notna()`, these are included for classes Categorical, Index, Series, and DataFrame. (GH15001).

The configuration option `pd.options.mode.use_inf_as_null` is deprecated, and `pd.options.mode.use_inf_as_na` is added as a replacement.

### 1.6.2.5 Iteration of Series/Index will now return Python scalars

Previously, when using certain iteration methods for a Series with dtype `int` or `float`, you would receive a numpy scalar, e.g. a `np.int64`, rather than a Python `int`. Issue (GH10904) corrected this for `Series.tolist()` and `list(Series)`. This change makes all iteration methods consistent, in particular, for `__iter__()` and `.map()`. Note that this only affects int/float dtypes. (GH13236, GH13258, GH14216).

```
In [40]: s = pd.Series([1, 2, 3])
In [41]: s
Out[41]:
0  1
1  2
2  3
dtype: int64

Previously:

```
In [2]: type(list(s)[0])
Out[2]: numpy.int64
```

New Behaviour:

```
In [42]: type(list(s)[0])
Out[42]: int
```

Furthermore this will now correctly box the results of iteration for `DataFrame.to_dict()` as well.

```
In [43]: d = {'a':[1], 'b':['b']}
In [44]: df = pd.DataFrame(d)
```
Previously:

```
In [8]: type(df.to_dict()['a'][0])
Out[8]: numpy.int64
```

New Behaviour:

```
In [45]: type(df.to_dict()['a'][0])
Out[45]: int
```

### 1.6.2.6 Indexing with a Boolean Index

Previously when passing a boolean Index to `.loc`, if the index of the Series/DataFrame had boolean labels, you would get a label based selection, potentially duplicating result labels, rather than a boolean indexing selection (where `True` selects elements), this was inconsistent how a boolean numpy array indexed. The new behavior is to act like a boolean numpy array indexer. (GH17738)

Previous Behavior:

```
In [46]: s = pd.Series([1, 2, 3], index=[False, True, False])
In [47]: s
Out[47]:
False 1
True 2
False 3
dtype: int64
In [59]: s.loc[pd.Index([True, False, True])]
Out[59]:
True 2
False 1
False 3
True 2
dtype: int64
```

Current Behavior

```
In [48]: s.loc[pd.Index([True, False, True])]
Out[48]:
False 1
False 3
dtype: int64
```

Furthermore, previously if you had an index that was non-numeric (e.g. strings), then a boolean Index would raise a `KeyError`. This will now be treated as a boolean indexer.

Previously Behavior:

```
In [49]: s = pd.Series([1,2,3], index=['a', 'b', 'c'])
In [50]: s
Out[50]:
a 1
b 2
c 3
dtype: int64
```
```python
s.loc[pd.Index([True, False, True])]
```

```
KeyError: "None of [Index([True, False, True], dtype='object')] are in the [index]"
```

Current Behavior

```python
s.loc[pd.Index([True, False, True])]
```

```
Out[51]:
a  1
c  3
dtype: int64
```

1.6.2.7 PeriodIndex resampling

In previous versions of pandas, resampling a Series/DataFrame indexed by a PeriodIndex returned a DatetimeIndex in some cases (GH12884). Resampling to a multiplied frequency now returns a PeriodIndex (GH15944). As a minor enhancement, resampling a PeriodIndex can now handle NaT values (GH13224)

Previous Behavior:

```python
pi = pd.period_range('2017-01', periods=12, freq='M')
s = pd.Series(np.arange(12), index=pi)
resampled = s.resample('2Q').mean()
resampled
```

```
2017-03-31  1.0
2017-09-30  5.5
2018-03-31 10.0
Freq: 2Q-DEC, dtype: float64
```

```python
resampled.index
```

```
DatetimeIndex(["2017-03-31", "2017-09-30", "2018-03-31"], dtype='datetime64[ns]', freq='2Q-DEC')
```

New Behavior:

```python
pi = pd.period_range('2017-01', periods=12, freq='M')
s = pd.Series(np.arange(12), index=pi)
resampled = s.resample('2Q').mean()
resampled
```

```
2017Q1  2.5
2017Q3  8.5
Freq: 2Q-DEC, dtype: float64
```

```python
resampled.index
```

```
PeriodIndex(['2017Q1', '2017Q3'], dtype='period[2Q-DEC]', freq='2Q-DEC')
```

Upsampling and calling .ohlc() previously returned a Series, basically identical to calling .asfreq(). OHLC upsampling now returns a DataFrame with columns open, high, low and close (GH13083). This is consistent with downsampling and DatetimeIndex behavior.
Previous Behavior:

```python
In [1]: pi = pd.PeriodIndex(start='2000-01-01', freq='D', periods=10)

In [2]: s = pd.Series(np.arange(10), index=pi)

In [3]: s.resample('H').ohlc()
Out[3]:
2000-01-01 00:00 0.0
...
2000-01-10 23:00 NaN
Freq: H, Length: 240, dtype: float64

In [4]: s.resample('M').ohlc()
Out[4]:
   open  high  low  close
2000-01  0 9 0 9
```

New Behavior:

```python
In [57]: pi = pd.PeriodIndex(start='2000-01-01', freq='D', periods=10)

In [58]: s = pd.Series(np.arange(10), index=pi)

In [59]: s.resample('H').ohlc()
Out[59]:
   open  high  low  close
2000-01-01 00:00 0.0 0.0 0.0 0.0
2000-01-01 01:00 NaN NaN NaN NaN
2000-01-01 02:00 NaN NaN NaN NaN
2000-01-01 03:00 NaN NaN NaN NaN
2000-01-01 04:00 NaN NaN NaN NaN
2000-01-01 05:00 NaN NaN NaN NaN
2000-01-01 06:00 NaN NaN NaN NaN
...
2000-01-10 17:00 NaN NaN NaN NaN
2000-01-10 18:00 NaN NaN NaN NaN
2000-01-10 19:00 NaN NaN NaN NaN
2000-01-10 20:00 NaN NaN NaN NaN
2000-01-10 21:00 NaN NaN NaN NaN
2000-01-10 22:00 NaN NaN NaN NaN
2000-01-10 23:00 NaN NaN NaN NaN
[240 rows x 4 columns]

In [60]: s.resample('M').ohlc()
```

1.6.2.8 Improved error handling during item assignment in `pd.eval`

`eval()` will now raise a `ValueError` when item assignment malfunctions, or inplace operations are specified, but there is no item assignment in the expression (GH16732)
Previously, if you attempted the following expression, you would get a not very helpful error message:

```
In [3]: pd.eval("a = 1 + 2", target=arr, inplace=True)
...: IndexError: only integers, slices (':'), ellipsis ('...'), numpy.newaxis ('None')
and integer or boolean arrays are valid indices
```

This is a very long way of saying numpy arrays don’t support string-item indexing. With this change, the error message is now this:

```
In [3]: pd.eval("a = 1 + 2", target=arr, inplace=True)
...: ValueError: Cannot assign expression output to target
```

It also used to be possible to evaluate expressions inplace, even if there was no item assignment:

```
In [4]: pd.eval("1 + 2", target=arr, inplace=True)
Out[4]: 3
```

However, this input does not make much sense because the output is not being assigned to the target. Now, a `ValueError` will be raised when such an input is passed in:

```
In [4]: pd.eval("1 + 2", target=arr, inplace=True)
...: ValueError: Cannot operate inplace if there is no assignment
```

### 1.6.2.9 Dtype Conversions

Previously assignments, `.where()` and `.fillna()` with a `bool` assignment, would coerce to same the type (e.g. `int` / `float`), or raise for datetimelikes. These will now preserve the bools with `object` dtypes. (GH16821).

```
In [62]: s = Series([1, 2, 3])
In [5]: s[1] = True
```

```
In [6]: s
Out[6]:
0   1
1   1
2   3
dtype: int64
```

New Behavior

```
In [63]: s[1] = True
In [64]: s
Out[64]:
0   1
1   True
2   3
dtype: object
```
Previously, as assignment to a datetimelike with a non-datetimelike would coerce the non-datetime-like item being assigned (GH14145).

```
In [65]: s = pd.Series([pd.Timestamp('2011-01-01'), pd.Timestamp('2012-01-01')])

In [1]: s[1] = 1

In [2]: s
Out[2]:
0  2011-01-01 00:00:00.000000000
1  1970-01-01 00:00:00.000000001
dtype: datetime64[ns]
```

These now coerce to object dtype.

```
In [66]: s[1] = 1

In [67]: s
Out[67]:
0  2011-01-01 00:00:00
1  1
dtype: object
```

- Inconsistent behavior in .where() with datetimelikes which would raise rather than coerce to object (GH16402)
- Bug in assignment against int64 data with np.ndarray with float64 dtype may keep int64 dtype (GH14001)

### 1.6.2.10 MultiIndex Constructor with a Single Level

The MultiIndex constructors no longer squeezes a MultiIndex with all length-one levels down to a regular Index. This affects all the MultiIndex constructors. (GH17178)

Previous behavior:

```
In [2]: pd.MultiIndex.from_tuples([('a',), ('b',)])
Out[2]: Index(['a', 'b'], dtype='object')
```

Length 1 levels are no longer special-cased. They behave exactly as if you had length 2+ levels, so a MultiIndex is always returned from all of the MultiIndex constructors:

```
In [68]: pd.MultiIndex.from_tuples([('a',), ('b',)])
Out[68]: MultiIndex(levels=['a', 'b'],
labels=[[0, 1]])
```

### 1.6.2.11 UTC Localization with Series

Previously, `to_datetime()` did not localize datetime Series data when utc=True was passed. Now, `to_datetime()` will correctly localize Series with a datetime64[ns, UTC] dtype to be consistent with how list-like and Index data are handled. (GH6415).

Previous Behavior

```
1.6. v0.21.0 (October 27, 2017) 71
```
In [69]: s = Series(["20130101 00:00:00"] * 3)

In [12]: pd.to_datetime(s, utc=True)
Out[12]:
0  2013-01-01
1  2013-01-01
2  2013-01-01
dtype: datetime64[ns]

New Behavior

In [70]: pd.to_datetime(s, utc=True)
Out[70]:
0  2013-01-01 00:00:00+00:00
1  2013-01-01 00:00:00+00:00
2  2013-01-01 00:00:00+00:00
dtype: datetime64[ns, UTC]

Additionally, DataFrames with datetime columns that were parsed by `read_sql_table()` and `read_sql_query()` will also be localized to UTC only if the original SQL columns were timezone aware datetime columns.

1.6.2.12 Consistency of Range Functions

In previous versions, there were some inconsistencies between the various range functions: `date_range()`, `bdate_range()`, `period_range()`, `timedelta_range()`, and `interval_range()` (GH17471).

One of the inconsistent behaviors occurred when the `start`, `end` and `period` parameters were all specified, potentially leading to ambiguous ranges. When all three parameters were passed, `interval_range` ignored the `period` parameter, `period_range` ignored the `end` parameter, and the other range functions raised. To promote consistency among the range functions, and avoid potentially ambiguous ranges, `interval_range` and `period_range` will now raise when all three parameters are passed.

Previous Behavior:

In [2]: pd.interval_range(start=0, end=4, periods=6)
Out[2]:
IntervalIndex([(0, 1], (1, 2], (2, 3]],
closed='right',
dtype='interval[int64]')

In [3]: pd.period_range(start='2017Q1', end='2017Q4', periods=6, freq='Q')
Out[3]: PeriodIndex(['2017Q1', '2017Q2', '2017Q3', '2017Q4', '2018Q1', '2018Q2'],
dtype='period[Q-DEC]', freq='Q-DEC')

New Behavior:

In [2]: pd.interval_range(start=0, end=4, periods=6)
---------------------------------------------------------------------------
ValueError: Of the three parameters: start, end, and periods, exactly two must be
->specified

In [3]: pd.period_range(start='2017Q1', end='2017Q4', periods=6, freq='Q')
---------------------------------------------------------------------------
ValueError: Of the three parameters: start, end, and periods, exactly two must be
->specified
Additionally, the endpoint parameter \texttt{end} was not included in the intervals produced by \texttt{interval_range}. However, all other range functions include \texttt{end} in their output. To promote consistency among the range functions, \texttt{interval_range} will now include \texttt{end} as the right endpoint of the final interval, except if \texttt{freq} is specified in a way which skips \texttt{end}.

\textbf{Previous Behavior:}

\begin{verbatim}
In [4]: pd.interval_range(start=0, end=4)
Out[4]:
IntervalIndex([[(0, 1], (1, 2], (2, 3)]]
closed='right',
dtype='interval[int64]')
\end{verbatim}

\textbf{New Behavior:}

\begin{verbatim}
In [71]: pd.interval_range(start=0, end=4)
Out[71]:
IntervalIndex([[(0, 1], (1, 2], (2, 3], (3, 4)]]
closed='right',
dtype='interval[int64]')
\end{verbatim}

\subsection*{1.6.2.13 No Automatic Matplotlib Converters}

Pandas no longer registers our \texttt{date}, \texttt{time}, \texttt{datetime}, \texttt{datetime64}, and \texttt{Period} converters with matplotlib when pandas is imported. Matplotlib plot methods (\texttt{plt.plot}, \texttt{ax.plot}, . . . ), will not nicely format the x-axis for \texttt{DatetimeIndex} or \texttt{PeriodIndex} values. You must explicitly register these methods:

Pandas built-in Series.plot and DataFrame.plot will register these converters on first-use (GH17710).

\textbf{Note: } This change has been temporarily reverted in pandas 0.21.1, for more details see \texttt{here}.

\subsection*{1.6.2.14 Other API Changes}

- The Categorical constructor no longer accepts a scalar for the \texttt{categories} keyword. (GH16022)
- Accessing a non-existent attribute on a closed \texttt{HDFStore} will now raise an AttributeError rather than a ClosedFileError (GH16301)
- \texttt{read_csv()} now issues a UserWarning if the \texttt{names} parameter contains duplicates (GH17095)
- \texttt{read_csv()} now treats \texttt{'null'} and \texttt{'n/a'} strings as missing values by default (GH16471, GH16078)
- pandas.HDFStore's string representation is now faster and less detailed. For the previous behavior, use pandas.HDFStore.info(). (GH16503).
- Compression defaults in HDF stores now follow pytables standards. Default is no compression and if \texttt{complib} is missing and \texttt{complevel} > 0 zlib is used (GH15943)
- \texttt{Index.get_indexer_non_unique()} now returns a ndarray indexer rather than an Index; this is consistent with \texttt{Index.get_indexer()} (GH16819)
- Removed the \texttt{@slow} decorator from pandas.util.testing, which caused issues for some downstream packages’ test suites. Use \texttt{@pytest.mark.slow} instead, which achieves the same thing (GH16850)
- Moved definition of MergeError to the pandas.errors module.
• The signature of `Series.set_axis()` and `DataFrame.set_axis()` has been changed from `set_axis(axis, labels)` to `set_axis(labels, axis=0)`, for consistency with the rest of the API. The old signature is deprecated and will show a `FutureWarning` (GH14636).

• `Series.argmin()` and `Series.argmax()` will now raise a `TypeError` when used with object dtypes, instead of a `ValueError` (GH13595).

• `Period` is now immutable, and will now raise an `AttributeError` when a user tries to assign a new value to the ordinal or freq attributes (GH17116).

• `to_datetime()` when passed a tz-aware `origin=` kwarg will now raise a more informative `ValueError` rather than a `TypeError` (GH16842).

• `to_datetime()` now raises a `ValueError` when format includes `%W` or `%U` without also including day of the week and calendar year (GH16774).

• Renamed non-functional `index` to `index_col` in `read_stata()` to improve API consistency (GH16342).

• Bug in `DataFrame.drop()` caused boolean labels `False` and `True` to be treated as labels 0 and 1 respectively when dropping indices from a numeric index. This will now raise a `ValueError` (GH16877).

• Restricted `DateOffset` keyword arguments. Previously, `DateOffset` subclasses allowed arbitrary keyword arguments which could lead to unexpected behavior. Now, only valid arguments will be accepted. (GH17176).

### 1.6.3 Deprecations

• `DataFrame.from_csv()` and `Series.from_csv()` have been deprecated in favor of `read_csv()` (GH4191).

• `read_excel()` has deprecated `sheetname` in favor of `sheet_name` for consistency with `.to_excel()` (GH10559).

• `read_excel()` has deprecated `parse_cols` in favor of `usecols` for consistency with `read_csv()` (GH4988).

• `read_csv()` has deprecated the `tupleize_cols` argument. Column tuples will always be converted to a MultiIndex (GH17060).

• `DataFrame.to_csv()` has deprecated the `tupleize_cols` argument. Multi-index columns will be always written as rows in the CSV file (GH17060).

• The `convert` parameter has been deprecated in the `.take()` method, as it was not being respected (GH16948).

• `pd.options.html.border` has been deprecated in favor of `pd.options.display.html.border` (GH15793).

• `SeriesGroupBy.nth()` has deprecated `True` in favor of `'all'` for its `dropna` (GH11038).

• `DataFrame.as_blocks()` is deprecated, as this is exposing the internal implementation (GH17302).

• `pd.TimeGrouper` is deprecated in favor of `pandas.Grouper` (GH16747).

• `cdate_range` has been deprecated in favor of `bdate_range()`, which has gained `weekmask` and `holidays` parameters for building custom frequency date ranges. See the documentation for more details (GH17596).

• passing `categories` or `ordered` kwargs to `Series.astype()` is deprecated, in favor of passing a `CategoricalDtype` (GH17636).

• `.get_value` and `.set_value` on `Series`, `DataFrame`, `Panel`, `SparseSeries`, and `SparseDataFrame` are deprecated in favor of using `.iat[]` or `.at[]` accessors (GH15269).
• Passing a non-existent column in `.to_excel(..., columns=)` is deprecated and will raise a `KeyError` in the future (GH17295)

• `raise_on_error` parameter to `Series.where()`, `Series.mask()`, `DataFrame.where()`, `DataFrame.mask()` is deprecated, in favor of `errors=` (GH14968)

• Using `DataFrame.rename_axis()` and `Series.rename_axis()` to alter index or column `labels` is now deprecated in favor of using `.rename.rename_axis` may still be used to alter the name of the index or columns (GH17833).

• `reindex_axis()` has been deprecated in favor of `reindex()`. See here for more (GH17833).

1.6.3.1 Series.select and DataFrame.select

The `Series.select()` and `DataFrame.select()` methods are deprecated in favor of using `df.loc[labels.map(crit)]` (GH12401)

```python
In [72]: df = DataFrame({
'A': [1, 2, 3],
}, index=['foo', 'bar', 'baz'])

In [3]: df.select(lambda x: x in ['bar', 'baz'])
```

```
FutureWarning: select is deprecated and will be removed in a future release. You can use .loc[crit] as a replacement
```

```python
Out[3]:
   A
bar 2
baz 3
```

```python
In [73]: df.loc[df.index.map(lambda x: x in ['bar', 'baz'])]
```

```
Out[73]:
   A
bar 2
baz 3
```

1.6.3.2 Series.argmax and Series.argmin

The behavior of `Series.argmax()` and `Series.argmin()` have been deprecated in favor of `Series.idxmax()` and `Series.idxmin()`, respectively (GH16830).

For compatibility with NumPy arrays, `pd.Series` implements `argmax` and `argmin`. Since pandas 0.13.0, `argmax` has been an alias for `pandas.Series.idxmax()`, and `argmin` has been an alias for `pandas.Series.idxmin()`. They return the `label` of the maximum or minimum, rather than the `position`.

We’ve deprecated the current behavior of `Series.argmax` and `Series.argmin`. Using either of these will emit a `FutureWarning`. Use `Series.idxmax()` if you want the label of the maximum. Use `Series.values.argmax()` if you want the position of the maximum. Likewise for the minimum. In a future release `Series.argmax` and `Series.argmin` will return the position of the maximum or minimum.

1.6.4 Removal of prior version deprecations/changes

• `read_excel()` has dropped the `has_index_names` parameter (GH10967)

• The `pd.options.display.height` configuration has been dropped (GH3663)

• The `pd.options.display.line_width` configuration has been dropped (GH2881)

• The `pd.options.display.mpl_style` configuration has been dropped (GH12190)
• Index has dropped the `.sym_diff()` method in favor of `.symmetric_difference()` (GH12591)
• Categorical has dropped the `.order()` and `.sort()` methods in favor of `.sort_values()` (GH12882)
• `eval()` and `DataFrame.eval()` have changed the default of `inplace` from `None` to `False` (GH11149)
• The function `get_offset_name` has been dropped in favor of the `.freqstr` attribute for an offset (GH11834)
• pandas no longer tests for compatibility with hdf5-files created with pandas < 0.11 (GH17404).

1.6.5 Performance Improvements

• Improved performance of instantiating `SparseDataFrame` (GH16773)
• `Series.dt` no longer performs frequency inference, yielding a large speedup when accessing the attribute (GH17210)
• Improved performance of `set_categories()` by not materializing the values (GH17508)
• `Timestamp.microsecond` no longer re-computes on attribute access (GH17331)
• Improved performance of the `CategoricalIndex` for data that is already categorical dtype (GH17513)
• Improved performance of `RangeIndex.min()` and `RangeIndex.max()` by using `RangeIndex` properties to perform the computations (GH17607)

1.6.6 Documentation Changes

• Several `NaT` method docstrings (e.g. `NaT.ctime()`) were incorrect (GH17327)
• The documentation has had references to versions < v0.17 removed and cleaned up (GH17442, GH17442, GH17404 & GH17504)

1.6.7 Bug Fixes

1.6.7.1 Conversion

• Bug in assignment against datetime-like data with `int` may incorrectly convert to datetime-like (GH14145)
• Bug in assignment against `int64` data with `np.ndarray` with `float64` dtype may keep `int64` dtype (GH14001)
• Fixed the return type of `IntervalIndex.is_non_overlapping_monotonic` to be a Python `bool` for consistency with similar attributes/methods. Previously returned a numpy.bool_. (GH17237)
• Bug in `IntervalIndex.is_non_overlapping_monotonic` when intervals are closed on both sides and overlap at a point (GH16560)
• Bug in `Series.fillna()` returns frame when `inplace=True` and `value` is dict (GH16156)
• Bug in `Timestamp.weekday_name` returning a UTC-based weekday name when localized to a timezone (GH17354)
• Bug in `Timestamp.replace` when replacing `tzinfo` around DST changes (GH15683)
• Bug in `Timedelta` construction and arithmetic that would not propagate the `Overflow` exception (GH17367)
• Bug in `astype()` converting to object dtype when passed extension type classes (`DatetimeTZDtype`, `CategoricalDtype`) rather than instances. Now a `TypeError` is raised when a class is passed (GH17780).

• Bug in `to_numeric()` in which elements were not always being coerced to numeric when `errors='coerce'` (GH17007, GH17125)

• Bug in `DataFrame` and `Series` constructors where `range` objects are converted to `int32` dtype on Windows instead of `int64` (GH16804)

1.6.7.2 Indexing

• When called with a null slice (e.g. `df.iloc[:],`), the `.iloc` and `.loc` indexers return a shallow copy of the original object. Previously they returned the original object. (GH13873).

• When called on an unsorted `MultiIndex`, the `.loc` indexer now will raise `UnsortedIndexError` only if proper slicing is used on non-sorted levels (GH16734).

• Fixes regression in 0.20.3 when indexing with a string on a `TimedeltaIndex` (GH16896).

• Fixed `TimedeltaIndex.get_loc()` handling of `np.timedelta64` inputs (GH16909).

• Fix `MultiIndex.sort_index()` ordering when `ascending` argument is a list, but not all levels are specified, or are in a different order (GH16934).

• Fixes bug where indexing with `np.inf` caused an `OverflowError` to be raised (GH16957)

• Bug in reindexing on an empty `CategoricalIndex` (GH16770)

• Fixes `DataFrame.loc` for setting with alignment and tz-aware `DatetimeIndex` (GH16889)

• Avoids `IndexError` when passing an `Index` or `Series` to `.iloc` with older `numpy` (GH17193)

• Allow unicode empty strings as placeholders in multilevel columns in Python 2 (GH17099)

• Bug in `.iloc` when used with inplace addition or assignment and an int indexer on a `MultiIndex` causing the wrong indexes to be read from and written to (GH17148)

• Bug in `.isin()` in which checking membership in empty `Series` objects raised an error (GH16991)

• Bug in `CategoricalIndex` reindexing in which specified indices containing duplicates were not being respected (GH17323)

• Bug in intersection of `RangeIndex` with negative step (GH17296)

• Bug in `IntervalIndex` where performing a scalar lookup fails for included right endpoints of non-overlapping monotonic decreasing indexes (GH16417, GH17271)

• Bug in `DataFrame.first_valid_index()` and `DataFrame.last_valid_index()` when no valid entry (GH17400)

• Bug in `Series.rename()` when called with a callable, incorrectly alters the name of the `Series`, rather than the name of the `Index`. (GH17407)

• Bug in `String.str_get()` raises `IndexError` instead of inserting NaNs when using a negative index. (GH17704)

1.6.7.3 I/O

• Bug in `read_hdf()` when reading a timezone aware index from fixed format HDFStore (GH17618)

• Bug in `read_csv()` in which columns were not being thoroughly de-duplicated (GH17060)

• Bug in `read_csv()` in which specified column names were not being thoroughly de-duplicated (GH17095)
• Bug in `read_csv()` in which non integer values for the header argument generated an unhelpful / unrelated error message (GH16338)

• Bug in `read_csv()` in which memory management issues in exception handling, under certain conditions, would cause the interpreter to segfault (GH14696, GH16798).

• Bug in `read_csv()` when called with `low_memory=False` in which a CSV with at least one column > 2GB in size would incorrectly raise a MemoryError (GH16798).

• Bug in `read_csv()` when called with a single-element list `header` would return a DataFrame of all NaN values (GH7757)

• Bug in `DataFrame.to_csv()` defaulting to ‘ascii’ encoding in Python 3, instead of ‘utf-8’ (GH17097)

• Bug in `read_stata()` where value labels could not be read when using an iterator (GH16923)

• Bug in `read_stata()` where the index was not set (GH16342)

• Bug in `read_html()` where import check fails when run in multiple threads (GH16928)

• Bug in `read_csv()` where automatic delimiter detection caused a TypeError to be thrown when a bad line was encountered rather than the correct error message (GH13374)

• Bug in `DataFrame.to_html()` with `notebook=True` where DataFrames with named indices or non-MultiIndex indices had undesired horizontal or vertical alignment for column or row labels, respectively (GH16792)

• Bug in `DataFrame.to_html()` in which there was no validation of the `justify` parameter (GH17527)

• Bug in `HDFStore.select()` when reading a contiguous mixed-data table featuring VLArray (GH17021)

• Bug in `to_json()` where several conditions (including objects with unprintable symbols, objects with deep recursion, overlong labels) caused segfaults instead of raising the appropriate exception (GH14256)

1.6.7.4 Plotting

• Bug in plotting methods using `secondary_y` and `fontsize` not setting secondary axis font size (GH12565)

• Bug when plotting `timedelta` and `datetime` dtypes on y-axis (GH16953)

• Line plots no longer assume monotonic x data when calculating xlims, they show the entire lines now even for unsorted x data. (GH11310, GH11471)

• With matplotlib 2.0.0 and above, calculation of x limits for line plots is left to matplotlib, so that its new default settings are applied. (GH15495)

• Bug in `Series.plot.bar` or `DataFrame.plot.bar` with `y` not respecting user-passed color (GH16822)

• Bug causing `plotting.parallel_coordinates` to reset the random seed when using random colors (GH17525)

1.6.7.5 Groupby/Resample/Rolling

• Bug in `DataFrame.resample(...).size()` where an empty `DataFrame` did not return a Series (GH14962)

• Bug in `infer_freq()` causing indices with 2-day gaps during the working week to be wrongly inferred as business daily (GH16624)

• Bug in `.rolling(...).quantile()` which incorrectly used different defaults than `Series.quantile()` and `DataFrame.quantile()` (GH9413, GH16211)
pandas: powerful Python data analysis toolkit, Release 0.23.2

- Bug in `groupby.transform()` that would coerce boolean dtypes back to float (GH16875)
- Bug in `Series.resample(...) .apply()` where an empty `Series` modified the source index and did not return the name of a `Series` (GH14313)
- Bug in `rolling(...).apply(...)` with a `DataFrame` with a `DatetimeIndex`, a window of a `timedelta`-convertible and `min_periods >= 1` (GH15305)
- Bug in `DataFrame.groupby` where index and column keys were not recognized correctly when the number of keys equaled the number of elements on the groupby axis (GH16859)
- Bug in `groupby.nunique()` with `TimeGrouper` which cannot handle `NaT` correctly (GH17575)
- Bug in `DataFrame.groupby` where a single level selection from a `MultiIndex` unexpectedly sorts (GH17537)
- Bug in `DataFrame.groupby` where spurious warning is raised when `Grouper` object is used to override ambiguous column name (GH17383)
- Bug in `TimeGrouper` differs when passes as a list and as a scalar (GH17530)

1.6.7.6 Sparse

- Bug in `SparseSeries` raises `AttributeError` when a dictionary is passed in as data (GH16905)
- Bug in `SparseDataFrame.fillna()` not filling all NaNs when frame was instantiated from SciPy sparse matrix (GH16112)
- Bug in `SparseSeries.unstack()` and `SparseDataFrame.stack()` (GH16614, GH15045)
- Bug in `make_sparse()` treating two numeric/boolean data, which have same bits, as same when array dtype is `object` (GH17574)
- `SparseArray.all()` and `SparseArray.any()` are now implemented to handle `SparseArray`, these were used but not implemented (GH17570)

1.6.7.7 Reshaping

- Joining/Merging with a non unique `PeriodIndex` raised a `TypeError` (GH16871)
- Bug in `crosstab()` where non-aligned series of integers were casted to float (GH17005)
- Bug in merging with categorical dtypes with datetimelikes incorrectly raised a `TypeError` (GH16900)
- Bug when using `isin()` on a large object series and large comparison array (GH16012)
- Fixes regression from 0.20, `Series.aggregate()` and `DataFrame.aggregate()` allow dictionaries as return values again (GH17013)
- Fixes dtype of result with integer dtype input, from `pivot_table()` when called with `margins=True` (GH17013)
- Bug in `crosstab()` where passing two `Series` with the same name raised a `KeyError` (GH13279)
- `Series.argmin()`, `Series.argmax()`, and their counterparts on `DataFrame` and groupby objects work correctly with floating point data that contains infinite values (GH13595).
- Bug in `unique()` where checking a tuple of strings raised a `TypeError` (GH13595)
- Bug in `concat()` where order of result index was unpredictable if it contained non-comparable elements (GH17344)
• Fixes regression when sorting by multiple columns on a `datetime64` dtype `Series` with NaT values (GH16836)
• Bug in `pivot_table()` where the result’s columns did not preserve the categorical dtype of columns when `dropna` was `False` (GH17842)
• Bug in `DataFrame.drop_duplicates` where dropping with non-unique column names raised a ValueError (GH17836)
• Bug in `unstack()` which, when called on a list of levels, would discard the `fillna` argument (GH13971)
• Bug in the alignment of `range` objects and other list-likes with `DataFrame` leading to operations being performed row-wise instead of column-wise (GH17901)

1.6.7.8 Numeric
• Bug in `.clip()` with `axis=1` and a list-like for `threshold` is passed; previously this raised `ValueError` (GH15390)
• `Series.clip()` and `DataFrame.clip()` now treat NA values for upper and lower arguments as `None` instead of raising `ValueError` (GH17276).

1.6.7.9 Categorical
• Bug in `Series.isin()` when called with a categorical (GH16639)
• Bug in the categorical constructor with empty values and categories causing the `.categories` to be an empty `Float64Index` rather than an empty `Index` with object dtype (GH17248)
• Bug in categorical operations with `Series.cat` not preserving the original Series’ name (GH17509)
• Bug in `DataFrame.merge()` failing for categorical columns with boolean/int data types (GH17187)
• Bug in constructing a `Categorical/CategoricalDtype` when the specified categories are of categorical type (GH17884).

1.6.7.10 PyPy
• Compatibility with PyPy in `read_csv()` with `usecols=[<unsorted ints>]` and `read_json()` (GH17351)
• Split tests into cases for CPython and PyPy where needed, which highlights the fragility of index matching with `float('nan')`, `np.nan` and `NAT` (GH17351)
• Fix `DataFrame.memory_usage()` to support PyPy. Objects on PyPy do not have a fixed size, so an approximation is used instead (GH17228)

1.6.7.11 Other
• Bug where some inplace operators were not being wrapped and produced a copy when invoked (GH12962)
• Bug in `eval()` where the `inplace` parameter was being incorrectly handled (GH16732)
1.7 v0.20.3 (July 7, 2017)

This is a minor bug-fix release in the 0.20.x series and includes some small regression fixes and bug fixes. We recommend that all users upgrade to this version.

What’s new in v0.20.3

- **Bug Fixes**
  - Conversion
  - Indexing
  - I/O
  - Plotting
  - Reshaping
  - Categorical

1.7.1 Bug Fixes

- Fixed a bug in failing to compute rolling computations of a column-MultiIndexed DataFrame (GH16789, GH16825)
- Fixed a pytest marker failing downstream packages’ tests suites (GH16680)

1.7.1.1 Conversion

- Bug in pickle compat prior to the v0.20.x series, when UTC is a timezone in a Series/DataFrame/Index (GH16608)
- Bug in Series construction when passing a Series with dtype='category' (GH16524).
- Bug in DataFrame.astype() when passing a Series as the dtype kwarg. (GH16717).

1.7.1.2 Indexing

- Bug in Float64Index causing an empty array instead of None to be returned from .get(np.nan) on a Series whose index did not contain any NaNs (GH8569)
- Bug in MultiIndex.isin causing an error when passing an empty iterable (GH16777)
- Fixed a bug in a slicing DataFrame/Series that have a TimedeltaIndex (GH16637)

1.7.1.3 I/O

- Bug in read_csv() in which files weren’t opened as binary files by the C engine on Windows, causing EOF characters mid-field, which would fail (GH16039, GH16559, GH16675)
- Bug in read_hdf() in which reading a Series saved to an HDF file in ‘fixed’ format fails when an explicit mode=’r’ argument is supplied (GH16583)
• Bug in DataFrame.to_latex() where bold_rows was wrongly specified to be True by default, whereas in reality row labels remained non-bold whatever parameter provided. (GH16707)
• Fixed an issue with DataFrame.style() where generated element ids were not unique (GH16780)
• Fixed loading a DataFrame with a PeriodIndex, from a format='fixed' HDFStore, in Python 3, that was written in Python 2 (GH16781)

1.7.1.4 Plotting
• Fixed regression that prevented RGB and RGBA tuples from being used as color arguments (GH16233)
• Fixed an issue with DataFrame.plot.scatter() that incorrectly raised a KeyError when categorical data is used for plotting (GH16199)

1.7.1.5 Reshaping
• PeriodIndex/TimedeltaIndex.join was missing the sort= kwarg (GH16541)
• Bug in joining on a MultiIndex with a category dtype for a level (GH16627).
• Bug in merge() when merging/joining with multiple categorical columns (GH16767)

1.7.1.6 Categorical
• Bug in DataFrame.sort_values not respecting the kind parameter with categorical data (GH16793)

1.8 v0.20.2 (June 4, 2017)
This is a minor bug-fix release in the 0.20.x series and includes some small regression fixes, bug fixes and performance improvements. We recommend that all users upgrade to this version.

What’s new in v0.20.2
• Enhancements
• Performance Improvements
• Bug Fixes
  – Conversion
  – Indexing
  – I/O
  – Plotting
  – Groupby/Resample.Rolling
  – Sparse
  – Reshaping
  – Numeric
  – Categorical
1.8.1 Enhancements

- Series provides a `to_latex` method (GH16180)
- A new groupby method `ngroup()`, parallel to the existing `cumcount()`, has been added to return the group order (GH11642); see here.

1.8.2 Performance Improvements

- Performance regression fix when indexing with a list-like (GH16285)
- Performance regression fix for MultiIndexes (GH16319, GH16346)
- Improved performance of `.clip()` with scalar arguments (GH15400)
- Improved performance of groupby with categorical groupers (GH16413)
- Improved performance of `MultiIndex.remove_unused_levels()` (GH16556)

1.8.3 Bug Fixes

- Silenced a warning on some Windows environments about “tput: terminal attributes: No such device or address” when detecting the terminal size. This fix only applies to python 3 (GH16496)
- Bug in using `pathlib.Path` or `py.path.local` objects with io functions (GH16291)
- Bug in `Index.symmetric_difference()` on two equal MultiIndex’s, results in a `TypeError` (GH13490)
- Bug in `DataFrame.update()` with `overwrite=False` and `NaN` values (GH15593)
- Passing an invalid engine to `read_csv()` now raises an informative `ValueError` rather than `UnboundLocalError`. (GH16511)
- Bug in `unique()` on an array of tuples (GH16519)
- Bug in `cut()` when labels are set, resulting in incorrect label ordering (GH16459)
- Fixed a compatibility issue with IPython 6.0’s tab completion showing deprecation warnings on Categoricals (GH16409)

1.8.3.1 Conversion

- Bug in `to_numeric()` in which empty data inputs were causing a segfault of the interpreter (GH16302)
- Silence numpy warnings when broadcasting `DataFrame` to `Series` with comparison ops (GH16378, GH16306)
1.8.3.2 Indexing

- Bug in `DataFrame.reset_index(level=)` with single level index (GH16263)
- Bug in partial string indexing with a monotonic, but not strictly-monotonic, index incorrectly reversing the slice bounds (GH16515)
- Bug in `MultiIndex.remove_unused_levels()` that would not return a `MultiIndex` equal to the original. (GH16556)

1.8.3.3 I/O

- Bug in `read_csv()` when `comment` is passed in a space delimited text file (GH16472)
- Bug in `read_csv()` not raising an exception with nonexistent columns in `usecols` when it had the correct length (GH14671)
- Bug that would force importing of the clipboard routines unnecessarily, potentially causing an import error on startup (GH16288)
- Bug that raised `IndexError` when HTML-rendering an empty `DataFrame` (GH15953)
- Bug in `read_csv()` in which tarfile object inputs were raising an error in Python 2.x for the C engine (GH16530)
- Bug where `DataFrame.to_html()` ignored the `index_names` parameter (GH16493)
- Bug where `pd.read_hdf()` returns numpy strings for index names (GH13492)
- Bug in `HDFStore.select_as_multiple()` where start/stop arguments were not respected (GH16209)

1.8.3.4 Plotting

- Bug in `DataFrame.plot` with a single column and a list-like color (GH3486)
- Bug in `plot` where `NaT` in `DatetimeIndex` results in `Timestamp.min` (GH12405)
- Bug in `DataFrame.boxplot` where `figsize` keyword was not respected for non-grouped boxplots (GH11959)

1.8.3.5 Groupby/Resample/Rolling

- Bug in creating a time-based rolling window on an empty `DataFrame` (GH15819)
- Bug in `rolling.cov()` with offset window (GH16058)
- Bug in `.resample()` and `.groupby()` when aggregating on integers (GH16361)

1.8.3.6 Sparse

- Bug in construction of `SparseDataFrame` from `scipy.sparse.dok_matrix` (GH16179)
1.8.3.7 Reshaping

• Bug in `DataFrame.stack` with unsorted levels in `MultiIndex` columns (GH16323)
• Bug in `pd.wide_to_long()` where no error was raised when `i` was not a unique identifier (GH16382)
• Bug in `Series.isin( )` with a list of tuples (GH16394)
• Bug in construction of a `DataFrame` with mixed dtypes including an all-NaT column. (GH16395)
• Bug in `DataFrame.agg()` and `Series.agg()` with aggregating on non-callable attributes (GH16405)

1.8.3.8 Numeric

• Bug in `.interpolate()`, where `limit_direction` was not respected when `limit=None` (default) was passed (GH16282)

1.8.3.9 Categorical

• Fixed comparison operations considering the order of the categories when both categoricals are unordered (GH16014)

1.8.3.10 Other

• Bug in `DataFrame.drop()` with an empty-list with non-unique indices (GH16270)

1.9 v0.20.1 (May 5, 2017)

This is a major release from 0.19.2 and includes a number of API changes, deprecations, new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

• New `.agg()` API for Series/DataFrame similar to the groupby-rolling-resample API’s, see here
• Integration with the feather-format, including a new top-level `pd.read_feather()` and `DataFrame.to_feather()` method, see here.
• The `.ix` indexer has been deprecated, see here
• `Panel` has been deprecated, see here
• Addition of an IntervalIndex and Interval scalar type, see here
• Improved user API when grouping by index levels in `.groupby()`, see here
• Improved support for `UInt64` dtypes, see here
• A new orient for JSON serialization, `orient='table'`, that uses the Table Schema spec and that gives the possibility for a more interactive repr in the Jupyter Notebook, see here
• Experimental support for exporting styled DataFrames (DataFrame.style) to Excel, see here
• Window binary corr/cov operations now return a MultiIndexed DataFrame rather than a Panel, as Panel is now deprecated, see here
• Support for S3 handling now uses s3fs, see here
Google BigQuery support now uses the pandas-gbq library, see here.

**Warning:** Pandas has changed the internal structure and layout of the codebase. This can affect imports that are not from the top-level pandas.* namespace, please see the changes here.

Check the API Changes and deprecations before updating.

**Note:** This is a combined release for 0.20.0 and and 0.20.1. Version 0.20.1 contains one additional change for backwards-compatibility with downstream projects using pandas’ utils routines. (GH16250)

**What’s new in v0.20.0**

- **New features**
  - `agg` API for DataFrame/Series
  - `dtype` keyword for data IO
  - `.to_datetime()` has gained an origin parameter
  - Groupby Enhancements
  - Better support for compressed URLs in `read_csv`
  - Pickle file I/O now supports compression
  - UInt64 Support Improved
  - GroupBy on Categoricals
  - Table Schema Output
  - SciPy sparse matrix from/to SparseDataFrame
  - Excel output for styled DataFrames
  - `IntvallIndex`
  - Other Enhancements

- **Backwards incompatible API changes**
  - Possible incompatibility for HDF5 formats created with pandas < 0.13.0
  - Map on Index types now return other Index types
  - Accessing datetime fields of Index now return Index
  - `pd.unique` will now be consistent with extension types
  - `S3 File Handling`
  - Partial String Indexing Changes
  - Concat of different float dtypes will not automatically upcast
  - Pandas Google BigQuery support has moved
  - Memory Usage for Index is more Accurate
  - `DataFrame.sort_index` changes
1.9.1 New features

1.9.1.1 agg API for DataFrame/Series

Series & DataFrame have been enhanced to support the aggregation API. This is a familiar API from groupby, window operations, and resampling. This allows aggregation operations in a concise way by using `agg()` and
transform(). The full documentation is here (GH1623).

Here is a sample

```python
In [1]: df = pd.DataFrame(np.random.randn(10, 3), columns=['A', 'B', 'C'],
    ...:                        index=pd.date_range('1/1/2000', periods=10))

In [2]: df.iloc[3:7] = np.nan

In [3]: df
Out[3]:
   A          B          C
2000-01-01  1.682600  0.413582  1.689516
2000-01-02 -2.099110 -1.180182  1.595661
2000-01-03 -0.419048  0.522165 -1.208946
2000-01-04    NaN        NaN        NaN
2000-01-05    NaN        NaN        NaN
2000-01-06    NaN        NaN        NaN
2000-01-07    NaN        NaN        NaN
2000-01-08  0.955435 -0.133009  2.011466
2000-01-09  0.578780  0.897126 -0.980013
2000-01-10 -0.045748  0.361601 -0.208039
```

One can operate using string function names, callables, lists, or dictionaries of these.

Using a single function is equivalent to .apply.

```python
In [4]: df.agg('sum')
Out[4]:
   A    0.652908
   B    0.881282
   C    2.899645
dtype: float64
```

Multiple aggregations with a list of functions.

```python
In [5]: df.agg(['sum', 'min'])
Out[5]:
    A          B          C
   sum  0.652908  0.881282  2.899645
   min -2.099110 -1.180182 -1.208946
```

Using a dict provides the ability to apply specific aggregations per column. You will get a matrix-like output of all of the aggregators. The output has one column per unique function. Those functions applied to a particular column will be NaN:

```python
In [6]: df.agg({'A' : ['sum', 'min'], 'B' : ['min', 'max']})
Out[6]:
   A          B
max    NaN  0.897126
min -2.099110 -1.180182
sum  0.652908    NaN
```

The API also supports a .transform() function for broadcasting results.

```python
In [7]: df.transform(['abs', lambda x: x - x.min()])
Out[7]:
```

(continues on next page)
When presented with mixed dtypes that cannot be aggregated, `.agg()` will only take the valid aggregations. This is similar to how `groupby` `.agg()` works. (GH15015)

```python
In [8]: df = pd.DataFrame({'A': [1, 2, 3],
                      'B': [1., 2., 3.],
                      'C': ['foo', 'bar', 'baz'],
                      'D': pd.date_range('20130101', periods=3)})

In [9]: df.dtypes
Out[9]:
A     int64
B     float64
C     object
D  datetime64[ns]
dtype: object

In [10]: df.agg(['min', 'sum'])
Out[10]:
  A   B     C     D
min 1  1.0   bar   2013-01-01
sum 6  6.0  foobar baz  NaT
```

### 1.9.1.2 `dtype` keyword for data IO

The `python` engine for `read_csv()`, as well as the `read_fwf()` function for parsing fixed-width text files and `read_excel()` for parsing Excel files, now accept the `dtype` keyword argument for specifying the types of specific columns (GH14295). See the `io docs` for more information.

```python
In [11]: data = "a b\n1 \n2\n3 4"

In [12]: pd.read_fwf(StringIO(data)).dtypes
Out[12]:
a    int64
b    int64
dtype: object

In [13]: pd.read_fwf(StringIO(data), dtype={'a':'float64', 'b':'object'}).dtypes
     a: float64
     b: object
dtype: object
```

1.9. v0.20.1 (May 5, 2017)
1.9.1.3 `.to_datetime()` has gained an origin parameter

to_datetime() has gained a new parameter, origin, to define a reference date from where to compute the resulting timestamps when parsing numerical values with a specific unit specified. (GH11276, GH11745)

For example, with 1960-01-01 as the starting date:

```
In [14]: pd.to_datetime([1, 2, 3], unit='D', origin=pd.Timestamp('1960-01-01'))
Out[14]: DatetimeIndex(['1960-01-02', '1960-01-03', '1960-01-04'], dtype='datetime64[ns]', freq=None)
```

The default is set at origin='unix', which defaults to 1970-01-01 00:00:00, which is commonly called 'unix epoch' or POSIX time. This was the previous default, so this is a backward compatible change.

```
In [15]: pd.to_datetime([1, 2, 3], unit='D')
Out[15]: DatetimeIndex(['1970-01-02', '1970-01-03', '1970-01-04'], dtype='datetime64[ns]', freq=None)
```

1.9.1.4 Groupby Enhancements

Strings passed to DataFrame.groupby() as the by parameter may now reference either column names or index level names. Previously, only column names could be referenced. This allows to easily group by a column and index level at the same time. (GH5677)

```
In [16]: arrays = [['bar', 'bar', 'baz', 'baz', 'foo', 'foo', 'qux', 'qux'],
                ['one', 'two', 'one', 'two', 'one', 'two', 'one', 'two']]
In [17]: index = pd.MultiIndex.from_arrays(arrays, names=['first', 'second'])
In [18]: df = pd.DataFrame({'A': [1, 1, 1, 1, 2, 2, 3, 3],
                    'B': np.arange(8)},
                    index=index)
In [19]: df
Out [19]:
    A  B
first second
   bar one  1  0
         two  1  1
   baz one  1  2
         two  1  3
   foo one  2  4
         two  2  5
   qux one  3  6
         two  3  7
In [20]: df.groupby(['second', 'A']).sum()
   →
    B
second A
   one  1  2
        2  4
        3  6
```

(continues on next page)
1.9.1.5 Better support for compressed URLs in read_csv

The compression code was refactored (GH12688). As a result, reading dataframes from URLs in read_csv() or read_table() now supports additional compression methods: xz, bz2, and zip (GH14570). Previously, only gzip compression was supported. By default, compression of URLs and paths are now inferred using their file extensions. Additionally, support for bz2 compression in the python 2 C-engine improved (GH14874).

```python
In [21]: url = 'https://github.com/{repo}/raw/{branch}/{path}'.format(
    repo = 'pandas-dev/pandas',
    branch = 'master',
    path = 'pandas/tests/io/parser/data/salaries.csv.bz2',
)

In [22]: df = pd.read_table(url, compression='infer')  # default, infer compression
In [23]: df = pd.read_table(url, compression='bz2')   # explicitly specify compression
In [24]: df.head(2)
Out[24]:
          S       X       E       M
0   13876  1.0000  1.0000  1.0000
1   11608  1.0000  3.0000  0.0000
```

1.9.1.6 Pickle file I/O now supports compression

read_pickle(), DataFrame.to_pickle() and Series.to_pickle() can now read from and write to compressed pickle files. Compression methods can be an explicit parameter or be inferred from the file extension. See the docs here.

```python
In [25]: df = pd.DataFrame({
    'A': np.random.randn(1000),
    'B': 'foo',
    'C': pd.date_range('20130101', periods=1000, freq='s')})

In [26]: df.to_pickle("data.pkl.compress", compression="gzip")
In [27]: rt = pd.read_pickle("data.pkl.compress", compression="gzip")
In [28]: rt.head()
Out[28]:
       A         B          C
0  1.578227  foo 2013-01-01 00:00:00
1 -0.230575  foo 2013-01-01 00:00:01
2  0.695530  foo 2013-01-01 00:00:02
3 -0.466001  foo 2013-01-01 00:00:03
4 -0.154972  foo 2013-01-01 00:00:04
```
The default is to infer the compression type from the extension (compression='infer'):

```python
In [29]: df.to_pickle("data.pkl.gz")

In [30]: rt = pd.read_pickle("data.pkl.gz")

In [31]: rt.head()
Out[31]:
   A       B       C
0  1.578227 foo 2013-01-01 00:00:00
1 -0.230575 foo 2013-01-01 00:00:01
2  0.695530 foo 2013-01-01 00:00:02
3 -0.466001 foo 2013-01-01 00:00:03
4 -0.154972 foo 2013-01-01 00:00:04

In [32]: df["A"].to_pickle("s1.pkl.bz2")

In [33]: rt = pd.read_pickle("s1.pkl.bz2")

In [34]: rt.head()
Out[34]:
   0   1.578227
   1  -0.230575
   2   0.695530
   3  -0.466001
   4  -0.154972

Name: A, dtype: float64
```

### 1.9.1.7 UInt64 Support Improved

Pandas has significantly improved support for operations involving unsigned, or purely non-negative, integers. Previously, handling these integers would result in improper rounding or data-type casting, leading to incorrect results. Notably, a new numerical index, `UInt64Index`, has been created (GH14937)

```python
In [35]: idx = pd.UInt64Index([1, 2, 3])

In [36]: df = pd.DataFrame({'A': ['a', 'b', 'c'], index=idx})

In [37]: df.index
Out[37]: UInt64Index([1, 2, 3], dtype='uint64')
```

- Bug in converting object elements of array-like objects to unsigned 64-bit integers (GH4471, GH14982)
- Bug in `Series.unique()` in which unsigned 64-bit integers were causing overflow (GH14721)
- Bug in `DataFrame` construction in which unsigned 64-bit integer elements were being converted to objects (GH14881)
- Bug in `pd.read_csv()` in which unsigned 64-bit integer elements were being improperly converted to the wrong data types (GH14983)
- Bug in `pd.unique()` in which unsigned 64-bit integers were causing overflow (GH14915)
- Bug in `pd.value_counts()` in which unsigned 64-bit integers were being erroneously truncated in the output (GH14934)
1.9.1.8 GroupBy on Categoricals

In previous versions, `.groupby(..., sort=False)` would fail with a `ValueError` when grouping on a categorical series with some categories not appearing in the data. (GH13179)

```python
In [38]: chromosomes = np.r_[np.arange(1, 23).astype(str), ['X', 'Y']]
In [39]: df = pd.DataFrame(
    ...:     {'A': np.random.randint(100),
    ...:      'B': np.random.randint(100),
    ...:      'C': np.random.randint(100),
    ...:      'chromosomes': pd.Categorical(np.random.choice(chromosomes, 100),
    ...:                                     categories=chromosomes,
    ...:                                     ordered=True))
In [40]: df
Out[40]:
   A  B  C  chromosomes
  0  80 36  94          12
  1  80 36  94           X
  2  80 36  94           19
  3  80 36  94           22
  4  80 36  94           17
  5  80 36  94            6
  6  80 36  94           13
...
93  80 36  94           21
94  80 36  94           20
95  80 36  94           11
96  80 36  94           16
97  80 36  94           21
98  80 36  94           18
99  80 36  94            8
[100 rows x 4 columns]
```

Previous Behavior:

```python
In [3]: df[df.chromosomes != '1'].groupby('chromosomes', sort=False).sum()
---------------------------------------------------------------------------
ValueError: items in new_categories are not the same as in old categories
```

New Behavior:

```python
In [41]: df[df.chromosomes != '1'].groupby('chromosomes', sort=False).sum()
Out[41]:
   A  B  C  chromosomes
  2 320 144  376
  3 400 180  470
  4 240 108  282
  5 240 108  282
  6 400 180  470
  7 400 180  470
  8 480 216  564
...
19 400 180  470
(continues on next page)
1.9.1.9 Table Schema Output

The new orient 'table' for `DataFrame.to_json()` will generate a Table Schema compatible string representation of the data.

```python
In [42]: df = pd.DataFrame(
       ...:     {'A': [1, 2, 3],
       ...:     'B': ['a', 'b', 'c'],
       ...:     'C': pd.date_range('2016-01-01', freq='d', periods=3),
       ...:     }, index=pd.Index(range(3), name='idx'))

In [43]: df
Out[43]:
       A  B             C
      idx
0   1   a 2016-01-01
1   2   b 2016-01-02
2   3   c 2016-01-03

In [44]: df.to_json(orient='table')

"schema": {
    "fields": [
        {
            "name": "idx",
            "type": "integer"
        },
        {
            "name": "A",
            "type": "integer"
        },
        {
            "name": "B",
            "type": "string"
        },
        {
            "name": "C",
            "type": "datetime"
        }
    ],
    "primaryKey": ["idx"],
    "pandas_version": "0.20.0",
    "data": [
        {
            "idx": 0,
            "A": 1,
            "B": "a",
            "C": "2016-01-01T00:00:00.000Z"
        },
        {
            "idx": 1,
            "A": 2,
            "B": "b",
            "C": "2016-01-02T00:00:00.000Z"
        },
        {
            "idx": 2,
            "A": 3,
            "B": "c",
            "C": "2016-01-03T00:00:00.000Z"
        }
    ]
)
```

See [IO: Table Schema for more information.](#)

Additionally, the repr for DataFrame and Series can now publish this JSON Table schema representation of the Series or DataFrame if you are using IPython (or another frontend like nteract using the Jupyter messaging protocol). This gives frontends like the Jupyter notebook and nteract more flexibility in how they display pandas objects, since they have more information about the data. You must enable this by setting the `display.html.table_schema` option to `True`.

1.9.1.10 SciPy sparse matrix from/to SparseDataFrame

Pandas now supports creating sparse dataframes directly from `scipy.sparse.spmatrix` instances. See the [documentation](#) for more information. (GH4343)

All sparse formats are supported, but matrices that are not in `COOrdinate` format will be converted, copying data as needed.
In [45]: from scipy.sparse import csr_matrix

In [46]: arr = np.random.random(size=(1000, 5))

In [47]: arr[arr < .9] = 0

In [48]: sp_arr = csr_matrix(arr)

In [49]: sp_arr

Out[49]:
<1000x5 sparse matrix of type '<class 'numpy.float64'>'
with 521 stored elements in Compressed Sparse Row format>

In [50]: sdf = pd.SparseDataFrame(sp_arr)

In [51]: sdf

Out[51]:

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>1</td>
<td>NaN</td>
<td>NaN</td>
<td>0.955103</td>
<td>NaN</td>
</tr>
<tr>
<td>2</td>
<td>NaN</td>
<td>NaN</td>
<td>0.900469</td>
<td>NaN</td>
</tr>
<tr>
<td>3</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>4</td>
<td>0.924771</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>5</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>6</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>993</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>994</td>
<td>NaN</td>
<td>NaN</td>
<td>0.972191</td>
<td>NaN</td>
</tr>
<tr>
<td>995</td>
<td>0.979898</td>
<td>0.97901</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>996</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>997</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>998</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>999</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
</tbody>
</table>

[1000 rows x 5 columns]

To convert a SparseDataFrame back to sparse SciPy matrix in COO format, you can use:

In [52]: sdf.to_coo()

Out[52]:
<1000x5 sparse matrix of type '<class 'numpy.float64'>'
with 521 stored elements in COOrdinate format>

1.9.1.11 Excel output for styled DataFrames

Experimental support has been added to export DataFrame.style formats to Excel using the openpyxl engine. (GH15530)

For example, after running the following, styled.xlsx renders as below:

In [53]: np.random.seed(24)

In [54]: df = pd.DataFrame({'A': np.linspace(1, 10, 10)})

In [55]: df = pd.concat([df, pd.DataFrame(np.random.RandomState(24).randn(10, 4),
....:                columns=list('BCDE'))],
(continues on next page)
In [56]: df.iloc[0, 2] = np.nan

In [57]: df

Out[57]:

     A    B       C      D       E
0  1.0  1.329212 NaN -0.316280 -0.990810
1  2.0 -1.070816 -1.438713  0.564417  0.295722
2  3.0 -1.626404  0.219565  0.678805  1.889273
3  4.0  0.961538  0.104011 -0.481165  0.850229
4  5.0  1.453425  1.057737  0.165562  0.515018
5  6.0 -1.336936  0.562861  1.392855 -0.063328
6  7.0  0.121668  1.207603 -0.002040  1.627796
7  8.0  0.354493  1.037528 -0.385684  0.519818
8  9.0  1.686583 -1.325963  1.428984 -2.089354
9 10.0 -0.129820  0.631523 -0.586538  0.290720

In [58]: styled = df.style.

In [59]: styled.to_excel('styled.xlsx', engine='openpyxl')

See the Style documentation for more detail.

1.9.1.12 IntervalIndex

pandas has gained an IntervalIndex with its own dtype, interval as well as the Interval scalar type. These allow first-class support for interval notation, specifically as a return type for the categories in cut() and qcut(). The IntervalIndex allows some unique indexing, see the docs. (GH7640, GH8625)
Warning: These indexing behaviors of the IntervalIndex are provisional and may change in a future version of pandas. Feedback on usage is welcome.

Previous behavior:

The returned categories were strings, representing Intervals

In [1]: c = pd.cut(range(4), bins=2)

In [2]: c
Out[2]:
[(-0.003, 1.5], (-0.003, 1.5], (1.5, 3], (1.5, 3]]
Categories (2, object): [(-0.003, 1.5] < (1.5, 3]]

In [3]: c.categories
Out[3]: Index(['(-0.003, 1.5]', '(1.5, 3]'], dtype='object')

New behavior:

In [60]: c = pd.cut(range(4), bins=2)

In [61]: c
Out[61]:
[(-0.003, 1.5], (-0.003, 1.5], (1.5, 3.0], (1.5, 3.0]]
Categories (2, interval[float64]): [(-0.003, 1.5] < (1.5, 3.0]]

In [62]: c.categories

IntervalIndex([(-0.003, 1.5], (1.5, 3.0]
   closed='right',
   dtype='interval[float64]')

Furthermore, this allows one to bin other data with these same bins, with NaN representing a missing value similar to other dtypes.

In [63]: pd.cut([0, 3, 1, 1], bins=c.categories)
Out[63]:
[(-0.003, 1.5], (1.5, 3.0], NaN, (-0.003, 1.5]]
Categories (2, interval[float64]): [(-0.003, 1.5] < (1.5, 3.0]]

An IntervalIndex can also be used in Series and DataFrame as the index.

In [64]: df = pd.DataFrame({'A': range(4),
....:            'B': pd.cut([0, 3, 1, 1], bins=c.categories)}
....: ).set_index('B')

In [65]: df
Out[65]:
   A
   B
(-0.003, 1.5]  0
(1.5, 3.0]  1
(-0.003, 1.5]  2
(-0.003, 1.5]  3
Selecting via a specific interval:

```
In [66]: df.loc[pd.Interval(1.5, 3.0)]
Out[66]:
   A
Name: (1.5, 3.0], dtype: int64
```

Selecting via a scalar value that is contained in the intervals.

```
In [67]: df.loc[0]
Out[67]:

   A
  B
(-0.003, 1.5]  0
(-0.003, 1.5]  2
(-0.003, 1.5]  3
```

### 1.9.1.13 Other Enhancements

- DataFrame.rolling() now accepts the parameter `closed='right'|'left'|'both'|'neither'` to choose the rolling window-endpoint closedness. See the documentation (GH13965).

- Integration with the feather-format, including a new top-level `pd.read_feather()` and `DataFrame.to_feather()` method, see here.

- Series.str.replace() now accepts a callable, as replacement, which is passed to `re.sub` (GH15055).

- Series.str.replace() now accepts a compiled regular expression as a pattern (GH15446).

- Series.sort_index accepts parameters `kind` and `na_position` (GH13589, GH14444).

- DataFrame and DataFrame.groupby() have gained a `nunique()` method to count the distinct values over an axis (GH14336, GH15197).

- DataFrame has gained a `melt()` method, equivalent to `pd.melt()`, for unpivoting from a wide to long format (GH12640).

- `pd.read_excel()` now preserves sheet order when using `sheetname=None` (GH9930).

- Multiple offset aliases with decimal points are now supported (e.g. 0.5min is parsed as 30s) (GH8419).

- `.isnull()` and `.notnull()` have been added to Index object to make them more consistent with the Series API (GH15300).

- New UnsortedIndexError (subclass of KeyError) raised when indexing/slicing into an unsorted MultiIndex (GH11897). This allows differentiation between errors due to lack of sorting or an incorrect key. See here.

- MultiIndex has gained a `.to_frame()` method to convert to a DataFrame (GH12397).

- `pd.cut` and `pd.qcut` now support `datetime64` and `timedelta64` dtypes (GH14714, GH14798).

- `pd.qcut` has gained the `duplicates='raise'|'drop'` option to control whether to raise on duplicated edges (GH7751).

- Series provides a `to_excel` method to output Excel files (GH8825).

- The `usecols` argument in `pd.read_csv()` now accepts a callable function as a value (GH14154).

- The `skiprows` argument in `pd.read_csv()` now accepts a callable function as a value (GH10882).

- The `nrows` and `chunksize` arguments in `pd.read_csv()` are supported if both are passed (GH6774, GH15755).
**pandas: powerful Python data analysis toolkit, Release 0.23.2**

- `DataFrame.plot` now prints a title above each subplot if `subplots=True` and `title` is a list of strings (GH14753)
- `DataFrame.plot` can pass the matplotlib 2.0 default color cycle as a single string as color parameter, see here. (GH15516)
- `Series.interpolate()` now supports timedelta as an index type with `method='time'` (GH6424)
- Addition of a level keyword to `DataFrame/Series.rename` to rename labels in the specified level of a MultiIndex (GH4160).
- `DataFrame.reset_index()` will now interpret a tuple `index.name` as a key spanning across levels of columns, if this is a MultiIndex (GH16164)
- `Timedelta.isoformat` method added for formatting Timedeltas as an ISO 8601 duration. See the `Timedelta docs` (GH15136)
- `.select_dtypes()` now allows the string `datetimetz` to generically select datetimes with tz (GH14910)
- The `.to_latex()` method will now accept `multicolumn` and `multirow` arguments to use the accompanying LaTeX enhancements
- `pd.merge_asof()` gained the option `direction='backward' | 'forward' | 'nearest'` (GH14887)
- `Series/DataFrame.asfreq()` have gained a `fill_value` parameter, to fill missing values (GH3715).
- `Series/DataFrame.resample.asfreq` have gained a `fill_value` parameter, to fill missing values during resampling (GH3715).
- `pandas.util.hash_pandas_object()` has gained the ability to hash a MultiIndex (GH15224)
- `Series/DataFrame.squeeze()` have gained the `axis` parameter. (GH15339)
- `DataFrame.to_excel()` has a new `freeze_panes` parameter to turn on Freeze Panes when exporting to Excel (GH15160)
- `pd.read_html()` will parse multiple header rows, creating a MutliIndex header. (GH13434).
- HTML table output skips `colspan` or `rowspan` attribute if equal to 1. (GH15403)
- `pandas.io.formats.style.Styler` template now has blocks for easier extension, see the example notebook (GH15649)
- `Styler.render()` now accepts `**kwargs` to allow user-defined variables in the template (GH15649)
- Compatibility with Jupyter notebook 5.0; MultiIndex column labels are left-aligned and MultiIndex row-labels are top-aligned (GH15379)
- `TimedeltaIndex` now has a custom date-tick formatter specifically designed for nanosecond level precision (GH8711)
- `pd.api.types.union_categoricals` gained the `ignore_ordered` argument to allow ignoring the ordered attribute of unioned categoricals (GH13410). See the `categorical union docs` for more information.
- `DataFrame.to_latex()` and `DataFrame.to_string()` now allow optional header aliases. (GH15536)
- Re-enable the `parse_dates` keyword of `pd.read_excel()` to parse string columns as dates (GH14326)
- Added `.empty` property to subclasses of Index. (GH15270)
- Enabled floor division for `Timedelta` and `TimedeltaIndex` (GH15828)
- `pandas.io.json.json_normalize()` gained the option `errors='ignore' | 'raise';` the default is `errors='raise'` which is backward compatible. (GH14583)
• pandas.io.json.json_normalize() with an empty list will return an empty DataFrame (GH15534)

• pandas.io.json.json_normalize() has gained a sep option that accepts str to separate joined fields; the default is ‘.’, which is backward compatible. (GH14883)

• MultiIndex.remove_unused_levels() has been added to facilitate removing unused levels. (GH15694)

• pd.read_csv() will now raise a ParserError error whenever any parsing error occurs (GH15913, GH15925)

• pd.read_csv() now supports the error_bad_lines and warn_bad_lines arguments for the Python parser (GH15925)

• The display.show_dimensions option can now also be used to specify whether the length of a Series should be shown in its repr (GH7117).

• parallel_coordinates() has gained a sort_labels keyword argument that sorts class labels and the colors assigned to them (GH15908)

• Options added to allow one to turn on/off using bottleneck and numexpr, see here (GH16157)

• DataFrame.style.bar() now accepts two more options to further customize the bar chart. Bar alignment is set with align='left'|'mid'|'zero', the default is “left”, which is backward compatible; You can now pass a list of color=[color_negative, color_positive]. (GH14757)

1.9.2 Backwards incompatible API changes

1.9.2.1 Possible incompatibility for HDF5 formats created with pandas < 0.13.0

pd.TimeSeries was deprecated officially in 0.17.0, though has already been an alias since 0.13.0. It has been dropped in favor of pd.Series. (GH15098).

This may cause HDF5 files that were created in prior versions to become unreadable if pd.TimeSeries was used. This is most likely to be for pandas < 0.13.0. If you find yourself in this situation. You can use a recent prior version of pandas to read in your HDF5 files, then write them out again after applying the procedure below.

```
In [2]: s = pd.TimeSeries([1,2,3], index=pd.date_range('20130101', periods=3))

In [3]: s
Out[3]:
2013-01-01  1
2013-01-02  2
2013-01-03  3
Freq: D, dtype: int64

In [4]: type(s)
Out[4]: pandas.core.series.TimeSeries

In [5]: s = pd.Series(s)

In [6]: s
Out[6]:
2013-01-01  1
2013-01-02  2
2013-01-03  3
Freq: D, dtype: int64
```

(continues on next page)
In [7]: type(s)
Out[7]: pandas.core.series.Series

1.9.2.2 Map on Index types now return other Index types

map on an Index now returns an Index, not a numpy array (GH12766)

In [68]: idx = Index([1, 2])
In [69]: idx
Out[69]: Int64Index([1, 2], dtype='int64')
In [70]: mi = MultiIndex.from_tuples([(1, 2), (2, 4)])
In [71]: mi
Out[71]: MultiIndex(levels=[[1, 2], [2, 4]], labels=[[0, 1], [0, 1]])

Previous Behavior:

In [5]: idx.map(lambda x: x * 2)
Out[5]: array([2, 4])
In [6]: idx.map(lambda x: (x, x * 2))
Out[6]: array([(1, 2), (2, 4)], dtype=object)
In [7]: mi.map(lambda x: x)
Out[7]: array([(1, 2), (2, 4)], dtype=object)
In [8]: mi.map(lambda x: x[0])
Out[8]: array([1, 2])

New Behavior:

In [72]: idx.map(lambda x: x * 2)
Out[72]: Int64Index([2, 4], dtype='int64')
In [73]: idx.map(lambda x: (x, x * 2))
MultiIndex(levels=[[1, 2], [2, 4]], labels=[[0, 1], [0, 1]])
In [74]: mi.map(lambda x: x)
MultiIndex(levels=[[1, 2], [2, 4]], labels=[[0, 1], [0, 1]])
In [75]: mi.map(lambda x: x[0])
Int64Index([1, 2], dtype='int64')

map on a Series with datetime64 values may return int64 dtypes rather than int32
In [76]: s = Series(date_range('2011-01-02T00:00', '2011-01-02T02:00', freq='H').tz_localize('Asia/Tokyo'))

In [77]: s
Out[77]:
0  2011-01-02 00:00:00+09:00
1  2011-01-02 01:00:00+09:00
2  2011-01-02 02:00:00+09:00

dtype: datetime64[ns, Asia/Tokyo]

Previous Behavior:

In [9]: s.map(lambda x: x.hour)
Out[9]:
0  0
1  1
2  2
dtype: int32

New Behavior:

In [78]: s.map(lambda x: x.hour)
Out[78]:
0  0
1  1
2  2
dtype: int64

1.9.2.3 Accessing datetime fields of Index now return Index

The datetime-related attributes (see here for an overview) of DatetimeIndex, PeriodIndex and TimedeltaIndex previously returned numpy arrays. They will now return a new Index object, except in the case of a boolean field, where the result will still be a boolean ndarray. (GH15022)

Previous behaviour:

In [1]: idx = pd.date_range("2015-01-01", periods=5, freq='10H')

In [2]: idx.hour
Out[2]: array([ 0, 10, 20, 6, 16], dtype=int32)

New Behavior:

In [79]: idx = pd.date_range("2015-01-01", periods=5, freq='10H')

In [80]: idx.hour
Out[80]: Int64Index([0, 10, 20, 6, 16], dtype='int64')

This has the advantage that specific Index methods are still available on the result. On the other hand, this might have backward incompatibilities: e.g. compared to numpy arrays, Index objects are not mutable. To get the original ndarray, you can always convert explicitly using np.asarray(idx.hour).

1.9.2.4 pd.unique will now be consistent with extension types

In prior versions, using Series.unique() and pandas.unique() on Categorical and tz-aware data-types would yield different return types. These are now made consistent. (GH15903)
Datetime tz-aware

Previous behaviour:

```
# Series
In [5]: pd.Series([pd.Timestamp('20160101', tz='US/Eastern'),
                   pd.Timestamp('20160101', tz='US/Eastern')]).unique()
Out[5]: array([Timestamp('2016-01-01 00:00:00-0500', tz='US/Eastern')],
               dtype=object)

In [6]: pd.unique(pd.Series([pd.Timestamp('20160101', tz='US/Eastern'),
                           pd.Timestamp('20160101', tz='US/Eastern')]))
Out[6]: array(['2016-01-01T05:00:00.000000000'], dtype='datetime64[ns]')

# Index
In [7]: pd.Index([pd.Timestamp('20160101', tz='US/Eastern'),
                pd.Timestamp('20160101', tz='US/Eastern')]).unique()
Out[7]: DatetimeIndex(['2016-01-01 00:00:00-05:00'],
                     dtype='datetime64[ns, US/Eastern]', freq=None)

In [8]: pd.unique(pd.Index([pd.Timestamp('20160101', tz='US/Eastern'),
                         pd.Timestamp('20160101', tz='US/Eastern')]))
Out[8]: DatetimeIndex(['2016-01-01 00:00:00-05:00'],
                     dtype='datetime64[ns, US/Eastern]', freq=None)
```

New Behavior:

```
# Series, returns an array of Timestamp tz-aware
In [81]: pd.Series([pd.Timestamp('20160101', tz='US/Eastern'),
                   ...:  pd.Timestamp('20160101', tz='US/Eastern')]).unique()
   ...:  Out[81]: array([Timestamp('2016-01-01 00:00:00-0500', tz='US/Eastern')],
                    dtype=object)

In [82]: pd.unique(pd.Series([pd.Timestamp('20160101', tz='US/Eastern'),
                         ...:  pd.Timestamp('20160101', tz='US/Eastern')]))
   ...:  Out[82]: array([Timestamp('2016-01-01 00:00:00-0500', tz='US/Eastern')],
                    dtype=object)

# Index, returns a DatetimeIndex
In [83]: pd.Index([pd.Timestamp('20160101', tz='US/Eastern'),
                ...:  pd.Timestamp('20160101', tz='US/Eastern')]).unique()
   ...:  Out[83]: DatetimeIndex(['2016-01-01 00:00:00-05:00'],
                           dtype='datetime64[ns, US/Eastern]',
                           freq=None)

In [84]: pd.unique(pd.Index([pd.Timestamp('20160101', tz='US/Eastern'),
                         ...:  pd.Timestamp('20160101', tz='US/Eastern')]))
   ...:  Out[84]: DatetimeIndex(['2016-01-01 00:00:00-05:00'],
                           dtype='datetime64[ns, US/Eastern]',
                           freq=None)
```

Categoricals

Previous behaviour:
### 1.9.2.5 S3 File Handling

pandas now uses `s3fs` for handling S3 connections. This shouldn’t break any code. However, since `s3fs` is not a required dependency, you will need to install it separately, like `boto` in prior versions of pandas. (GH11915).

### 1.9.2.6 Partial String Indexing Changes

`DatetimeIndex Partial String Indexing` now works as an exact match, provided that string resolution coincides with index resolution, including a case when both are seconds (GH14826). See `Slice vs. Exact Match` for details.
### 1.9.2.7 Concat of different float dtypes will not automatically upcast

Previously, `concat` of multiple objects with different `float` dtypes would automatically upcast results to a dtype of `float64`. Now the smallest acceptable dtype will be used (GH13247)

```python
In [88]: df1 = pd.DataFrame(np.array([1.0], dtype=np.float32, ndmin=2))
In [89]: df1.dtypes
Out[89]:
0  float32
   dtype: object
In [90]: df2 = pd.DataFrame(np.array([np.nan], dtype=np.float32, ndmin=2))
In [91]: df2.dtypes
Out[91]:
0  float32
   dtype: object

Previous Behavior:

```python
In [7]: pd.concat([df1, df2]).dtypes
Out[7]:
0  float64
   dtype: object
```

New Behavior:

```python
In [92]: pd.concat([df1, df2]).dtypes
Out[92]:
0  float32
   dtype: object
```

### 1.9.2.8 Pandas Google BigQuery support has moved

pandas has split off Google BigQuery support into a separate package `pandas-gbq`. You can `conda` install `pandas-gbq` -c conda-forge or `pip` install `pandas-gbq` to get it. The functionality of `read_gbq()` and `DataFrame.to_gbq()` remain the same with the currently released version of `pandas-gbq=0.1.4`. Documentation is now hosted here (GH15347)

### 1.9.2.9 Memory Usage for Index is more Accurate

In previous versions, showing `.memory_usage()` on a pandas structure that has an index, would only include actual index values and not include structures that facilitated fast indexing. This will generally be different for `Index` and `MultiIndex` and less-so for other index types. (GH15237)

Previous Behavior:

```python
In [8]: index = Index(['foo', 'bar', 'baz'])
In [9]: index.memory_usage(deep=True)
Out[9]: 180
In [10]: index.get_loc('foo')
Out[10]: 0
```

(continues on next page)
In [11]: index.memory_usage(deep=True)
Out[11]: 180

New Behavior:

In [8]: index = Index(['foo', 'bar', 'baz'])
In [9]: index.memory_usage(deep=True)
Out[9]: 180
In [10]: index.get_loc('foo')
Out[10]: 0
In [11]: index.memory_usage(deep=True)
Out[11]: 260

1.9.2.10 DataFrame.sort_index changes

In certain cases, calling .sort_index() on a MultiIndexed DataFrame would return the same DataFrame without seeming to sort. This would happen with a lexsorted, but non-monotonic levels. (GH15622, GH15687, GH14015, GH13431, GH15797)

This is unchanged from prior versions, but shown for illustration purposes:

In [93]: df = DataFrame(np.arange(6), columns=['value'], index=MultiIndex.from_product([list('BA'), range(3)])

In [94]: df
Out[94]:
   value
  B 0  0
   1  1
   2  2
  A 0  3
   1  4
   2  5

In [95]: df.index.is_lexsorted()
Out[95]: False
In [96]: df.index.is_monotonic
Out[96]: False

Sorting works as expected

In [97]: df.sort_index()
Out[97]:
   value
  A  0  3
   1  4
   2  5
  B  0  0
   1  1
   2  2
However, this example, which has a non-monotonic 2nd level, doesn’t behave as desired.

```
In [100]: df = pd.DataFrame(
       .....:    {'value': [1, 2, 3, 4]},
       .....:    index=pd.MultiIndex(levels=[['a', 'b'], ['bb', 'aa']],
       .....:                        labels=[[0, 0, 1, 1], [0, 1, 0, 1]]))

In [101]: df
Out[101]:
     value
  a  bb  1
  a  aa  2
  b  bb  3
  b  aa  4
```

Previous Behavior:

```
In [11]: df.sort_index()
Out[11]:
     value
  a  bb  1
  a  aa  2
  b  bb  3
  b  aa  4
In [14]: df.sort_index().index.is_lexsorted()
Out[14]: True
In [15]: df.sort_index().index.is_monotonic
Out[15]: False
```

New Behavior:

```
In [102]: df.sort_index()
Out[102]:
     value
  a  aa  2
  b  bb  1
  b  aa  4
  a  bb  3
In [103]: df.sort_index().index.is_lexsorted()
Out[103]: True
In [104]: df.sort_index().index.is_monotonic
Out[104]: True
```
1.9.2.11 Groupby Describe Formatting

The output formatting of `groupby.describe()` now labels the `describe()` metrics in the columns instead of the index. This format is consistent with `groupby.agg()` when applying multiple functions at once. (GH4792)

Previous Behavior:

```python
In [1]: df = pd.DataFrame({
    'A': [1, 1, 2, 2],
    'B': [1, 2, 3, 4]
})

In [2]: df.groupby('A').describe()
Out[2]:
         B
   A   count  mean   std  min  25%  50%  75%  max
1     2.0  1.50  0.71  1.0  1.25  1.5  1.75  2.0
2     2.0  3.50  0.71  3.0  3.25  3.5  3.75  4.0
```

New Behavior:

```python
In [105]: df = pd.DataFrame({
    'A': [1, 1, 2, 2],
    'B': [1, 2, 3, 4]
})

In [106]: df.groupby('A').describe()
Out[106]:
       B
   count  mean  std  min  25%  50%  75%  max
A  1  2.0  1.50  0.71  1.0  1.25  1.5  1.75  2.0
  2  2.0  3.50  0.71  3.0  3.25  3.5  3.75  4.0
```

1.9.2.12 Window Binary Corr/Cov operations return a MultiIndex DataFrame

A binary window operation, like `.corr()` or `.cov()`, when operating on a `.rolling()`, `.expanding()`, or `.ewm()` object, will now return a 2-level MultiIndexed DataFrame rather than a `Panel`, as `Panel` is now deprecated, see `here`. These are equivalent in function, but a MultiIndexed DataFrame enjoys more support in pandas. See the section on Windowed Binary Operations for more information. (GH15677)

```
In [108]: np.random.seed(1234)

In [109]: df = pd.DataFrame(np.random.rand(100, 2),
     ...:                  columns=pd.Index(['A', 'B'], name='bar'),
     ...:                  index=pd.date_range('20160101',
     ...:                  periods=100, freq='D', name='foo'))

In [110]: df.tail()
Out[110]:
bar   A    B
foo
2016-04-05  0.640880  0.126205
2016-04-06  0.171465  0.737086
2016-04-07  0.127029  0.369650
2016-04-08  0.604334  0.103104
2016-04-09  0.802374  0.945553
```

Previous Behavior:

```
In [2]: df.rolling(12).corr()
Out[2]:
<class 'pandas.core.panel.Panel'>
Dimensions: 100 (items) x 2 (major_axis) x 2 (minor_axis)
Items axis: 2016-01-01 00:00:00 to 2016-04-09 00:00:00
Major_axis axis: A to B
Minor_axis axis: A to B
```

New Behavior:

```
In [111]: res = df.rolling(12).corr()

In [112]: res.tail()
Out[112]:
bar   A    B
foo   bar
2016-04-07  B  -0.132090  1.000000
2016-04-08  A  1.000000  -0.145775
     B  -0.145775  1.000000
2016-04-09  A  1.000000   0.119645
     B   0.119645  1.000000
```

Retrieving a correlation matrix for a cross-section

```
In [113]: df.rolling(12).corr().loc['2016-04-07']
Out[113]:
bar   A    B
foo   bar
2016-04-07  A  1.000000  -0.13209
     B  -0.132090  1.000000
```
1.9.2.13 HDFStore where string comparison

In previous versions most types could be compared to string column in a HDFStore usually resulting in an invalid comparison, returning an empty result frame. These comparisons will now raise a TypeError (GH15492).

```python
In [114]: df = pd.DataFrame({
   ...:     'unparsed_date': ['2014-01-01', '2014-01-01']
   ...: })
In [115]: df.to_hdf('store.h5', 'key', format='table', data_columns=True)
In [116]: df.dtypes
Out[116]:
unparsed_date  object
dtype: object
```

Previous Behavior:
```
In [4]: pd.read_hdf('store.h5', 'key', where='unparsed_date > ts')
File "<string>", line 1
   (unparsed_date > 1970-01-01 00:00:00)
^ SyntaxError: invalid token
```

New Behavior:
```
In [18]: ts = pd.Timestamp('2014-01-01')
In [19]: pd.read_hdf('store.h5', 'key', where='unparsed_date > ts')
```

1.9.2.14 Index.intersection and inner join now preserve the order of the left Index

Index.intersection() now preserves the order of the calling Index (left) instead of the other Index (right) (GH15582). This affects inner joins, DataFrame.join() and merge(), and the .align method.

- Index.intersection

```python
In [117]: left = pd.Index([2, 1, 0])
In [118]: left
Out[118]: Int64Index([2, 1, 0], dtype='int64')
In [119]: right = pd.Index([1, 2, 3])
In [120]: right
Out[120]: Int64Index([1, 2, 3], dtype='int64')
```

Previous Behavior:
```
In [4]: left.intersection(right)
Out[4]: Int64Index([1, 2], dtype='int64')
```

New Behavior:
```
In [121]: left.intersection(right)
Out[121]: Int64Index([2, 1], dtype='int64')
```
• DataFrame.join and pd.merge

```
In [122]: left = pd.DataFrame({'a': [20, 10, 0]}, index=[2, 1, 0])
In [123]: left
Out[123]:
   a
2  20
1  10
0  0
```

```
In [124]: right = pd.DataFrame({'b': [100, 200, 300]}, index=[1, 2, 3])
In [125]: right
Out[125]:
   b
1  100
2  200
3  300
```

Previous Behavior:

```
In [4]: left.join(right, how='inner')
Out[4]:
   a  b
1  10 100
2  20 200
```

New Behavior:

```
In [126]: left.join(right, how='inner')
Out[126]:
   a  b
2  20 200
1  10 100
```

1.9.2.15 Pivot Table always returns a DataFrame

The documentation for `pivot_table()` states that a DataFrame is always returned. Here a bug is fixed that allowed this to return a Series under certain circumstance. (GH4386)

```
In [127]: df = DataFrame({'col1': [3, 4, 5],
.....:       'col2': ['C', 'D', 'E'],
.....:       'col3': [1, 3, 9]})
In [128]: df
Out[128]:
   col1 col2 col3
0    3    C   1
1    4    D   3
2    5    E   9
```

Previous Behavior:
In [2]: df.pivot_table('col1', index=['col3', 'col2'], aggfunc=np.sum)
Out[2]:
   col3  col2
1   C    3
3   D    4
9   E    5
Name: col1, dtype: int64

New Behavior:

In [129]: df.pivot_table('col1', index=['col3', 'col2'], aggfunc=np.sum)
Out[129]:
   col1
   col3  col2
1   C    3
3   D    4
9   E    5

1.9.2.16 Other API Changes

- numexpr version is now required to be >= 2.4.6 and it will not be used at all if this requisite is not fulfilled (GH15213).
- CParserError has been renamed to ParserError in pd.read_csv() and will be removed in the future (GH12665)
- SparseArray.cumsum() and SparseSeries.cumsum() will now always return SparseArray and SparseSeries respectively (GH12855)
- DataFrame.applymap() with an empty DataFrame will return a copy of the empty DataFrame instead of a Series (GH8222)
- Series.map() now respects default values of dictionary subclasses with a __missing__ method, such as collections.Counter (GH15999)
- .loc has compat with .ix for accepting iterators, and NamedTuples (GH15120)
- interpolate() and fillna() will raise a ValueError if the limit keyword argument is not greater than 0. (GH9217)
- pd.read_csv() will now issue a ParserWarning whenever there are conflicting values provided by the dialect parameter and the user (GH14898)
- pd.read_csv() will now raise a ValueError for the C engine if the quote character is larger than than one byte (GH15192)
- inplace arguments now require a boolean value, else a ValueError is thrown (GH14189)
- pandas.api.types.is_datetime64_ns_dtype will now report True on a tz-aware dtype, similar to pandas.api.types.is_datetime64_any_dtype
- DataFrame.asof() will return a null filled Series instead the scalar NaN if a match is not found (GH15118)
- Specific support for copy.copy() and copy.deepcopy() functions on NDFrame objects (GH15444)
- Series.sort_values() accepts a one element list of bool for consistency with the behavior of DataFrame.sort_values() (GH15604)
- .merge() and .join() on category dtype columns will now preserve the category dtype when possible (GH10409)
• SparseDataFrame.default_fill_value will be 0, previously was nan in the return from pd.get_dummies(..., sparse=True) (GH15594)

• The default behaviour of Series.str.match has changed from extracting groups to matching the pattern. The extracting behaviour was deprecated since pandas version 0.13.0 and can be done with the Series.str.extract method (GH5224). As a consequence, the as_indexer keyword is ignored (no longer needed to specify the new behaviour) and is deprecated.

• NaT will now correctly report False for datetimelike boolean operations such as is_month_start (GH15781)

• NaT will now correctly return np.nan for Timedelta and Period accessors such as days and quarter (GH15782)

• NaT will now returns NaT for tz_localize and tz_convert methods (GH15830)

• DataFrame and Panel constructors with invalid input will now raise ValueError rather than PandasError, if called with scalar inputs and not axes (GH15541)

• DataFrame and Panel constructors with invalid input will now raise ValueError rather than pandas.core.common.PandasError, if called with scalar inputs and not axes; The exception PandasError is removed as well. (GH15541)

• The exception pandas.core.common.AmbiguousIndexError is removed as it is not referenced (GH15541)

1.9.3 Reorganization of the library: Privacy Changes

1.9.3.1 Modules Privacy Has Changed

Some formerly public python/c/c++/cython extension modules have been moved and/or renamed. These are all removed from the public API. Furthermore, the pandas.core, pandas.compat, and pandas.util top-level modules are now considered to be PRIVATE. If indicated, a deprecation warning will be issued if you reference theses modules. (GH12588)
### New Location

<table>
<thead>
<tr>
<th>Previous Location</th>
<th>New Location</th>
<th>Deprecated</th>
</tr>
</thead>
<tbody>
<tr>
<td>pandas.lib</td>
<td>pandas._libs.lib</td>
<td>X</td>
</tr>
<tr>
<td>pandas.tslib</td>
<td>pandas._libs.tslib</td>
<td>X</td>
</tr>
<tr>
<td>pandas.computation</td>
<td>pandas.core.computation</td>
<td>X</td>
</tr>
<tr>
<td>pandas.msgpack</td>
<td>pandas.io.msgpack</td>
<td></td>
</tr>
<tr>
<td>pandas.index</td>
<td>pandas._libs.index</td>
<td></td>
</tr>
<tr>
<td>pandas.algos</td>
<td>pandas._libs.algos</td>
<td></td>
</tr>
<tr>
<td>pandas.hashtable</td>
<td>pandas._libs.hashtable</td>
<td></td>
</tr>
<tr>
<td>pandas.indexes</td>
<td>pandas.core.indexes</td>
<td></td>
</tr>
<tr>
<td>pandas.json</td>
<td>pandas._libs.json / pandas.io.json</td>
<td>X</td>
</tr>
<tr>
<td>pandas.parser</td>
<td>pandas._libs.parsers</td>
<td>X</td>
</tr>
<tr>
<td>pandas.formats</td>
<td>pandas.io.formats</td>
<td></td>
</tr>
<tr>
<td>pandas.sparse</td>
<td>pandas.core.sparse</td>
<td></td>
</tr>
<tr>
<td>pandas.tools</td>
<td>pandas.core.reshape</td>
<td>X</td>
</tr>
<tr>
<td>pandas.types</td>
<td>pandas.core.dtypes</td>
<td>X</td>
</tr>
<tr>
<td>pandas.io.sas.saslib</td>
<td>pandas.io.sas._sas</td>
<td></td>
</tr>
<tr>
<td>pandas._join</td>
<td>pandas._libs.join</td>
<td></td>
</tr>
<tr>
<td>pandas._hash</td>
<td>pandas._libs.hashing</td>
<td></td>
</tr>
<tr>
<td>pandas._period</td>
<td>pandas._libs.period</td>
<td></td>
</tr>
<tr>
<td>pandas._sparse</td>
<td>pandas._libs.sparse</td>
<td></td>
</tr>
<tr>
<td>pandas._testing</td>
<td>pandas._libs.testing</td>
<td></td>
</tr>
<tr>
<td>pandas._window</td>
<td>pandas._libs.window</td>
<td></td>
</tr>
</tbody>
</table>

Some new subpackages are created with public functionality that is not directly exposed in the top-level namespace: pandas.errors, pandas.plotting and pandas.testing (more details below). Together with pandas.api.types and certain functions in the pandas.io and pandas.tseries submodules, these are now the public subpackages.

Further changes:

- The function `union_categoricals()` is now importable from pandas.api.types, formerly from pandas.types.concat (GH15998)
- The type import pandas.tslib.NaTType is deprecated and can be replaced by using `type(pandas.NaT)` (GH16146)
- The public functions in pandas.tools.hashing deprecated from that locations, but are now importable from pandas.util (GH16223)
- The modules in pandas.util: decorators, print_versions, doctools, validators, depr_module are now private. Only the functions exposed in pandas.util itself are public (GH16223)

#### 1.9.3.2 pandas.errors

We are adding a standard public module for all pandas exceptions & warnings pandas.errors. (GH14800). Previously these exceptions & warnings could be imported from pandas.core.common or pandas.io.common. These exceptions and warnings will be removed from the *.common locations in a future release. (GH15541)

The following are now part of this API:

```python
['DtypeWarning',
'EmptyDataError',
'OutOfBoundsDatetime',
'ParserError',
'
(continues on next page)
```
1.9.3.3 pandas.testing

We are adding a standard module that exposes the public testing functions in pandas.testing (GH9895). Those functions can be used when writing tests for functionality using pandas objects.

The following testing functions are now part of this API:

- testing.assert_frame_equal()
- testing.assert_series_equal()
- testing.assert_index_equal()

1.9.3.4 pandas.plotting

A new public pandas.plotting module has been added that holds plotting functionality that was previously in either pandas.tools.plotting or in the top-level namespace. See the deprecations sections for more details.

1.9.3.5 Other Development Changes

- Building pandas for development now requires cython >= 0.23 (GH14831)
- Require at least 0.23 version of cython to avoid problems with character encodings (GH14699)
- Switched the test framework to use pytest (GH13097)
- Reorganization of tests directory layout (GH14854, GH15707).

1.9.4 Deprecations

1.9.4.1 Deprecate .ix

The .ix indexer is deprecated, in favor of the more strict .iloc and .loc indexers. .ix offers a lot of magic on the inference of what the user wants to do. To wit, .ix can decide to index positionally OR via labels, depending on the data type of the index. This has caused quite a bit of user confusion over the years. The full indexing documentation is here. (GH14218)

The recommended methods of indexing are:

- .loc if you want to label index
- .iloc if you want to positionally index.

Using .ix will now show a DeprecationWarning with a link to some examples of how to convert code here.

```python
In [130]: df = pd.DataFrame({'A': [1, 2, 3],
                   'B': [4, 5, 6]},
                   index=list('abc'))
```

(continues on next page)
Previous Behavior, where you wish to get the 0th and the 2nd elements from the index in the ‘A’ column.

In [3]: df.ix[[0, 2], 'A']
Out[3]:
a 1
Name: A, dtype: int64

Using .loc. Here we will select the appropriate indexes from the index, then use label indexing.

In [132]: df.loc[df.index[[0, 2]], 'A']
Out[132]:
a 1
Name: A, dtype: int64

Using .iloc. Here we will get the location of the ‘A’ column, then use positional indexing to select things.

In [133]: df.iloc[[0, 2], df.columns.get_loc('A')]
Out[133]:
a 1
Name: A, dtype: int64

1.9.4.2 Deprecate Panel

Panel is deprecated and will be removed in a future version. The recommended way to represent 3-D data are with a MultiIndex on a DataFrame via the to_frame() or with the xarray package. Pandas provides a to_xarray() method to automate this conversion. For more details see Deprecate Panel documentation. (GH13563).

In [134]: p = tm.makePanel()

In [135]: p
Out[135]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 3 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-05 00:00:00
Minor_axis axis: A to D

Convert to a MultiIndex DataFrame

In [136]: p.to_frame()
Out[136]:
                 ItemA  ItemB         ItemC
major minor
2000-01-03 A  0.628776 -1.409432  0.209395
Convert to an xarray DataArray

In [137]: p.to_xarray()
Out[137]:
xarray.DataArray (items: 3, major_axis: 3, minor_axis: 4)
array([[ 0.628776, 0.988138, -0.938153, -0.223019],
[ 0.186494, -0.072608, -1.239072, 2.123692],
[ 0.952478, -0.550603, 0.139683, 0.122273]],
[[ -1.409432, -1.347533, 1.272395, -0.591863],
[ 1.422986, 0.363565, -1.449567, -0.414505],
[ -2.147855, -0.014752, -1.195524, -1.425795]],
[[ 0.209395, -0.896581, -0.161137, -1.051539],
[-0.592886, 1.104352, 0.889157, -0.319561],
[-1.473116, -0.431550, 0.288377, -0.619993]]]
Coordinates:
* items (items) object 'ItemA' 'ItemB' 'ItemC'
* major_axis (major_axis) datetime64[ns] 2000-01-03 2000-01-04 2000-01-05
* minor_axis (minor_axis) object 'A' 'B' 'C' 'D'

1.9.4.3 Deprecate groupby.agg() with a dictionary when renaming

The .groupby(..).agg(..), .rolling(..).agg(..), and .resample(..).agg(..) syntax can accept a variable of inputs, including scalars, list, and a dict of column names to scalars or lists. This provides a useful syntax for constructing multiple (potentially different) aggregations.

However, .agg(..) can also accept a dict that allows `renaming` of the result columns. This is a complicated and confusing syntax, as well as not consistent between Series and DataFrame. We are deprecating this `renaming` functionality.

- We are deprecating passing a dict to a grouped/rolled/resampled Series. This allowed one to rename the resulting aggregation, but this had a completely different meaning than passing a dictionary to a grouped DataFrame, which accepts column-to-aggregations.
- We are deprecating passing a dict-of-dicts to a grouped/rolled/resampled DataFrame in a similar manner.

This is an illustrative example:

In [138]: df = pd.DataFrame({
'B': range(5),
'C': range(5)})
Here is a typical useful syntax for computing different aggregations for different columns. This is a natural, and useful syntax. We aggregate from the dict-to-list by taking the specified columns and applying the list of functions. This returns a `MultiIndex` for the columns (this is not deprecated).

```python
In [140]: df.groupby('A').agg({'B': 'sum', 'C': 'min'})
Out[140]:
            B  C
   A
1  3  0
2  7  3
```

Here’s an example of the first deprecation, passing a dict to a grouped `Series`. This is a combination aggregation & renaming:

```python
In [6]: df.groupby('A').B.agg({'foo': 'count'})
FutureWarning: using a dict on a Series for aggregation is deprecated and will be removed in a future version
Out[6]:
        foo
   A
1  3
2  2
```

You can accomplish the same operation, more idiomatically by:

```python
In [141]: df.groupby('A').B.agg({'count'}).rename(columns={'count': 'foo'})
Out[141]:
       foo
   A
1  3
2  2
```

Here’s an example of the second deprecation, passing a dict-of-dict to a grouped `DataFrame`:

```python
In [23]: (df.groupby('A')
   .agg({'B': {'foo': 'sum'}, 'C': {'bar': 'min'}})
FutureWarning: using a dict with renaming is deprecated and will be removed in a future version
Out[23]:
      B  C
   foo
   A
1  3  0
2  7  3
```
You can accomplish nearly the same by:

```python
In [142]: (df.groupby('A')
    ....:   .agg({'B': 'sum', 'C': 'min'})
    ....:   .rename(columns={'B': 'foo', 'C': 'bar'})
    ....:   )
Out[142]:
  foo  bar
  A
  1   3  0
  2   7  3
```

### 1.9.4.4 Deprecate `.plotting`

The `pandas.tools.plotting` module has been deprecated, in favor of the top level `pandas.plotting` module. All the public plotting functions are now available from `pandas.plotting` (GH12548).

Furthermore, the top-level `pandas.scatter_matrix` and `pandas.plot_params` are deprecated. Users can import these from `pandas.plotting` as well.

Previous script:

```python
pd.tools.plotting.scatter_matrix(df)
pd.scatter_matrix(df)
```

Should be changed to:

```python
pd.plotting.scatter_matrix(df)
```

### 1.9.4.5 Other Deprecations

- `SparseArray.to_dense()` has deprecated the `fill` parameter, as that parameter was not being respected (GH14647)
- `SparseSeries.to_dense()` has deprecated the `sparse_only` parameter (GH14647)
- `Series.repeat()` has deprecated the `reps` parameter in favor of `repeats` (GH12662)
- The `Series` constructor and `.astype` method have deprecated accepting timestamp dtypes without a frequency (e.g. `np.datetime64`) for the `dtype` parameter (GH15524)
- `Index.repeat()` and `MultiIndex.repeat()` have deprecated the `n` parameter in favor of `repeats` (GH12662)
- `Categorical.searchsorted()` and `Series.searchsorted()` have deprecated the `v` parameter in favor of `value` (GH12662)
- `TimedeltaIndex.searchsorted()`, `DatetimeIndex.searchsorted()`, and `PeriodIndex.searchsorted()` have deprecated the key parameter in favor of `value` (GH12662)
- `DataFrame.astype()` has deprecated the `raise_on_error` parameter in favor of `errors` (GH14878)
- `Series.sortlevel` and `DataFrame.sortlevel` have been deprecated in favor of `Series.sort_index` and `DataFrame.sort_index` (GH15099)
- importing `concat` from `pandas.tools.merge` has been deprecated in favor of imports from the `pandas` namespace. This should only affect explicit imports (GH15358)
• Series/DataFrame/Panel.consolidate() been deprecated as a public method. (GH15483)
• The as_indexer keyword of Series.str.match() has been deprecated (ignored keyword) (GH15257).
• The following top-level pandas functions have been deprecated and will be removed in a future version (GH13790, GH15940)
  - pd.pnow(), replaced by Period.now()
  - pd.Term, is removed, as it is not applicable to user code. Instead use in-line string expressions in the where clause when searching in HDFStore
  - pd.Expr, is removed, as it is not applicable to user code.
  - pd.match(), is removed.
  - pd.groupby(), replaced by using the .groupby() method directly on a Series/DataFrame
  - pd.get_store(), replaced by a direct call to pd.HDFStore(...)
• is_any_int_dtype, is_floating_dtype, and is_sequence are deprecated from pandas.api.types (GH16042)

1.9.5 Removal of prior version deprecations/changes

• The pandas.rpy module is removed. Similar functionality can be accessed through the rpy2 project. See the R interfacing docs for more details.
• The pandas.io.ga module with a google-analytics interface is removed (GH11308). Similar functionality can be found in the Google2Pandas package.
• pd.to_datetime and pd.to_timedelta have dropped the coerce parameter in favor of errors (GH13602)
• pandas.stats.fama_macbeth, pandas.stats.ols, pandas.stats.plm and pandas.stats.var, as well as the top-level pandas.fama_macbeth and pandas.ols routines are removed. Similar functionality can be found in the statsmodels package. (GH11898)
• The TimeSeries and SparseTimeSeries classes, aliases of Series and SparseSeries, are removed (GH10890, GH15098).
• Series.is_time_series is dropped in favor of Series.index.is_all_dates (GH15098)
• The deprecated irow, icol, iget and iget_value methods are removed in favor of iloc and iat as explained here (GH10711).
• The deprecated DataFrame.iterkv() has been removed in favor of DataFrame.iteritems() (GH10711)
• The Categorical constructor has dropped the name parameter (GH10632)
• Categorical has dropped support for NaN categories (GH10748)
• The take_last parameter has been dropped from duplicated(), drop_duplicates(), nlargest(), and nsmallest() methods (GH10236, GH10792, GH10920)
• Series, Index, and DataFrame have dropped the sort and order methods (GH10726)
• Where clauses in pytables are only accepted as strings and expressions types and not other data-types (GH12027)
• DataFrame has dropped the combineAdd and combineMult methods in favor of add and mul respectively (GH10735)
1.9.6 Performance Improvements

- Improved performance of `pd.wide_to_long()` (GH14779)
- Improved performance of `pd.factorize()` by releasing the GIL with object dtype when inferred as strings (GH14859, GH16057)
- Improved performance of timeseries plotting with an irregular DatetimeIndex (or with `compat_x=True`) (GH15073).
- Improved performance of `groupby().cummin()` and `groupby().cummax()` (GH15048, GH15109, GH15561, GH15635)
- Improved performance and reduced memory when indexing with a MultiIndex (GH15245)
- When reading buffer object in `read_sas()` method without specified format, filepath string is inferred rather than buffer object. (GH14947)
- Improved performance of `.rank()` for categorical data (GH15498)
- Improved performance when using `.unstack()` (GH15503)
- Improved performance of merge/join on category columns (GH10409)
- Improved performance of `drop_duplicates()` on bool columns (GH12963)
- Improve performance of `pd.core.groupby.GroupBy.apply` when the applied function used the `.name` attribute of the group DataFrame (GH15062).
- Improved performance of `iloc` indexing with a list or array (GH15504).
- Improved performance of `Series.sort_index()` with a monotonic index (GH15694)
- Improved performance in `pd.read_csv()` on some platforms with buffered reads (GH16039)

1.9.7 Bug Fixes

1.9.7.1 Conversion

- Bug in `Timestamp.replace` now raises `TypeError` when incorrect argument names are given; previously this raised `ValueError` (GH15240)
- Bug in `Timestamp.replace` with compat for passing long integers (GH15030)
- Bug in `Timestamp` returning UTC based time/date attributes when a timezone was provided (GH13303, GH15777)
- Bug in `Timestamp` incorrectly localizing timezones during construction (GH11481, GH15777)
- Bug in `TimedeltaIndex` addition where overflow was being allowed without error (GH14816)
- Bug in `TimedeltaIndex` raising a `ValueError` when boolean indexing with `loc` (GH14946)
- Bug in catching an overflow in `Timestamp + Timedelta/Offset` operations (GH15126)
- Bug in `DatetimeIndex.round()` and `Timestamp.round()` floating point accuracy when rounding by milliseconds or less (GH14440, GH15578)
- Bug in `astype()` where `inf` values were incorrectly converted to integers. Now raises error now with `astype()` for Series and DataFrames (GH14265)
- Bug in `DataFrame(..).apply(to_numeric)` when values are of type decimal.Decimal. (GH14827)
• Bug in `describe()` when passing a numpy array which does not contain the median to the `percentiles` keyword argument (GH14908)
• Cleaned up `PeriodIndex` constructor, including raising on floats more consistently (GH13277)
• Bug in using `__deepcopy__` on empty NDFrame objects (GH15370)
• Bug in `.replace()` may result in incorrect dtypes. (GH12747, GH15765)
• Bug in `Series.replace` and `DataFrame.replace` which failed on empty replacement dicts (GH15289)
• Bug in `Series.replace` which replaced a numeric by string (GH15743)
• Bug in `Index` construction with NaN elements and integer dtype specified (GH15187)
• Bug in `Series` construction with a datetimetz (GH14928)
• Bug in `Series.dt.round()` inconsistent behaviour on NaT's with different arguments (GH14940)
• Bug in `Series` constructor when both `copy=True` and `dtype` arguments are provided (GH15125)
• Incorrect dtyped `Series` was returned by comparison methods (e.g., `lt`, `gt`, ...) against a constant for an empty `DataFrame` (GH15077)
• Bug in `Series.ffill()` with mixed dtypes containing tz-aware datetimes. (GH14956)
• Bug in `DataFrame.fillna()` where the argument `downcast` was ignored when fillna value was of type dict (GH15277)
• Bug in `.asfreq()`, where frequency was not set for empty `Series` (GH14320)
• Bug in `DataFrame` construction with nulls and datetimes in a list-like (GH15869)
• Bug in `DataFrame.fillna()` with tz-aware datetimes (GH15855)
• Bug in `is_string_dtype`, `is_timedelta64_ns_dtype`, and `is_string_like_dtype` in which an error was raised when None was passed in (GH15941)
• Bug in the return type of `pd.unique` on a `Categorical`, which was returning an ndarray and not a `Categorical` (GH15903)
• Bug in `Index.to_series()` where the index was not copied (and so mutating later would change the original), (GH15949)
• Bug in indexing with partial string indexing with a len-1 `DataFrame` (GH16071)
• Bug in `Series` construction where passing invalid dtype didn’t raise an error. (GH15520)

1.9.7.2 Indexing

• Bug in `Index` power operations with reversed operands (GH14973)
• Bug in `DataFrame.sort_values()` when sorting by multiple columns where one column is of type int64 and contains NaT (GH14922)
• Bug in `DataFrame.reindex()` in which method was ignored when passing columns (GH14992)
• Bug in `DataFrame.loc` with indexing a MultiIndex with a Series indexer (GH14730, GH15424)
• Bug in `DataFrame.loc` with indexing a MultiIndex with a numpy array (GH15434)
• Bug in `Series.asof` which raised if the series contained all np.nan (GH15713)
• Bug in `.at` when selecting from a tz-aware column (GH15822)
• Bug in `Series.where()` and `DataFrame.where()` where array-like conditionals were being rejected (GH15414)
• Bug in `Series.where()` where TZ-aware data was converted to float representation (GH15701)
• Bug in `.loc` that would not return the correct dtype for scalar access for a DataFrame (GH11617)
• Bug in output formatting of a `MultiIndex` when names are integers (GH12223, GH15262)
• Bug in `Categorical.searchsorted()` where alphabetical instead of the provided categorical order was used (GH14522)
• Bug in `Series.iloc` where a `Categorical` object for list-like indexes input was returned, where a `Series` was expected. (GH14580)
• Bug in `DataFrame.isin` comparing datetimelike to empty frame (GH15473)
• Bug in `.reset_index()` when an all NaN level of a `MultiIndex` would fail (GH6322)
• Bug in `.reset_index()` when raising error for index name already present in `MultiIndex` columns (GH16120)
• Bug in creating a `MultiIndex` with tuples and not passing a list of names; this will now raise `ValueError` (GH15110)
• Bug in the HTML display with with a `MultiIndex` and truncation (GH14882)
• Bug in the display of `.info()` where a qualifier (+) would always be displayed with a `MultiIndex` that contains only non-strings (GH15245)
• Bug in `pd.concat()` where the names of `MultiIndex` of resulting `DataFrame` are not handled correctly when `None` is presented in the names of `MultiIndex` of input `DataFrame` (GH15787)
• Bug in `DataFrame.sort_index()` and `Series.sort_index()` where `na_position` doesn’t work with a `MultiIndex` (GH14784, GH16604)
• Bug in in `pd.concat()` when combining objects with a `CategoricalIndex` (GH16111)
• Bug in indexing with a scalar and a `CategoricalIndex` (GH16123)

1.9.7.3 I/O

• Bug in `pd.to_numeric()` in which float and unsigned integer elements were being improperly casted (GH14941, GH15005)
• Bug in `pd.read_fwf()` where the skiprows parameter was not being respected during column width inference (GH11256)
• Bug in `pd.read_csv()` in which the dialect parameter was not being verified before processing (GH14898)
• Bug in `pd.read_csv()` in which missing data was being improperly handled with usecols (GH6710)
• Bug in `pd.read_csv()` in which a file containing a row with many columns followed by rows with fewer columns would cause a crash (GH14125)
• Bug in `pd.read_csv()` for the C engine where usecols were being indexed incorrectly with parse_dates (GH14792)
• Bug in `pd.read_csv()` with parse_dates when multiline headers are specified (GH15376)
• Bug in `pd.read_csv()` with float_precision='round_trip' which caused a segfault when a text entry is parsed (GH15140)
• Bug in `pd.read_csv()` when an index was specified and no values were specified as null values (GH15835)
• Bug in `pd.read_csv()` in which certain invalid file objects caused the Python interpreter to crash (GH15337)
• Bug in `pd.read_csv()` in which invalid values for `nrows` and `chunksize` were allowed (GH15767)
• Bug in `pd.read_csv()` for the Python engine in which unhelpful error messages were being raised when parsing errors occurred (GH15910)
• Bug in `pd.read_csv()` in which the `skipfooter` parameter was not being properly validated (GH15925)
• Bug in `pd.to_csv()` in which there was numeric overflow when a timestamp index was being written (GH15982)
• Bug in `pd.util.hashing.hash_pandas_object()` in which hashing of categoricals depended on the ordering of categories, instead of just their values. (GH15143)
• Bug in `.to_json()` where `lines=True` and contents (keys or values) contain escaped characters (GH15096)
• Bug in `.to_json()` causing single byte ascii characters to be expanded to four byte unicode (GH15344)
• Bug in `.to_json()` for the C engine where rollover was not correctly handled for case where frac is odd and diff is exactly 0.5 (GH15716, GH15864)
• Bug in `pd.read_json()` for Python 2 where `lines=True` and contents contain non-ascii unicode characters (GH15132)
• Bug in `pd.read_msgpack()` in which `Series` categoricals were being improperly processed (GH14901)
• Bug in `pd.read_msgpack()` which did not allow loading of a dataframe with an index of type `CategoricalIndex` (GH15487)
• Bug in `pd.read_msgpack()` when deserializing a `CategoricalIndex` (GH15487)
• Bug in `DataFrame.to_records()` with converting a `DatetimeIndex` with a timezone (GH13937)
• Bug in `DataFrame.to_records()` which failed with unicode characters in column names (GH11879)
• Bug in `.to_sql()` when writing a `DataFrame` with numeric index names (GH15404).
• Bug in `DataFrame.to_html()` with `index=False` and `max_rows` raising in `IndexError` (GH14998)
• Bug in `pd.read_hdf()` passing a `Timestamp` to the `where` parameter with a non date column (GH15492)
• Bug in `DataFrame.to_stata()` and `StataWriter` which produces incorrectly formatted files to be produced for some locales (GH13856)
• Bug in `StataReader` and `StataWriter` which allows invalid encodings (GH15723)
• Bug in the `Series` `repr` not showing the length when the output was truncated (GH15962).

1.9.7.4 Plotting

• Bug in `DataFrame.hist` where `plt.tight_layout` caused an `AttributeError` (use `matplotlib >= 2.0.1`) (GH9351)
• Bug in `DataFrame.boxplot` where `fontsize` was not applied to the tick labels on both axes (GH15108)
• Bug in the date and time converters pandas registers with `matplotlib` not handling multiple dimensions (GH16026)
• Bug in `pd.scatter_matrix()` could accept either `color` or `c`, but not both (GH14855)
1.9.7.5 Groupby/Resample/Rolling

- Bug in `.groupby(..).resample()` when passed the on= kwarg. (GH15021)
- Properly set `__name__` and `__qualname__` for Groupby.* functions (GH14620)
- Bug in `GroupBy.get_group()` failing with a categorical grouper (GH15155)
- Bug in `.groupby(...).rolling(...)` when on is specified and using a `DatetimeIndex` (GH15130, GH13966)
- Bug in `Groupby` operations with `timedelta64` when passing numeric_only=False (GH5724)
- Bug in `groupby.apply()` coercing object dtypes to numeric types, when not all values were numeric (GH14423, GH15421, GH15670)
- Bug in `resample`, where a non-string `loffset` argument would not be applied when resampling a timeseries (GH13218)
- Bug in `DataFrame.groupby().describe()` when grouping on `Index` containing tuples (GH14848)
- Bug in `groupby()`.nunique() with a datetimelike-grouper where bins counts were incorrect (GH13453)
- Bug in `groupby.transform()` that would coerce the resultant dtypes back to the original (GH10972, GH11444)
- Bug in `groupby.agg()` incorrectly localizing timezone on `datetime` (GH15426, GH10668, GH13046)
- Bug in `.rolling/expanded()` functions where count() was not counting np.Inf, nor handling object dtypes (GH12541)
- Bug in `.rolling()` where `pd.Timedelta` or `datetime.timedelta` was not accepted as a window argument (GH15440)
- Bug in `Rolling.quantile` function that caused a segmentation fault when called with a quantile value outside of the range [0, 1] (GH15463)
- Bug in `DataFrame.resample().median()` if duplicate column names are present (GH14233)

1.9.7.6 Sparse

- Bug in `SparseSeries.reindex` on single level with list of length 1 (GH15447)
- Bug in repr-formatting a `SparseDataFrame` after a value was set on (a copy of) one of its series (GH15488)
- Bug in `SparseDataFrame` construction with lists not coercing to dtype (GH15682)
- Bug in sparse array indexing in which indices were not being validated (GH15863)

1.9.7.7 Reshaping

- Bug in `pd.merge_asof()` where left_index or right_index caused a failure when multiple by was specified (GH15676)
- Bug in `pd.merge_asof()` where left_index/right_index together caused a failure when tolerance was specified (GH15135)
- Bug in `DataFrame.pivot_table()` where dropna=True would not drop all-NaN columns when the columns was a category dtype (GH15193)
- Bug in `pd.melt()` where passing a tuple value for value_vars caused a TypeError (GH15348)
pandas: powerful Python data analysis toolkit, Release 0.23.2

- Bug in pd.pivot_table() where no error was raised when values argument was not in the columns (GH14938)
- Bug in pd.concat() in which concatenating with an empty dataframe with join='inner' was being improperly handled (GH15328)
- Bug with sort=True in DataFrame.join and pd.merge when joining on indexes (GH15582)
- Bug in DataFrame.nsmallest and DataFrame.nlargest where identical values resulted in duplicated rows (GH15297)
- Bug in pandas.pivot_table() incorrectly raising UnicodeError when passing unicode input for margins keyword (GH13292)

1.9.7.8 Numeric

- Bug in .rank() which incorrectly ranks ordered categories (GH15420)
- Bug in .corr() and .cov() where the column and index were the same object (GH14617)
- Bug in .mode() where mode was not returned if was only a single value (GH15714)
- Bug in pd.cut() with a single bin on an all 0s array (GH15428)
- Bug in pd.qcut() with a single quantile and an array with identical values (GH15431)
- Bug in pandas.tools.utils.cartesian_product() with large input can cause overflow on windows (GH15265)
- Bug in .eval() which caused multiline evals to fail with local variables not on the first line (GH15342)

1.9.7.9 Other

- Compat with SciPy 0.19.0 for testing on .interpolate() (GH15662)
- Compat for 32-bit platforms for .qcut/cut; bins will now be int64 dtype (GH14866)
- Bug in interactions with Qt when a QtApplication already exists (GH14372)
- Avoid use of np.finfo() during import pandas removed to mitigate deadlock on Python GIL misuse (GH14641)

1.10 v0.19.2 (December 24, 2016)

This is a minor bug-fix release in the 0.19.x series and includes some small regression fixes, bug fixes and performance improvements. We recommend that all users upgrade to this version.

Highlights include:

- Compatibility with Python 3.6
- Added a Pandas Cheat Sheet. (GH13202)

What’s new in v0.19.2

- Enhancements
- Performance Improvements
• **Bug Fixes**

### 1.10.1 Enhancements

The `pd.merge_asof()`, added in 0.19.0, gained some improvements:

- `pd.merge_asof()` gained `left_index/right_index` and `left_by/right_by` arguments (GH14253)
- `pd.merge_asof()` can take multiple columns in `by` parameter and has specialized dtypes for better performance (GH13936)

### 1.10.2 Performance Improvements

- Performance regression with `PeriodIndex` (GH14822)
- Performance regression in indexing with `getitem` (GH14930)
- Improved performance of `.replace()` (GH12745)
- Improved performance Series creation with a datetime index and dictionary data (GH14894)

### 1.10.3 Bug Fixes

- Compat with python 3.6 for pickling of some offsets (GH14685)
- Compat with python 3.6 for some indexing exception types (GH14684, GH14689)
- Compat with python 3.6 for deprecation warnings in the test suite (GH14681)
- Compat with python 3.6 for Timestamp pickles (GH14689)
- Compat with `dateutil==2.6.0`; segfault reported in the testing suite (GH14621)
- Allow `nanoseconds` in `Timestamp.replace` as a kwarg (GH14621)
- Bug in `pd.read_csv` in which aliasing was being done for `na_values` when passed in as a dictionary (GH14203)
- Bug in `pd.read_csv` in which column indices for a dict-like `na_values` were not being respected (GH14203)
- Bug in `pd.read_csv` where reading files fails, if the number of headers is equal to the number of lines in the file (GH14515)
- Bug in `pd.read_csv` for the Python engine in which an unhelpful error message was being raised when multi-char delimiters were not being respected with quotes (GH14582)
- Fix bugs (GH14734, GH13654) in `pd.read_sas` and `pandas.io.sas.SAS7BDATReader` that caused problems when reading a SAS file incrementally.
- Bug in `pd.read_csv` for the Python engine in which an unhelpful error message was being raised when `skipfooter` was not being respected by Python’s CSV library (GH13879)
- Bug in `.fillna()` in which timezone aware datetime64 values were incorrectly rounded (GH14872)
- Bug in `.groupby(..., sort=True)` of a non-lexsorted MultiIndex when grouping with multiple levels (GH14776)
- Bug in `pd.cut` with negative values and a single bin (GH14652)
• Bug in `pd.to_numeric` where a 0 was not unsigned on a `downcast='unsigned'` argument (GH14401)
• Bug in plotting regular and irregular timeseries using shared axes (sharex=True or ax.twinx()) (GH13341, GH14322).
• Bug in not propagating exceptions in parsing invalid datetimes, noted in python 3.6 (GH14561)
• Bug in resampling a `DateTimeIndex` in local TZ, covering a DST change, which would raise `AmbiguousTimeError` (GH14682)
• Bug in `hdfstore` when writing a `MultiIndex` when using `data_columns=True` (GH14435)
• Bug in `hdfstore.append()` when writing a series and passing a `min_itemsize` argument containing a value for the index (GH11412)
• Bug in writing to a `hdfstore` in table format with a `min_itemsize` value for the index and without asking to append (GH10381)
• Bug in `Series.groupby.nunique()` raising an `IndexError` for an empty `Series` (GH12553)
• Bug in `DataFrame.nlargest` and `DataFrame.nsmallest` when the index had duplicate values (GH13412)
• Bug in clipboard functions on linux with python2 with unicode and separators (GH13747)
• Bug in clipboard functions on Windows 10 and python 3 (GH14362, GH12807)
• Bug in `.to_clipboard()` and Excel compat (GH12529)
• Bug in `DataFrame.combine_first()` for integer columns (GH14687).
• Bug in `pd.read_csv()` in which the `dtype` parameter was not being respected for empty data (GH14712)
• Bug in `pd.read_csv()` in which the `nrows` parameter was not being respected for large input when using the C engine for parsing (GH7626)
• Bug in `pd.merge_asof()` could not handle timezone-aware `DateTimeIndex` when a tolerance was specified (GH14844)
• Explicit check in `to_stata` and `StataWriter` for out-of-range values when writing doubles (GH14618)
• Bug in `.plot(kind='kde')` which did not drop missing values to generate the KDE Plot, instead generating an empty plot. (GH14821)
• Bug in `unstack()` if called with a list of column(s) as an argument, regardless of the dtypes of all columns, they get coerced to object (GH11847)

11 1.11 v0.19.1 (November 3, 2016)

This is a minor bug-fix release from 0.19.0 and includes some small regression fixes, bug fixes and performance improvements. We recommend that all users upgrade to this version.

What’s new in v0.19.1

• *Performance Improvements*
• *Bug Fixes*
1.11.1 Performance Improvements

- Fixed performance regression in factorization of `Period` data (GH14338)
- Fixed performance regression in `Series.asof(wheret)` when `where` is a scalar (GH14461)
- Improved performance in `DataFrame.asof(where)` when `where` is a scalar (GH14461)
- Improved performance in `.to_json()` when `lines=True` (GH14408)
- Improved performance in certain types of `loc` indexing with a MultiIndex (GH14551).

1.11.2 Bug Fixes

- Source installs from PyPI will now again work without cython installed, as in previous versions (GH14204)
- Compat with Cython 0.25 for building (GH14496)
- Fixed regression where user-provided file handles were closed in `read_csv(c engine)` (GH14418).
- Fixed regression in `DataFrame.quantile` when missing values were present in some columns (GH14357).
- Fixed regression in `Index.difference` where the `freq` of a `DatetimeIndex` was incorrectly set (GH14323)
- Added back `pandas.core.common.array_equivalent` with a deprecation warning (GH14555).
- Bug in `pd.read_csv` for the C engine in which quotation marks were improperly parsed in skipped rows (GH14459)
- Bug in `pd.read_csv` for Python 2.x in which Unicode quote characters were no longer being respected (GH14477)
- Fixed regression in `Index.append` when categorical indices were appended (GH14545).
- Fixed regression in `pd.DataFrame` where constructor fails when given dict with None value (GH14381)
- Fixed regression in `DatetimeIndex._maybe_cast_slice_bound` when index is empty (GH14354).
- Bug in localizing an ambiguous timezone when a boolean is passed (GH14402)
- Bug in `TimedeltaIndex` addition with a Datetime-like object where addition overflow in the negative direction was not being caught (GH14068, GH14453)
- Bug in string indexing against data with object Index may raise `AttributeError` (GH14424)
- Correctly raise `ValueError` on empty input to `pd.eval()` and `df.query()` (GH13139)
- Bug in `RangeIndex.intersection` when result is a empty set (GH14364).
- Bug in groupby-transform broadcasting that could cause incorrect dtype coercion (GH14457)
- Bug in `Series.__getitem__` which allowed mutating read-only arrays (GH14359).
- Bug in `DataFrame.insert` where multiple calls with duplicate columns can fail (GH14291)
- `pd.merge()` will raise `ValueError` with non-boolean parameters in passed boolean type arguments (GH14434)
- Bug in `Timestamp` where dates very near the minimum (1677-09) could underflow on creation (GH14415)
- Bug in `pd.concat` where names of the keys were not propagated to the resulting MultiIndex (GH14252)
- Bug in `pd.concat` where axis cannot take string parameters 'rows' or 'columns' (GH14369)
• Bug in `pd.concat` with dataframes heterogeneous in length and tuple keys (GH14438)
• Bug in `MultiIndex.set_levels` where illegal level values were still set after raising an error (GH13754)
• Bug in `DataFrame.to_json` where `lines=True` and a value contained a `)` character (GH14391)
• Bug in `df.groupby` causing an `AttributeError` when grouping a single index frame by a column and the index level (GH14327)
• Bug in `df.groupby` where `TypeError` raised when `pd.Grouper(key=...)` is passed in a list (GH14334)
• Bug in `pd.pivot_table` may raise `TypeError` or `ValueError` when `index` or `columns` is not scalar and `values` is not specified (GH14380)

1.12 v0.19.0 (October 2, 2016)

This is a major release from 0.18.1 and includes number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:
• `merge_asof()` for asof-style time-series joining, see here
• `.rolling()` is now time-series aware, see here
• `read_csv()` now supports parsing `Categorical` data, see here
• A function `union_categorical()` has been added for combining categoricals, see here
• `PeriodIndex` now has its own `period` dtype, and changed to be more consistent with other `Index` classes. See here
• Sparse data structures gained enhanced support of `int` and `bool` dtypes, see here
• Comparison operations with `Series` no longer ignores the index, see here for an overview of the API changes.
• Introduction of a pandas development API for utility functions, see here.
• Deprecation of `Panel4D` and `PanelND`. We recommend to represent these types of n-dimensional data with the `xarray` package.
• Removal of the previously deprecated modules `pandas.io.data`, `pandas.io.wb`, `pandas.tools.rplot`.

Warning: pandas >= 0.19.0 will no longer silence numpy ufunc warnings upon import, see here.

What’s new in v0.19.0

• New features
  – `merge_asof` for asof-style time-series joining
  – `.rolling()` is now time-series aware
  – `read_csv` has improved support for duplicate column names
  – `read_csv` supports parsing `Categorical` directly
Categorical Concatenation

- Semi-Month Offsets
- New Index methods
- Google BigQuery Enhancements
- Fine-grained numpy errstate
- `get_dummies` now returns integer dtypes
- Downcast values to smallest possible dtype in `to_numeric`
- `pandas` development API
- Other enhancements

**API changes**

- `Series.tolist()` will now return Python types
- `Series` operators for different indexes
  * Arithmetic operators
  * Comparison operators
  * Logical operators
  * Flexible comparison methods
- `Series` type promotion on assignment
- `.to_datetime()` changes
- Merging changes
- `.describe()` changes
- `Period` changes
  * `PeriodIndex` now has period dtype
  * `Period('NaT')` now returns `pd.NaT`
  * `PeriodIndex.values` now returns array of `Period` object
- `Index` +/ - no longer used for set operations
- `Index.difference` and `.symmetric_difference` changes
- `Index.unique` consistently returns `Index`
- `MultiIndex` constructors, groupby and `set_index` preserve categorical dtypes
- `read_csv` will progressively enumerate chunks

**Sparse Changes**

- `int64` and `bool` support enhancements
- Operators now preserve dtypes
- Other sparse fixes
- `Indexer` dtype changes
- Other API Changes
1.12.1 New features

1.12.1.1 merge_asof for asof-style time-series joining

A long-time requested feature has been added through the `merge_asof()` function, to support asof style joining of time-series (GH1870, GH13695, GH13709, GH13902). Full documentation is here.

The `merge_asof()` performs an asof merge, which is similar to a left-join except that we match on nearest key rather than equal keys.

```python
In [1]: left = pd.DataFrame({'a': [1, 5, 10],
                     'left_val': ['a', 'b', 'c']})
In [2]: right = pd.DataFrame({'a': [1, 2, 3, 6, 7],
                       'right_val': [1, 2, 3, 6, 7]})
In [3]: left
Out[3]:
   a    left_val
0  1      a
1  5      b
2 10     c

In [4]: right
Out[4]:
   a    right_val
0  1       1
1  2       2
2  3       3
3  6       6
4  7       7
```

We typically want to match exactly when possible, and use the most recent value otherwise.

```python
In [5]: pd.merge_asof(left, right, on='a')
Out[5]:
   a    left_val    right_val
0  1      a         1
1  5      b         3
2 10     c         7
```

We can also match rows ONLY with prior data, and not an exact match.

```python
In [6]: pd.merge_asof(left, right, on='a', allow_exact_matches=False)
Out[6]:
   a    left_val    right_val
```

(continues on next page)
In a typical time-series example, we have trades and quotes and we want to asof-join them. This also illustrates using the by parameter to group data before merging.

```python
In [7]: trades = pd.DataFrame({
   ...:     'time': pd.to_datetime(['20160525 13:30:00.023',
   ...:                               '20160525 13:30:00.038',
   ...:                               '20160525 13:30:00.048',
   ...:                               '20160525 13:30:00.048',
   ...:                               '20160525 13:30:00.048'],
   ...:     'ticker': ['MSFT', 'MSFT', 'GOOG', 'GOOG', 'AAPL'],
   ...:     'price': [51.95, 51.95, 720.77, 720.92, 98.00],
   ...:     'quantity': [75, 155, 100, 100, 100],
   ...:     columns=['time', 'ticker', 'price', 'quantity'])
   ...

In [8]: quotes = pd.DataFrame({
   ...:     'time': pd.to_datetime(['20160525 13:30:00.023',
   ...:                               '20160525 13:30:00.023',
   ...:                               '20160525 13:30:00.030',
   ...:                               '20160525 13:30:00.041',
   ...:                               '20160525 13:30:00.049',
   ...:                               '20160525 13:30:00.049',
   ...:                               '20160525 13:30:00.072',
   ...:                               '20160525 13:30:00.075'],
   ...:     'ticker': ['GOOG', 'MSFT', 'MSFT', 'MSFT', 'GOOG', 'AAPL', 'GOOG',
   ...:                'MSFT'],
   ...:     'bid': [720.50, 51.95, 51.97, 51.99, 720.50, 97.99, 720.50, 52.01],
   ...:     'ask': [720.93, 51.96, 51.98, 52.00, 720.93, 98.01, 720.88, 52.03],
   ...:     columns=['time', 'ticker', 'bid', 'ask'])
   ...
```

```
In [9]: trades
Out[9]:
          time  ticker  price  quantity
0 2016-05-25 13:30:00.023  MSFT   51.95       75
1 2016-05-25 13:30:00.038  MSFT   51.95      155
2 2016-05-25 13:30:00.048  GOOG  720.77      100
3 2016-05-25 13:30:00.048  GOOG  720.92      100
4 2016-05-25 13:30:00.048   AAPL   98.00      100

In [10]: quotes
   \---------------------------------------------------------------------------
         time  ticker  bid  ask
0 2016-05-25 13:30:00.023  GOOG  720.50  720.93
1 2016-05-25 13:30:00.023  MSFT   51.95   51.96
```

(continues on next page)
An asof merge joins on the `on`, typically a datetimelike field, which is ordered, and in this case we are using a grouper in the `by` field. This is like a left-outer join, except that forward filling happens automatically taking the most recent non-NaN value.

```python
In [11]: pd.merge_asof(trades, quotes,
                           ....:
                           on='time',
                           ....:
                           by='ticker')
                           ....:
Out[11]:
```

```plaintext
time ticker price quantity bid ask
0 2016-05-25 13:30:00.023 MSFT 51.95 75 51.95 51.96
1 2016-05-25 13:30:00.038 MSFT 51.95 155 51.97 51.98
2 2016-05-25 13:30:00.048 GOOG 720.77 100 720.50 720.93
3 2016-05-25 13:30:00.048 GOOG 720.92 100 720.50 720.93
4 2016-05-25 13:30:00.048 AAPL 98.00 100 NaN NaN
```

This returns a merged DataFrame with the entries in the same order as the original left passed DataFrame (`trades` in this case), with the fields of the `quotes` merged.

### 1.12.1.2 `rolling()` is now time-series aware

`rolling()` objects are now time-series aware and can accept a time-series offset (or convertible) for the `window` argument (GH13327, GH12995). See the full documentation [here](#).

```python
In [12]: dft = pd.DataFrame({'B': [0, 1, 2, np.nan, 4]},
                           index=pd.date_range('20130101 09:00:00', periods=5, freq='s'))
                           ....:
In [13]: dft
Out[13]:
```

```plaintext
B
2013-01-01 09:00:00 0.0
2013-01-01 09:00:01 1.0
2013-01-01 09:00:02 2.0
2013-01-01 09:00:03 NaN
2013-01-01 09:00:04 4.0
```

This is a regular frequency index. Using an integer window parameter works to roll along the window frequency.

```python
In [14]: dft.rolling(2).sum()
Out[14]:
```

```plaintext
B
2013-01-01 09:00:00 NaN
2013-01-01 09:00:01 1.0
2013-01-01 09:00:02 3.0
2013-01-01 09:00:03 NaN
2013-01-01 09:00:04 NaN
```
Specifying an offset allows a more intuitive specification of the rolling frequency.

```python
In [16]: dft.rolling('2s').sum()
Out[16]:
    B
2013-01-01 09:00:00 0.0
2013-01-01 09:00:01 1.0
2013-01-01 09:00:02 3.0
2013-01-01 09:00:03 2.0
2013-01-01 09:00:04 4.0
```

Using a non-regular, but still monotonic index, rolling with an integer window does not impart any special calculation.

```python
In [17]: dft = DataFrame({'B': [0, 1, 2, np.nan, 4]},
                   index = pd.Index([pd.Timestamp('20130101 09:00:00'),
                                      pd.Timestamp('20130101 09:00:01'),
                                      pd.Timestamp('20130101 09:00:02'),
                                      pd.Timestamp('20130101 09:00:03'),
                                      pd.Timestamp('20130101 09:00:05')],
                                      name='foo'))

In [18]: dft
Out[18]:
    B
foo 2013-01-01 09:00:00 0.0
     2013-01-01 09:00:02 1.0
     2013-01-01 09:00:03 2.0
     2013-01-01 09:00:05 NaN
     2013-01-01 09:00:06 4.0

In [19]: dft.rolling(2).sum()
```

Using the time-specification generates variable windows for this sparse data.
Furthermore, we now allow an optional `on` parameter to specify a column (rather than the default of the index) in a DataFrame.

```
In [21]: dft = dft.reset_index()

In [22]: dft
Out[22]:
   foo  B
0  2013-01-01 09:00:00  0.0
1  2013-01-01 09:00:02  1.0
2  2013-01-01 09:00:03  2.0
3  2013-01-01 09:00:05  NaN
4  2013-01-01 09:00:06  4.0
```

```
In [23]: dft.rolling('2s', on='foo').sum()
```

```
0  2013-01-01 09:00:00  0.0
1  2013-01-01 09:00:02  1.0
2  2013-01-01 09:00:03  3.0
3  2013-01-01 09:00:05  NaN
4  2013-01-01 09:00:06  4.0
```

### 1.12.1.3 `read_csv` has improved support for duplicate column names

Duplicate column names are now supported in `read_csv()` whether they are in the file or passed in as the `names` parameter (GH7160, GH9424)

```
In [24]: data = '0,1,2
       :3,4,5'

In [25]: names = ['a', 'b', 'a']
```

Previous behavior:

```
In [2]: pd.read_csv(StringIO(data), names=names)
Out[2]:
   a  b  a
0  2  1  2
1  5  4  5
```

The first `a` column contained the same data as the second `a` column, when it should have contained the values `[0, 3]`.

New behavior:
1.12.1.4 `read_csv` supports parsing Categorical directly

The `read_csv()` function now supports parsing a Categorical column when specified as a dtype (GH10153). Depending on the structure of the data, this can result in a faster parse time and lower memory usage compared to converting to Categorical after parsing. See the io docs here.

```
In [27]: data = 'col1,col2,col3
    : a,b,1
    : a,b,2
    : c,d,3'

In [28]: pd.read_csv(StringIO(data))
Out[28]:
    col1  col2  col3
0    a     b     1
1    a     b     2
2    c     d     3

In [29]: pd.read_csv(StringIO(data)).dtypes
Out[29]:
    col1  col2  col3
    object object  int64

dtype: object

In [30]: pd.read_csv(StringIO(data), dtype='category').dtypes
Out[30]:
    col1  col2  col3
    category category category

dtype: object
```

Individual columns can be parsed as a Categorical using a dict specification

```
In [31]: pd.read_csv(StringIO(data), dtype={'col1': 'category'}).dtypes
Out[31]:
    col1  col2  col3
    category object  int64

dtype: object
```

Note: The resulting categories will always be parsed as strings (object dtype). If the categories are numeric they can be converted using the `to_numeric()` function, or as appropriate, another converter such as `to_datetime()`.

```
In [32]: df = pd.read_csv(StringIO(data), dtype='category')

In [33]: df.dtypes
Out[33]:
    col1  col2  col3
    category object  int64
```

(continues on next page)
In [34]: df['col3']
Out[34]:
0 1
1 2
2 3
Name: col3, dtype: category
Categories (3, object): [1, 2, 3]

In [35]: df['col3'].cat.categories = pd.to_numeric(df['col3'].cat.categories)

In [36]: df['col3']
Out[36]:
0 1
1 2
2 3
Name: col3, dtype: category
Categories (3, int64): [1, 2, 3]

1.12.1.5 Categorical Concatenation

- A function `union_categoricals()` has been added for combining categoricals, see [Unioning Categoricals](GH13361, GH13763, GH13846, GH14173)

```python
In [37]: from pandas.api.types import union_categoricals

In [38]: a = pd.Categorical(['b', 'c'])

In [39]: b = pd.Categorical(['a', 'b'])

In [40]: union_categoricals([a, b])
Out[40]:
[b, c, a]
Categories (3, object): [b, c, a]
```

- `concat` and `append` now can concat category dtypes with different categories as `object` dtype (GH13524)

```python
In [41]: s1 = pd.Series(['a', 'b'], dtype='category')

In [42]: s2 = pd.Series(['b', 'c'], dtype='category')

Previous behavior:

```
In [1]: pd.concat([s1, s2])
ValueError: incompatible categories in categorical concat
```

New behavior:

```python
In [43]: pd.concat([s1, s2])
Out[43]:
```
1.12.1.6 Semi-Month Offsets

Pandas has gained new frequency offsets, SemiMonthEnd (‘SM’) and SemiMonthBegin (‘SMS’). These provide date offsets anchored (by default) to the 15th and end of month, and 15th and 1st of month respectively. (GH1543)

```python
In [44]: from pandas.tseries.offsets import SemiMonthEnd, SemiMonthBegin

SemiMonthEnd:

In [45]: Timestamp('2016-01-01') + SemiMonthEnd()
Out[45]: Timestamp('2016-01-15 00:00:00')

In [46]: pd.date_range('2015-01-01', freq='SM', periods=4)
```

SemiMonthBegin:

```python
In [47]: Timestamp('2016-01-01') + SemiMonthBegin()
Out[47]: Timestamp('2016-01-15 00:00:00')

In [48]: pd.date_range('2015-01-01', freq='SMS', periods=4)
```

Using the anchoring suffix, you can also specify the day of month to use instead of the 15th.

```python
In [49]: pd.date_range('2015-01-01', freq='SMS-16', periods=4)
Out[49]: DatetimeIndex(['2015-01-01', '2015-01-16', '2015-02-01', '2015-02-16'],
                       dtype='datetime64[ns]', freq='SMS-16')

In [50]: pd.date_range('2015-01-01', freq='SM-14', periods=4)
```

1.12.1.7 New Index methods

The following methods and options are added to Index, to be more consistent with the Series and DataFrame API.

Index now supports the .where() function for same shape indexing (GH13170)

```python
In [51]: idx = pd.Index(['a', 'b', 'c'])

In [52]: idx.where([True, False, True])
Out[52]: Index(['a', nan, 'c'], dtype='object')
```
Index now supports `.dropna()` to exclude missing values (GH6194)

```python
In [53]: idx = pd.Index([1, 2, np.nan, 4])
In [54]: idx.dropna()
Out[54]: Float64Index([1.0, 2.0, 4.0], dtype='float64')
```

For `MultiIndex`, values are dropped if any level is missing by default. Specifying `how='all'` only drops values where all levels are missing.

```python
In [55]: midx = pd.MultiIndex.from_arrays([ [1, 2, np.nan, 4],
                                          [1, 2, np.nan, np.nan]])
In [56]: midx
Out[56]: MultiIndex(levels=[1, 2, 4], labels=[[0, 1, -1, 2], [0, 1, -1, -1]])
In [57]: midx.dropna()
Out[57]: MultiIndex(levels=[1, 2, 4], labels=[[0, 1, 2], [0, 1, -1]])
In [58]: midx.dropna(how='all')
Out[58]: MultiIndex(levels=[1, 2, 4], labels=[[0, 1, 2], [0, 1, -1]])
```

Index now supports `.str.extractall()` which returns a DataFrame, see the docs here (GH10008, GH13156)

```python
In [59]: idx = pd.Index(["a1a2", "b1", "c1"])
In [60]: idx.str.extractall("[ab](?P<digit>[0-9])")
Out[60]:
digit  match
0   0   1
1   2   2
1   0   1
```

`Index.astype()` now accepts an optional boolean argument `copy`, which allows optional copying if the requirements on dtype are satisfied (GH13209)

### 1.12.1.8 Google BigQuery Enhancements

- The `read_gbq()` method has gained the `dialect` argument to allow users to specify whether to use BigQuery’s legacy SQL or BigQuery’s standard SQL. See the docs for more details (GH13615).
- The `to_gbq()` method now allows the DataFrame column order to differ from the destination table schema (GH11359).
1.12.1.9 Fine-grained numpy errstate

Previous versions of pandas would permanently silence numpy’s ufunc error handling when pandas was imported. Pandas did this in order to silence the warnings that would arise from using numpy ufuncs on missing data, which are usually represented as NaNs. Unfortunately, this silenced legitimate warnings arising in non-pandas code in the application. Starting with 0.19.0, pandas will use the numpy.errstate context manager to silence these warnings in a more fine-grained manner, only around where these operations are actually used in the pandas codebase. (GH13109, GH13145)

After upgrading pandas, you may see new RuntimeWarnings being issued from your code. These are likely legitimate, and the underlying cause likely existed in the code when using previous versions of pandas that simply silenced the warning. Use numpy.errstate around the source of the RuntimeWarning to control how these conditions are handled.

1.12.1.10 get_dummies now returns integer dtypes

The pd.get_dummies function now returns dummy-encoded columns as small integers, rather than floats (GH8725). This should provide an improved memory footprint.

**Previous behavior:**

```
In [1]: pd.get_dummies(['a', 'b', 'a', 'c']).dtypes
Out[1]:
a float64
b float64
c float64
dtype: object
```

**New behavior:**

```
In [61]: pd.get_dummies(['a', 'b', 'a', 'c']).dtypes
Out[61]:
a uint8
b uint8
c uint8
dtype: object
```

1.12.1.11 Downcast values to smallest possible dtype in to_numeric

pd.to_numeric() now accepts a downcast parameter, which will downcast the data if possible to smallest specified numerical dtype (GH13352)

```
In [62]: s = ['1', 2, 3]

In [63]: pd.to_numeric(s, downcast='unsigned')
Out[63]: array([1, 2, 3], dtype=uint8)

In [64]: pd.to_numeric(s, downcast='integer')
```

```
Out[64]: array([1, 2, 3], dtype=int8)
```
1.12.1.12 pandas development API

As part of making pandas API more uniform and accessible in the future, we have created a standard sub-package of pandas, pandas.api to hold public API's. We are starting by exposing type introspection functions in pandas.api.types. More sub-packages and officially sanctioned API's will be published in future versions of pandas (GH13147, GH13634)

The following are now part of this API:

```python
In [65]: import pprint
In [66]: from pandas.api import types
In [67]: funcs = [ f for f in dir(types) if not f.startswith('_') ]
In [68]: pprint.pprint(funcs)
['CategoricalDtype',
 'DatetimeTZDtype',
 'IntervalDtype',
 'PeriodDtype',
 'infer_dtypes',
 'is_any_int_dtypes',
 'is_array_like',
 'is_bool',
 'is_bool_dtype',
 'is_categorical',
 'is_categorical_dtype',
 'is_complex',
 'is_complex_dtype',
 'is_datetime64_any_dtype',
 'is_datetime64_dtypes',
 'is_datetime64_ns_dtype',
 'is_datetime64tz_dtype',
 'is_datetimetz',
 'is_dict_like',
 'is_dtype_equal',
 'is_extension_type',
 'is_float',
 'is_dtype',
 'is_floating_dtype',
 'is_file_like',
 'is_hashable',
 'is_int64_dtype',
 'is_integer',
 'is_integer_dtype',
 'is_interval',
 'is_interval_dtype',
 'is_iterator',
 'is_list_like',
 'is_named_tuple',
 'is_number',
 'is_numeric_dtype',
 'is_object_dtype',
 'is_period',
 'is_period_dtype',
 'is_re',
 'is_re_compilable',
 'is_scalar',
```
1.12.1.13 Other enhancements

- **Timestamp** can now accept positional and keyword parameters similar to `datetime.datetime()` (GH10758, GH11630)

```python
In [69]: pd.Timestamp(2012, 1, 1)
Out[69]: Timestamp('2012-01-01 00:00:00')

In [70]: pd.Timestamp(year=2012, month=1, day=1, hour=8, minute=30)
    \n\nOut[70]: Timestamp('2012-01-01 08:30:00')
```

- The `.resample()` function now accepts a `on=` or `level=` parameter for resampling on a datetimelike column or `MultiIndex` level (GH13500)

```python
In [71]: df = pd.DataFrame({'date': pd.date_range('2015-01-01', freq='W', periods=5),
                    ....:       'a': np.arange(5),
                    ....:       index=pd.MultiIndex.from_arrays([
                    ....:           [1,2,3,4,5],
                    ....:           pd.date_range('2015-01-01', freq='W', periods=5)],
                    ....:       names=['v','d']})

In [72]: df
Out[72]:
    date  a
    v  d
    1 2015-01-04 2015-01-04 0
    2 2015-01-11 2015-01-11 1
    3 2015-01-18 2015-01-18 2
    4 2015-01-25 2015-01-25 3
    5 2015-02-01 2015-02-01 4

In [73]: df.resample('M', on='date').sum()
```

---

Note: Calling these functions from the internal module `pandas.core.common` will now show a `DeprecationWarning` (GH13990)
In [74]: df.resample('M', level='d').sum()

2015-01-31  6
2015-02-28  4

• The `get_credentials()` method of `GbqConnector` can now first try to fetch the application default credentials. See the docs for more details (GH13577).

• The `tz_localize()` method of `DatetimeIndex` and `Timestamp` has gained the `errors` keyword, so you can potentially coerce nonexistent timestamps to `NaT`. The default behavior remains to raising a `NonExistentTimeError` (GH13057).

• `.to_hdf/read_hdf()` now accept path objects (e.g. `pathlib.Path`, `py.path.local`) for the file path (GH11773).

• The `pd.read_csv()` with `engine='python'` has gained support for the `decimal` (GH12933), `na_filter` (GH13321) and the `memory_map` option (GH13381).

• Consistent with the Python API, `pd.read_csv()` will now interpret `+inf` as positive infinity (GH13274).

• The `pd.read_html()` has gained support for the `na_values`, `converters`, `keep_default_na` options (GH13461).

• `Categorical.astype()` now accepts an optional boolean argument `copy`, effective when `dtype` is categorical (GH13209).

• `DataFrame` has gained the `asof()` method to return the last non-NaN values according to the selected subset (GH13358).

• The `DataFrame` constructor will now respect key ordering if a list of `OrderedDict` objects are passed in (GH13304).

• `pd.read_html()` has gained support for the `decimal` option (GH12907).

• `Series` has gained the properties `.is_monotonic`, `.is_monotonic_increasing`, `.is_monotonic_decreasing`, similar to `Index` (GH13336).

• `DataFrame.to_sql()` now allows a single value as the SQL type for all columns (GH11886).

• `Series.append` now supports the `ignore_index` option (GH13677).

• `.to_stata()` and `StataWriter` can now write variable labels to Stata dta files using a dictionary to make column names to labels (GH13535, GH13536).

• `.to_stata()` and `StataWriter` will automatically convert `datetime64[ns]` columns to Stata format `%tc`, rather than raising a `ValueError` (GH12259).

• `read_stata()` and `StataReader` raise with a more explicit error message when reading Stata files with repeated value labels when `convert_categoricals=True` (GH13923).

• `DataFrame.style` will now render sparsified MultiIndexes (GH11655).

• `DataFrame.style` will now show column level names (e.g. `DataFrame.columns.names`) (GH13775).

• `DataFrame` has gained support to re-order the columns based on the values in a row using `df.sort_values(by='...', axis=1)` (GH10806).
In 

```python
df = pd.DataFrame({'A': [2, 7], 'B': [3, 5], 'C': [4, 8]},
                 index=['row1', 'row2'])
```

```python
In [76]: df
Out[76]:
   A  B  C
row1 2  3  4
row2 7  5  8
```

```python
In [77]: df.sort_values(by='row2', axis=1)
Out[77]:
   B  A  C
row1 3  2  4
row2 5  7  8
```

• Added documentation to I/O regarding the perils of reading in columns with mixed dtypes and how to handle it (GH13746)
• `to_html()` now has a `border` argument to control the value in the opening `<table>` tag. The default is the value of the html.border option, which defaults to 1. This also affects the notebook HTML repr, but since Jupyter’s CSS includes a border-width attribute, the visual effect is the same. (GH11563).
• Raise `ImportError` in the sql functions when `sqlalchemy` is not installed and a connection string is used (GH1920).
• Compatibility with matplotlib 2.0. Older versions of pandas should also work with matplotlib 2.0 (GH13333)
• Timestamp, Period, DatetimeIndex, PeriodIndex and `.dt` accessor have gained a `.is_leap_year` property to check whether the date belongs to a leap year. (GH13727)
• `astype()` will now accept a dict of column name to data types mapping as the `dtype` argument. (GH12086)
• The `pd.read_json` and `DataFrame.to_json` has gained support for reading and writing json lines with `lines` option see `Line delimited json` (GH9180)
• `read_excel()` now supports the true_values and false_values keyword arguments (GH13347)
• `groupby()` will now accept a scalar and a single-element list for specifying `level` on a non-MultiIndex grouper. (GH13907)
• Non-convertible dates in an excel date column will be returned without conversion and the column will be object dtype, rather than raising an exception (GH10001).
• `pd.Timedelta(None)` is now accepted and will return `NaT`, mirroring `pd.Timestamp` (GH13687)
• `pd.read_stata()` can now handle some format 111 files, which are produced by SAS when generating Stata dta files (GH11526)
• Series and Index now support `divmod` which will return a tuple of series or indices. This behaves like a standard binary operator with regards to broadcasting rules (GH14208).

### 1.12.2 API changes

#### 1.12.2.1 Series.tolist() will now return Python types

`Series.tolist()` will now return Python types in the output, mimicking NumPy `.tolist()` behavior (GH10904)
1.12.2.2 Series operators for different indexes

Following Series operators have been changed to make all operators consistent, including DataFrame (GH1134, GH4581, GH13538)

- Series comparison operators now raise ValueError when index are different.
- Series logical operators align both index of left and right hand side.

**Warning:** Until 0.18.1, comparing Series with the same length, would succeed even if the .index are different (the result ignores .index). As of 0.19.0, this will raises ValueError to be more strict. This section also describes how to keep previous behavior or align different indexes, using the flexible comparison methods like .eq.

As a result, Series and DataFrame operators behave as below:

### Arithmetic operators

Arithmetic operators align both index (no changes).

```python
In [80]: s1 = pd.Series([1, 2, 3], index=list('ABC'))
In [81]: s2 = pd.Series([2, 2, 2], index=list('ABD'))
In [82]: s1 + s2
Out[82]:
   A  3.0
   B  4.0
   C   NaN
   D   NaN
dtype: float64
```

```python
In [83]: df1 = pd.DataFrame([1, 2, 3], index=list('ABC'))
In [84]: df2 = pd.DataFrame([2, 2, 2], index=list('ABD'))
In [85]: df1 + df2
Out[85]:
   0  0
   A  3.0
```
Comparison operators

Comparison operators raise `ValueError` when `.index` are different.

**Previous Behavior (Series):**

Series compared values ignoring the `.index` as long as both had the same length:

```
In [1]: s1 == s2
Out[1]:
A   False
B    True
C   False
dtype: bool
```

**New behavior (Series):**

```
In [2]: s1 == s2
Out[2]:
ValueError: Can only compare identically-labeled Series objects
```

**Note:** To achieve the same result as previous versions (compare values based on locations ignoring `.index`), compare both `.values`.

```
In [86]: s1.values == s2.values
Out[86]: array([False, True, False], dtype=bool)
```

If you want to compare `Series` aligning its `.index`, see flexible comparison methods section below:

```
In [87]: s1.eq(s2)
Out[87]:
A   False
B    True
C   False
D   False
dtype: bool
```

**Current Behavior (DataFrame, no change):**

```
In [3]: df1 == df2
Out[3]:
ValueError: Can only compare identically-labeled DataFrame objects
```

Logical operators

Logical operators align both `.index` of left and right hand side.

**Previous behavior (Series), only left hand side index was kept:**
In [4]: s1 = pd.Series([True, False, True], index=list('ABC'))
In [5]: s2 = pd.Series([True, True, True], index=list('ABD'))
In [6]: s1 & s2
Out[6]:
A   True
B   False
C   False
dtype: bool

New behavior (Series):

In [88]: s1 = pd.Series([True, False, True], index=list('ABC'))
In [89]: s2 = pd.Series([True, True, True], index=list('ABD'))
In [90]: s1 & s2
Out[90]:
A   True
B   False
C   False
dtype: bool

Note: Series logical operators fill a NaN result with False.

Note: To achieve the same result as previous versions (compare values based on only left hand side index), you can use reindex_like:

In [91]: s1 & s2.reindex_like(s1)
Out[91]:
A   True
B   False
C   False
dtype: bool

Current Behavior (DataFrame, no change):

In [92]: df1 = pd.DataFrame([True, False, True], index=list('ABC'))
In [93]: df2 = pd.DataFrame([True, True, True], index=list('ABD'))
In [94]: df1 & df2
Out[94]:
   0
A   True
B   False
C  NaN
D  NaN
Flexible comparison methods

Series flexible comparison methods like `eq`, `ne`, `le`, `lt`, `ge` and `gt` now align both `index`. Use these operators if you want to compare two Series which has the different `index`.

```
In [95]: s1 = pd.Series([1, 2, 3], index=['a', 'b', 'c'])
In [96]: s2 = pd.Series([2, 2, 2], index=['b', 'c', 'd'])
In [97]: s1.eq(s2)
Out[97]:
a   False
b   True
c   False
d   False
dtype: bool

In [98]: s1.ge(s2)
Out[98]:
a   False
b   True
c   True
d   False
dtype: bool
```

Previously, this worked the same as comparison operators (see above).

1.12.2.3 Series type promotion on assignment

A Series will now correctly promote its dtype for assignment with incompat values to the current dtype (GH13234)

```
In [99]: s = pd.Series()

Previous behavior:

In [2]: s['a'] = pd.Timestamp("2016-01-01")
In [3]: s['b'] = 3.0
TypeError: invalid type promotion

New behavior:

In [100]: s['a'] = pd.Timestamp("2016-01-01")
In [101]: s['b'] = 3.0
In [102]: s
Out[102]:
a  2016-01-01 00:00:00
b    3
dtype: object
```

1.12. v0.19.0 (October 2, 2016)
1.12.2.4 .to_datetime() changes

Previously if .to_datetime() encountered mixed integers/floats and strings, but no datetimes with errors='coerce' it would convert all to NaT.

**Previous behavior:**

```
In [2]: pd.to_datetime([1, 'foo'], errors='coerce')
Out[2]: DatetimeIndex(['NaT', 'NaT'], dtype='datetime64[ns]', freq=None)
```

**Current behavior:**

This will now convert integers/floats with the default unit of ns.

```
In [104]: pd.to_datetime([1, 'foo'], errors='coerce')
Out[104]: DatetimeIndex(['1970-01-01 00:00:00.000000001', 'NaT'], dtype='datetime64[ns]', freq=None)
```

Bug fixes related to .to_datetime():

- Bug in pd.to_datetime() when passing integers or floats, and no unit and errors='coerce' (GH13180).
- Bug in pd.to_datetime() when passing invalid datatypes (e.g. bool); will now respect the errors keyword (GH13176)
- Bug in pd.to_datetime() which overflowed on int8, and int16 dtypes (GH13451)
- Bug in pd.to_datetime() raise AttributeError with NaN and the other string is not valid when errors='ignore' (GH12424)
- Bug in pd.to_datetime() did not cast floats correctly when unit was specified, resulting in truncated datetime (GH13834)

1.12.2.5 Merging changes

Merging will now preserve the dtype of the join keys (GH8596)

```
In [105]: df1 = pd.DataFrame({'key': [1], 'v1': [10]})
In [106]: df1
Out[106]:
   key  v1
0   1  10

In [107]: df2 = pd.DataFrame({'key': [1, 2], 'v1': [20, 30]})
In [108]: df2
Out[108]:
   key  v1
0   1  20
1   2  30
```

**Previous behavior:**

```
In [5]: pd.merge(df1, df2, how='outer')
Out[5]:
   key  v1
0   1.0 10.0
```

(continues on next page)
New behavior:

We are able to preserve the join keys

Of course if you have missing values that are introduced, then the resulting dtype will be upcast, which is unchanged from previous.

### 1.12.2.6 .describe() changes

Percentile identifiers in the index of a .describe() output will now be rounded to the least precision that keeps them distinct (GH13104)

Previous behavior:

The percentiles were rounded to at most one decimal place, which could raise ValueError for a data frame if the percentiles were duplicated.
In [3]: s.describe(percentiles=[0.0001, 0.0005, 0.001, 0.999, 0.9995, 0.9999])
Out[3]:
    count   5.000000
    mean    2.000000
    std   1.581139
    min   0.000000
    0.0%   0.000400
    0.1%   0.002000
    0.1%   0.004000
    50%    2.000000
    99.9%   3.996000
    100.0%  3.998000
    100.0%  3.999600
    max    4.000000
    dtype: float64

In [4]: df.describe(percentiles=[0.0001, 0.0005, 0.001, 0.999, 0.9995, 0.9999])
ValueError: cannot reindex from a duplicate axis

New behavior:

In [115]: s.describe(percentiles=[0.0001, 0.0005, 0.001, 0.999, 0.9995, 0.9999])
Out[115]:
    count   5.000000
    mean    2.000000
    std   1.581139
    min   0.000000
    0.0%   0.000400
    0.05%   0.002000
    0.1%   0.004000
    50%    2.000000
    99.9%   3.996000
    99.95%  3.998000
    99.99%  3.999600
    max    4.000000
    dtype: float64

In [116]: df.describe(percentiles=[0.0001, 0.0005, 0.001, 0.999, 0.9995, 0.9999])

Furthermore:
• Passing duplicated percentiles will now raise a `ValueError`.
• Bug in `.describe()` on a DataFrame with a mixed-dtype column index, which would previously raise a `TypeError` (GH13288)

### 1.12.2.7 Period changes

**PeriodIndex now has period dtype**

PeriodIndex now has its own period dtype. The period dtype is a pandas extension dtype like `category` or the `timezone aware dtype` (datetime64[ns, tz])(GH13941). As a consequence of this change, PeriodIndex no longer has an integer dtype:

**Previous behavior:**

```
In [1]: pi = pd.PeriodIndex(['2016-08-01'], freq='D')
In [2]: pi
Out[2]: PeriodIndex(['2016-08-01'], dtype='int64', freq='D')
In [3]: pd.api.types.is_integer_dtype(pi)
Out[3]: True
In [4]: pi.dtype
Out[4]: dtype('int64')
```

**New behavior:**

```
In [117]: pi = pd.PeriodIndex(['2016-08-01'], freq='D')
In [118]: pi
Out[118]: PeriodIndex(['2016-08-01'], dtype='period[D]', freq='D')
In [119]: pd.api.types.is_integer_dtype(pi)
Out[119]: False
In [120]: pd.api.types.is_period_dtype(pi)
Out[120]: True
In [121]: pi.dtype
Out[121]: period[D]
In [122]: type(pi.dtype)
Out[122]: pandas.core.dtypes.dtypes.PeriodDtype
```

**Period('NaT') now returns pd.NaT**

Previously, `Period` has its own `Period('NaT')` representation different from `pd.NaT`. Now `Period('NaT')` has been changed to return `pd.NaT` (GH12759, GH13582)

**Previous behavior:**
New behavior:

These result in `pd.NaT` without providing `freq` option.

Previous behavior:

To be compatible with `Period` addition and subtraction, `pd.NaT` now supports addition and subtraction with `int`. Previously it raised `ValueError`.

New behavior:

`PeriodIndex.values` now returns array of `Period` object

`.values` is changed to return an array of `Period` objects, rather than an array of integers (GH13988).

Previous behavior:

```
In [6]: pi = pd.PeriodIndex(['2011-01', '2011-02'], freq='M')
In [7]: pi.values
array([492, 493])
```

New behavior:

```
In [127]: pi = pd.PeriodIndex(['2011-01', '2011-02'], freq='M')
In [128]: pi.values
Out[128]: array([Period('2011-01', 'M'), Period('2011-02', 'M')], dtype=object)
```

1.12.2.8 Index + / – no longer used for set operations

Addition and subtraction of the base Index type and of DatetimeIndex (not the numeric index types) previously performed set operations (set union and difference). This behavior was already deprecated since 0.15.0 (in favor using the specific `.union()` and `.difference()` methods), and is now disabled. When possible, + and – are now used for element-wise operations, for example for concatenating strings or subtracting datetimes (GH8227, GH14127).

Previous behavior:
In [1]: pd.Index(['a', 'b']) + pd.Index(['a', 'c'])
FutureWarning: using '+' to provide set union with Indexes is deprecated, use '|' or .
union()
Out[1]: Index(['a', 'b', 'c'], dtype='object')

New behavior: the same operation will now perform element-wise addition:

In [129]: pd.Index(['a', 'b']) + pd.Index(['a', 'c'])
Out[129]: Index(['aa', 'bc'], dtype='object')

Note that numeric Index objects already performed element-wise operations. For example, the behavior of adding two integer Indexes is unchanged. The base Index is now made consistent with this behavior.

In [130]: pd.Index([1, 2, 3]) + pd.Index([2, 3, 4])
Out[130]: Int64Index([3, 5, 7], dtype='int64')

Further, because of this change, it is now possible to subtract two DatetimeIndex objects resulting in a TimedeltaIndex:

Previous behavior:

In [1]: pd.DatetimeIndex(['2016-01-01', '2016-01-02']) - pd.DatetimeIndex(['2016-01-02', '2016-01-03'])
FutureWarning: using '-' to provide set differences with datetimelike Indexes is deprecated, use .difference()
Out[1]: DatetimeIndex(['2016-01-01'], dtype='datetime64[ns]', freq=None)

New behavior:

In [131]: pd.DatetimeIndex(['2016-01-01', '2016-01-02']) - pd.DatetimeIndex(['2016-01-02', '2016-01-03'])
Out[131]: TimedeltaIndex(['-1 days', '-1 days'], dtype='timedelta64[ns]', freq=None)

1.12.2.9 Index.difference and .symmetric_difference changes

Index.difference and Index.symmetric_difference will now, more consistently, treat NaN values as any other values. (GH13514)

In [132]: idx1 = pd.Index([1, 2, 3, np.nan])
In [133]: idx2 = pd.Index([0, 1, np.nan])

Previous behavior:

In [3]: idx1.difference(idx2)
Out[3]: Float64Index([nan, 2.0, 3.0], dtype='float64')
In [4]: idx1.symmetric_difference(idx2)
Out[4]: Float64Index([0.0, nan, 2.0, 3.0], dtype='float64')

New behavior:

In [134]: idx1.difference(idx2)
Out[134]: Float64Index([2.0, 3.0], dtype='float64')
In [135]: idx1.symmetric_difference(idx2)
Out[135]: Float64Index([0.0, 2.0, 3.0], dtype='float64')

(continues on next page)
1.12.2.10 Index.unique consistently returns Index

Index.unique() now returns unique values as an Index of the appropriate dtype. (GH13395). Previously, most Index classes returned np.ndarray, and DatetimeIndex, TimedeltaIndex and PeriodIndex returned Index to keep metadata like timezone.

**Previous behavior:**

```
In [1]: pd.Index([1, 2, 3]).unique()
Out[1]: array([1, 2, 3])
```

```
In [2]: pd.DatetimeIndex(['2011-01-01', '2011-01-02', '2011-01-03'], tz='Asia/Tokyo').unique()
Out[2]: DatetimeIndex(['2011-01-01 00:00:00+09:00', '2011-01-02 00:00:00+09:00', '2011-01-03 00:00:00+09:00'], dtype='datetime64[ns, Asia/Tokyo]', freq=None)
```

**New behavior:**

```
In [136]: pd.Index([1, 2, 3]).unique()
Out[136]: Int64Index([1, 2, 3], dtype='int64')
```

```
In [137]: pd.DatetimeIndex(['2011-01-01', '2011-01-02', '2011-01-03'], tz='Asia/Tokyo').unique()
Out[137]: DatetimeIndex(['2011-01-01 00:00:00+09:00', '2011-01-02 00:00:00+09:00', '2011-01-03 00:00:00+09:00'], dtype='datetime64[ns, Asia/Tokyo]', freq=None)
```

1.12.2.11 MultiIndex constructors, groupby and set_index preserve categorical dtypes

MultiIndex.from_arrays and MultiIndex.from_product will now preserve categorical dtype in MultiIndex levels (GH13743, GH13854).

```
In [138]: cat = pd.Categorical(['a', 'b'], categories=list("bac"))
```

```
In [139]: lvll1 = ['foo', 'bar']
```

```
In [140]: midx = pd.MultiIndex.from_arrays([cat, lvll1])
```

```
In [141]: midx
Out[141]: MultiIndex(levels=[['b', 'a', 'c'], ['bar', 'foo']], labels=[[1, 0], [1, 0]], dtype='object')
```

**Previous behavior:**

```
In [4]: midx.levels[0]
Out[4]: Index(['b', 'a', 'c'], dtype='object')
```

```
In [5]: midx.get_level_values[0]
Out[5]: Index(['a', 'b'], dtype='object')
```
New behavior: the single level is now a CategoricalIndex:

```python
In [142]: midx.levels[0]
Out[142]: CategoricalIndex(['b', 'a', 'c'], categories=['b', 'a', 'c'], ordered=False, dtype='category')

In [143]: midx.get_level_values(0)
CategoricalIndex(['a', 'b'], categories=['b', 'a', 'c'], ordered=False, dtype='category')
```

An analogous change has been made to MultiIndex.from_product. As a consequence, groupby and set_index also preserve categorical dtypes in indexes

```python
In [144]: df = pd.DataFrame({
                   'A': [0, 1],
                   'B': [10, 11],
                   'C': cat})
In [145]: df_grouped = df.groupby(by=['A', 'C']).first()
In [146]: df_set_idx = df.set_index(['A', 'C'])
```

Previous behavior:

```python
In [11]: df_grouped.index.levels[1]
Out[11]: Index(['b', 'a', 'c'], dtype='object', name='C')
In [12]: df_grouped.reset_index().dtypes
Out[12]:
   A     int64
  C    object
   B  float64
dtype: object

In [13]: df_set_idx.index.levels[1]
Out[13]: Index(['b', 'a', 'c'], dtype='object', name='C')
In [14]: df_set_idx.reset_index().dtypes
Out[14]:
   A     int64
  C    object
   B     int64
dtype: object
```

New behavior:

```python
In [147]: df_grouped.index.levels[1]
Out[147]: CategoricalIndex(['b', 'a', 'c'], categories=['b', 'a', 'c'], ordered=False, name='C', dtype='category')
In [148]: df_grouped.reset_index().dtypes
   →
   A     int64
  C    category
   B  float64
dtype: object
In [149]: df_set_idx.index.levels[1]
   →
CategoricalIndex(['b', 'a', 'c'], categories=['b', 'a', 'c'], ordered=False, name='C', dtype='category')
```

(continues on next page)


1.12.2.12 read_csv will progressively enumerate chunks

When read_csv() is called with chunksize=n and without specifying an index, each chunk used to have an independently generated index from 0 to n-1. They are now given instead a progressive index, starting from 0 for the first chunk, from n for the second, and so on, so that, when concatenated, they are identical to the result of calling read_csv() without the chunksize= argument (GH12185).

Previous behavior:

```
In [2]: pd.concat(pd.read_csv(StringIO(data), chunksize=2))
Out[2]:
    A  B
   --- ---
  0  0  1
  1  2  3
  0  4  5
  1  6  7
```

New behavior:

```
In [152]: pd.concat(pd.read_csv(StringIO(data), chunksize=2))
Out[152]:
    A  B
   --- ---
  0  0  1
  1  2  3
  2  4  5
  3  6  7
```

1.12.2.13 Sparse Changes

These changes allow pandas to handle sparse data with more dtypes, and for work to make a smoother experience with data handling.

### int64 and bool support enhancements

Sparse data structures now gained enhanced support of int64 and bool dtype (GH667, GH13849).

Previously, sparse data were float64 dtype by default, even if all inputs were of int or bool dtype. You had to specify dtype explicitly to create sparse data with int64 dtype. Also, fill_value had to be specified explicitly because the default was np.nan which doesn’t appear in int64 or bool data.
In [1]: pd.SparseArray([1, 2, 0, 0])  
Out[1]:  
[1.0, 2.0, 0.0, 0.0]  
Fill: nan  
IntIndex  
Indices: array([0, 1, 2, 3], dtype=int32)  

# specifying int64 dtype, but all values are stored in sp_values because  
# fill_value default is np.nan  
In [2]: pd.SparseArray([1, 2, 0, 0], dtype=np.int64)  
Out[2]:  
[1, 2, 0, 0]  
Fill: nan  
IntIndex  
Indices: array([0, 1, 2, 3], dtype=int32)  

In [3]: pd.SparseArray([1, 2, 0, 0], dtype=np.int64, fill_value=0)  
Out[3]:  
[1, 2, 0, 0]  
Fill: 0  
IntIndex  
Indices: array([0, 1], dtype=int32)  

As of v0.19.0, sparse data keeps the input dtype, and uses more appropriate fill_value defaults (0 for int64 dtype, False for bool dtype).

In [153]: pd.SparseArray([1, 2, 0, 0], dtype=np.int64)  
Out[153]:  
[1, 2, 0, 0]  
Fill: 0  
IntIndex  
Indices: array([0, 1], dtype=int32)  

In [154]: pd.SparseArray([True, False, False, False])  
Out[154]:  
[True, False, False, False]  
Fill: False  
IntIndex  
Indices: array([0], dtype=int32)  

See the docs for more details.

Operators now preserve dtypes

- Sparse data structure now can preserve dtype after arithmetic ops (GH13848)

In [155]: s = pd.SparseSeries([0, 2, 0, 1], fill_value=0, dtype=np.int64)  
In [156]: s.dtype  
Out[156]:  
dtype('int64')  
In [157]: s + 1  
Out[157]:  
0 1  
1 3  
(continues on next page)
Sparse data structure now support `astype` to convert internal `dtype` (GH13900)

```python
In [158]: s = pd.SparseSeries([1., 0., 2., 0.], fill_value=0)
In [159]: s
Out[159]:
0  1.0
1  0.0
2  2.0
3  0.0
dtype: float64
```

```python
In [160]: s.astype(np.int64)
```

`astype` fails if data contains values which cannot be converted to specified `dtype`. Note that the limitation is applied to `fill_value` which default is `np.nan`.

```python
In [7]: pd.SparseSeries([1., np.nan, 2., np.nan], fill_value=np.nan).astype(np.
\astype{int64})
Out[7]:
ValueError: unable to coerce current fill_value nan to int64 dtype
```

Other sparse fixes

- Subclassed `SparseDataFrame` and `SparseSeries` now preserve class types when slicing or transposing. (GH13787)
- `SparseArray` with `bool` `dtype` now supports logical (bool) operators (GH14000)
- Bug in `SparseSeries` with `MultiIndex`[] indexing may raise `IndexError` (GH13144)
- Bug in `SparseSeries` with `MultiIndex`[] indexing result may have normal `Index` (GH13144)
- Bug in `SparseDataFrame` in which `axis=None` did not default to `axis=0` (GH13048)
- Bug in `SparseSeries` and `SparseDataFrame` creation with object `dtype` may raise `TypeError` (GH11633)
• Bug in SparseDataFrame doesn’t respect passed SparseArray or SparseSeries ‘s dtype and fill_value (GH13866)
• Bug in SparseArray and SparseSeries don’t apply ufunc to fill_value (GH13853)
• Bug in SparseSeries.abs incorrectly keeps negative fill_value (GH13853)
• Bug in single row slicing on multi-type SparseDataFrame s, types were previously forced to float (GH13917)
• Bug in SparseSeries slicing changes integer dtype to float (GH8292)
• Bug in SparseDataFrame comparison ops may raise TypeError (GH13001)
• Bug in SparseDataFrame.isnull raises ValueError (GH8276)
• Bug in SparseSeries representation with bool dtype may raise IndexError (GH13110)
• Bug in SparseSeries and SparseDataFrame of bool or int64 dtype may display its values like float64 dtype (GH13110)
• Bug in sparse indexing using SparseArray with bool dtype may return incorrect result (GH13985)
• Bug in SparseArray created from SparseSeries may lose dtype (GH13999)
• Bug in SparseSeries comparison with dense returns normal Series rather than SparseSeries (GH13999)

1.12.2.14 Indexer dtype changes

Note: This change only affects 64 bit python running on Windows, and only affects relatively advanced indexing operations

Methods such as Index.get_indexer that return an indexer array, coerce that array to a “platform int”, so that it can be directly used in 3rd party library operations like numpy.take. Previously, a platform int was defined as np.int_ which corresponds to a C integer, but the correct type, and what is being used now, is np.intp, which corresponds to the C integer size that can hold a pointer (GH3033, GH13972).

These types are the same on many platform, but for 64 bit python on Windows, np.int_ is 32 bits, and np.intp is 64 bits. Changing this behavior improves performance for many operations on that platform.

Previous behavior:

```python
In [1]: i = pd.Index(['a', 'b', 'c'])
In [2]: i.get_indexer(['b', 'b', 'c']).dtype
Out[2]: dtype('int32')
```

New behavior:

```python
In [1]: i = pd.Index(['a', 'b', 'c'])
In [2]: i.get_indexer(['b', 'b', 'c']).dtype
Out[2]: dtype('int64')
```
1.12.2.15 Other API Changes

- `Timestamp.to_pydatetime` will issue a `UserWarning` when `warn=True`, and the instance has a non-zero number of nanoseconds, previously this would print a message to stdout (GH14101).
- `Series.unique()` with `datetime` and `timezone` now returns return array of `Timestamp with timezone` (GH135665).
- `Panel.to_sparse()` will raise a `NotImplementedError` exception when called (GH13778).
- `Index.reshape()` will raise a `NotImplementedError` exception when called (GH12882).
- `.filter()` enforces mutual exclusion of the keyword arguments (GH12399).
- `eval`’s upcasting rules for `float32` types have been updated to be more consistent with NumPy’s rules. New behavior will not upcast to `float64` if you multiply a pandas `float32` object by a scalar `float64` (GH12388).
- An `UnsupportedFunctionCall` error is now raised if NumPy ufuncs like `np.mean` are called on groupby or resample objects (GH12811).
- `__setitem__` will no longer apply a callable rhs as a function instead of storing it. Call `where` directly to get the previous behavior (GH13299).
- Calls to `.sample()` will respect the random seed set via `numpy.random.seed(n)` (GH13161)
- `Styler.apply` is now more strict about the outputs your function must return. For `axis=0` or `axis=1`, the output shape must be identical. For `axis=None`, the output must be a DataFrame with identical columns and index labels (GH13222).
- `Float64Index.astype(int)` will now raise `ValueError` if `Float64Index` contains NaN values (GH13149)
- `TimedeltaIndex.astype(int)` and `DatetimeIndex.astype(int)` will now return `Int64Index` instead of `np.array` (GH13209)
- `DataFrame.values` will now return `float64` with a `DataFrame` of mixed `int64` and `uint64` dtypes, conforming to `np.find_common_type` (GH10364, GH13917)
- `.groupby.groups` will now return a dictionary of `Index objects`, rather than a dictionary of `np.ndarray` or `lists` (GH14293)
1.12.3 Deprecations

- Series.reshape and Categorical.reshape have been deprecated and will be removed in a subsequent release (GH12882, GH12882)
- PeriodIndex.to_datetime has been deprecated in favor of PeriodIndex.to_timestamp (GH8254)
- Timestamp.to_datetime has been deprecated in favor of Timestamp.to_pydatetime (GH8254)
- Index.to_datetime and DatetimeIndex.to_datetime have been deprecated in favor of pd.to_datetime (GH8254)
- pandas.core.datetools module has been deprecated and will be removed in a subsequent release (GH14094)
- SparseList has been deprecated and will be removed in a future version (GH13784)
- DataFrame.to_html() and DataFrame.to_latex() have dropped the colSpace parameter in favor of col_space (GH13857)
- DataFrame.to_sql() has deprecated the flavor parameter, as it is superfluous when SQLAlchemy is not installed (GH13611)
- Deprecated read_csv keywords:
  - compact_ints and use_unsigned have been deprecated and will be removed in a future version (GH13320)
  - buffer_lines has been deprecated and will be removed in a future version (GH13360)
  - as_recarray has been deprecated and will be removed in a future version (GH13373)
  - skip_footer has been deprecated in favor of skipfooter and will be removed in a future version (GH13349)
- top-level pd.ordered_merge() has been renamed to pd.merge_ordered() and the original name will be removed in a future version (GH13358)
- Timestamp.offset property (and named arg in the constructor), has been deprecated in favor of freq (GH12160)
- pd.tseries.util.pivot_annual is deprecated. Use pivot_table as alternative, an example is here (GH736)
- pd.tseries.util.isleapyear has been deprecated and will be removed in a subsequent release. Datetime-likes now have a .is_leap_year property (GH13727)
- Panel4D and PanelND constructors are deprecated and will be removed in a future version. The recommended way to represent these types of n-dimensional data are with the xarray package. Pandas provides a to_xarray() method to automate this conversion (GH13564).
- pandas.tseries.frequencies.get_standard_freq is deprecated. Use pandas.tseries.frequencies.to_offset(freq).rule_code instead (GH13874)
- pandas.tseries.frequencies.to_offset’s freqstr keyword is deprecated in favor of freq (GH13874)
- Categorical.from_array has been deprecated and will be removed in a future version (GH13854)

1.12.4 Removal of prior version deprecations/changes

- The SparsePanel class has been removed (GH13778)
• The pd.sandbox module has been removed in favor of the external library pandas-qt (GH13670)
• The pandas.io.data and pandas.io.wb modules are removed in favor of the pandas-datareader package (GH13724).
• The pandas.tools.rplot module has been removed in favor of the seaborn package (GH13855)
• DataFrame.to_csv() has dropped the engine parameter, as was deprecated in 0.17.1 (GH11274, GH13419)
• DataFrame.to_dict() has dropped the outtype parameter in favor of orient (GH13627, GH8486)
• pd.Categorical has dropped setting of the ordered attribute directly in favor of the set_ordered method (GH13671)
• pd.Categorical has dropped the levels attribute in favor of categories (GH8376)
• DataFrame.to_sql() has dropped the mysql option for the flavor parameter (GH13611)
• Panel.shift() has dropped the lags parameter in favor of periods (GH14041)
• pd.Index has dropped the diff method in favor of difference (GH13669)
• pd.DataFrame has dropped the to_wide method in favor of to_panel (GH14039)
• Series.to_csv has dropped the nanRep parameter in favor of na_rep (GH13804)
• Series.xs, DataFrame.xs, Panel.xs, Panel.major_xs, and Panel.minor_xs have dropped the copy parameter (GH13781)
• str.split has dropped the return_type parameter in favor of expand (GH13701)
• Removal of the legacy time rules (offset aliases), deprecated since 0.17.0 (this has been alias since 0.8.0) (GH13590, GH13868). Now legacy time rules raises ValueError. For the list of currently supported offsets, see here.
• The default value for the return_type parameter for DataFrame.plot.box and DataFrame.boxplot changed from None to "axes". These methods will now return a matplotlib axes by default instead of a dictionary of artists. See here (GH6581).
• The tquery and uquery functions in the pandas.io.sql module are removed (GH5950).

1.12.5 Performance Improvements

• Improved performance of sparse IntIndex.intersect (GH13082)
• Improved performance of sparse arithmetic with BlockIndex when the number of blocks are large, though recommended to use IntIndex in such cases (GH13082)
• Improved performance of DataFrame.quantile() as it now operates per-block (GH11623)
• Improved performance of float64 hash table operations, fixing some very slow indexing and groupby operations in python 3 (GH13166, GH13334)
• Improved performance of DataFrameGroupBy.transform (GH12737)
• Improved performance of Index and Series.duplicated (GH10235)
• Improved performance of Index.difference (GH12044)
• Improved performance of RangeIndex.is_monotonic_increasing and is_monotonic_decreasing (GH13749)
• Improved performance of datetime string parsing in DatetimeIndex (GH13692)
• Improved performance of hashing Period (GH12817)
• Improved performance of `factorize` of datetime with timezone (GH13750)
• Improved performance of by lazily creating indexing hashtables on larger Indexes (GH14266)
• Improved performance of `groupby.groups` (GH14293)
• Unnecessary materializing of a MultiIndex when introspecting for memory usage (GH14308)

1.12.6 Bug Fixes

• Bug in `groupby().shift()`, which could cause a segfault or corruption in rare circumstances when grouping by columns with missing values (GH13813)
• Bug in `groupby().cumsum()` calculating `cumprod` when `axis=1` (GH13994)
• Bug in `pd.to_timedelta()` in which the `errors` parameter was not being respected (GH13613)
• Bug in `io.json.json_normalize()`, where non-ascii keys raised an exception (GH13213)
• Bug when passing a not-default-indexed `Series` as `xerr` or `yerr` in `.plot()` (GH11858)
• Bug in area plot draws legend incorrectly if subplot is enabled or legend is moved after plot (matplotlib 1.5.0 is required to draw area plot legend properly) (GH9161, GH13544)
• Bug in `DataFrame` assignment with an object-dtyped Index where the resultant column is mutable to the original object. (GH13522)
• Bug in matplotlib `AutoDataFormatter`; this restores the second scaled formatting and re-adds micro-second scaled formatting (GH13131)
• Bug in selection from a `HDFStore` with a fixed format and `start` and/or `stop` specified will now return the selected range (GH8287)
• Bug in `Categorical.from_codes()` where an unhelpful error was raised when an invalid `ordered` parameter was passed in (GH13522)
• Bug in `Series` construction from a tuple of integers on windows not returning default dtype (int64) (GH13646)
• Bug in `TimedeltaIndex` addition with a Datetime-like object where addition overflow was not being caught (GH14068)
• Bug in `.groupby(..).resample(..)` when the same object is called multiple times (GH13174)
• Bug in `.to_records()` when index name is a unicode string (GH13172)
• Bug in calling `.memory_usage()` on object which doesn’t implement (GH12924)
• Regression in `Series.quantile` with nans (also shows up in `.median()` and `.describe()`); furthermore now names the Series with the quantile (GH13098, GH13146)
• Bug in `SeriesGroupBy.transform` with datetime values and missing groups (GH13191)
• Bug where empty `Series` were incorrectly coerced in datetime-like numeric operations (GH13844)
• Bug in `Categorical` constructor when passed a `Categorical` containing datetimes with timezones (GH14190)
• Bug in `Series.str.extractall()` with str index raises `ValueError` (GH13156)
• Bug in `Series.str.extractall()` with single group and quantifier (GH13382)
• Bug in `DatetimeIndex` and `Period` subtraction raises `ValueError` or `AttributeError` rather than `TypeError` (GH13078)
• Bug in `Index` and `Series` created with NaN and NaT mixed data may not have `datetime64` dtype (GH13324)
• Bug in Index and Series may ignore np.datetime64('nat') and np.timedelta64('nat') to infer dtype (GH13324)
• Bug in PeriodIndex and Period subtraction raises AttributeError (GH13071)
• Bug in PeriodIndex construction returning a float64 index in some circumstances (GH13067)
• Bug in .resample(...) with a PeriodIndex not changing its freq appropriately when empty (GH13067)
• Bug in .resample(...) with a PeriodIndex not retaining its type or name with an empty DataFrame appropriately when empty (GH13212)
• Bug in groupby(...).apply(...) when the passed function returns scalar values per group (GH13468).
• Bug in groupby(...).resample(...) where passing some keywords would raise an exception (GH13235)
• Bug in .tz_convert on a tz-aware DateTimeIndex that relied on index being sorted for correct results (GH13066)
• Bug in .tz_localize with dateutil.tz.tzlocal may return incorrect result (GH13583)
• Bug in DatetimeTZDtype dtype with dateutil.tz.tzlocal cannot be regarded as valid dtype (GH13583)
• Bug in pd.read_hdf() where attempting to load an HDF file with a single dataset, that had one or more categorical columns, failed unless the key argument was set to the name of the dataset. (GH13231)
• Bug in .rolling() that allowed a negative integer window in construction of the Rolling() object, but would later fail on aggregation (GH13383)
• Bug in Series indexing with tuple-valued data and a numeric index (GH13509)
• Bug in printing pd.DataFrame where unusual elements with the object dtype were causing segfaults (GH13717)
• Bug in ranking Series which could result in segfaults (GH13445)
• Bug in various index types, which did not propagate the name of passed index (GH12309)
• Bug in DatetimeIndex, which did not honour the copy=True (GH13205)
• Bug in DatetimeIndex.is_normalized returns incorrectly for normalized date_range in case of local timezones (GH13459)
• Bug in pd.concat and .append may coerce datetime64 and timedelta to object dtype containing python built-in datetime or timedelta rather than Timestamp or Timedelta (GH13626)
• Bug in PeriodIndex.append may raises AttributeError when the result is object dtype (GH13221)
• Bug in CategoricalIndex.append may accept normal list (GH13626)
• Bug in pd.concat and .append with the same timezone get reset to UTC (GH7795)
• Bug in Series and DataFrame .append raises AmbiguousTimeError if data contains datetime near DST boundary (GH13626)
• Bug in DataFrame.to_csv() in which float values were being quoted even though quotations were specified for non-numeric values only (GH12922, GH13259)
• Bug in DataFrame.describe() raising ValueError with only boolean columns (GH13898)
• Bug in MultiIndex slicing where extra elements were returned when level is non-unique (GH12896)
• Bug in .str.replace does not raise TypeError for invalid replacement (GH13438)
• Bug in MultiIndex.from_arrays which didn’t check for input array lengths matching (GH13599)
• Bug in `cartesian_product` and `MultiIndex.from_product` which may raise with empty input arrays (GH12258)

• Bug in `pd.read_csv()` which may cause a segfault or corruption when iterating in large chunks over a stream/file under rare circumstances (GH13703)

• Bug in `pd.read_csv()` which caused errors to be raised when a dictionary containing scalars is passed in for `na_values` (GH12224)

• Bug in `pd.read_csv()` which caused BOM files to be incorrectly parsed by not ignoring the BOM (GH4793)

• Bug in `pd.read_csv()` with `engine='python'` which raised errors when a numpy array was passed in for `usecols` (GH12546)

• Bug in `pd.read_csv()` where the index columns were being incorrectly parsed when parsed as dates with a `thousands` parameter (GH14066)

• Bug in `pd.read_csv()` with `engine='python'` in which NaN values weren’t being detected after data was converted to numeric values (GH13314)

• Bug in `pd.read_csv()` in which the `nrows` argument was not properly validated for both engines (GH10476)

• Bug in `pd.read_csv()` with `engine='python'` in which infinities of mixed-case forms were not being interpreted properly (GH13274)

• Bug in `pd.read_csv()` with `engine='python'` in which trailing NaN values were not being parsed (GH13320)

• Bug in `pd.read_csv()` with `engine='python'` when reading from a `tempfile.TemporaryFile` on Windows with Python 3 (GH13398)

• Bug in `pd.read_csv()` that prevents `usecols` kwarg from accepting single-byte unicode strings (GH13219)

• Bug in `pd.read_csv()` that prevents `usecols` from being an empty set (GH13402)

• Bug in `pd.read_csv()` in the C engine where the NULL character was not being parsed as NULL (GH14012)

• Bug in `pd.read_csv()` with `engine='c'` in which NULL `quotechar` was not accepted even though `quoting` was specified as None (GH13411)

• Bug in `pd.read_csv()` with `engine='c'` in which fields were not properly cast to float when quoting was specified as non-numeric (GH13411)

• Bug in `pd.read_csv()` in Python 2.x with non-UTF8 encoded, multi-character separated data (GH3404)

• Bug in `pd.read_csv()`, where aliases for utf-xx (e.g. UTF-xx, UTF_xx, utf_xx) raised `UnicodeDecodeError` (GH13549)

• Bug in `pd.read_csv`, `pd.read_table`, `pd.read_fwf`, `pd.read_stata` and `pd.read_sas` where files were opened by parsers but not closed if both `chunksize` and `iterator` were `None`. (GH13940)

• Bug in `StataReader`, `StataWriter`, `XportReader` and `SAS7BDATReader` where a file was not properly closed when an error was raised. (GH13940)

• Bug in `pd.pivot_table()` where margins_name is ignored when `aggfunc` is a list (GH13354)

• Bug in `pd.Series.str.zfill`, `center`, `ljust`, `rjust`, and `pad` when passing non-integers, did not raise `TypeError` (GH13598)

• Bug in checking for any null objects in a `TimedeltaIndex`, which always returned `True` (GH13603)

• Bug in `Series arithmetic raises TypeError` if it contains datetime-like as object dtype (GH13043)
• Bug `Series.isnull()` and `Series.notnull()` ignore `Period('NaT')` (GH13737)
• Bug `Series.fillna()` and `Series.dropna()` don’t affect to `Period('NaT')` (GH13737)
• Bug in `.fillna(value=np.nan)` incorrectly raises `KeyError` on a category dtyped `Series` (GH14021)
• Bug in extension dtype creation where the created types were not is/identical (GH13285)
• Bug in `.resample(...)` where incorrect warnings were triggered by IPython introspection (GH13618)
• Bug in NaT-`Period` raises `AttributeError` (GH13071)
• Bug in `Series` comparison may output incorrect result if rhs contains NaT (GH9005)
• Bug in `Series` and `Index` comparison may output incorrect result if it contains NaT with object dtype (GH13592)
• Bug in `Period` addition raises `TypeError` if `Period` is on right hand side (GH13069)
• Bug in `Period` and `Series` or `Index` comparison raises `TypeError` (GH13200)
• Bug in `pd.set_eng_float_format()` that would prevent NaN and Inf from formatting (GH11981)
• Bug in `.unstack` with Categorical dtype resets .ordered to True (GH13249)
• Clean some compile time warnings in datetime parsing (GH13607)
• Bug in `factorize` raises `AmbiguousTimeError` if data contains datetime near DST boundary (GH13750)
• Bug in `.set_index` raises `AmbiguousTimeError` if new index contains DST boundary and multi levels (GH12920)
• Bug in `.shift` raises `AmbiguousTimeError` if data contains datetime near DST boundary (GH13926)
• Bug in `pd.read_hdf()` returns incorrect result when a DataFrame with a categorical column and a query which doesn’t match any values (GH13792)
• Bug in `.iloc` when indexing with a non lex-sorted MultiIndex (GH13797)
• Bug in `.loc` when indexing with date strings in a reverse sorted `DatetimeIndex` (GH14316)
• Bug in `Series` comparison operators when dealing with zero dim NumPy arrays (GH13006)
• Bug in `.combine_first` may return incorrect dtype (GH7630, GH10567)
• Bug in `groupby` where apply returns different result depending on whether first result is None or not (GH12824)
• Bug in `groupby(...).nth()` where the group key is included inconsistently if called after `.head()` / `.tail()` (GH12839)
• Bug in `.to_html`, `.to_latex` and `.to_string` silently ignore custom datetime formatter passed through the formatters key word (GH10690)
• Bug in `DataFrame.iterrows()`, not yielding a `Series` subclass if defined (GH13977)
• Bug in `pd.to_numeric` when errors='coerce' and input contains non-hashable objects (GH13324)
• Bug in invalid `Timedelta` arithmetic and comparison may raise `ValueError` rather than `TypeError` (GH13624)
• Bug in invalid datetime parsing in to_datetime and `DatetimeIndex` may raise `TypeError` rather than `ValueError` (GH11169, GH11287)
• Bug in `Index` created with tz-aware `Timestamp` and mismatched tz option incorrectly coerces timezone (GH13692)
• Bug in `Series` when setting a slice with a `np.timedelta64` (GH14155)
• Bug in Index raises `OutOfBoundsDatetime` if datetime exceeds `datetime64[ns]` bounds, rather than coercing to object dtype (GH13663)
• Bug in Index may ignore specified `datetime64` or `timedelta64` passed as dtype (GH13981)
• Bug in RangeIndex can be created without no arguments rather than raises `TypeError` (GH13793)
• Bug in `.value_counts()` raises `OutOfBoundsDatetime` if data exceeds `datetime64[ns]` bounds (GH13663)
• Bug in DatetimeIndex may raise `OutOfBoundsDatetime` if input `np.datetime64` has other unit than `ns` (GH9114)
• Bug in Series creation with `np.datetime64` which has other unit than `ns` as object dtype results in incorrect values (GH13876)
• Bug in resample with timedelta data where data was casted to float (GH13119).
• Bug in `pd.isnull()` `pd.notnull()` raise `TypeError` if input datetime-like has other unit than `ns` (GH13389)
• Bug in `pd.merge()` may raise `TypeError` if input datetime-like has other unit than `ns` (GH13389)
• Bug in `HDFStore/read_hdf()` discarded `DatetimeIndex.name` if tz was set (GH13884)
• Bug in Categorical.remove_unused_categories() changes `.codes` dtype to platform int (GH13261)
• Bug in `groupby` with `as_index=False` returns all NaN’s when grouping on multiple columns including a categorical one (GH13204)
• Bug in `df.groupby(...)[[...]]` where `getitem` with `Int64Index` raised an error (GH13731)
• Bug in `pd.read_gbq()` could throw `ImportError`: No module named discovery as a result of a naming conflict with another python package called `apiclient` (GH13454)
• Bug in Index.union returns an incorrect result with a named empty index (GH13432)
• Bugs in Index.difference and DataFrame.join raise in Python3 when using mixed-integer indexes (GH13432, GH12814)
• Bug in subtract tz-aware `datetime.datetime` from tz-aware `datetime64` series (GH14088)
• Bug in `.to_excel()` when DataFrame contains a MultiIndex which contains a label with a NaN value (GH13511)
• Bug in invalid frequency offset string like “D1”, “-2-3H” may not raise `ValueError` (GH13930)
• Bug in concat and groupby for hierarchical frames with `RangeIndex` levels (GH13542).
• Bug in `Series.str.contains()` for Series containing only NaN values of object dtype (GH14171)
• Bug in `agg()` function on groupby dataframe changes dtype of `datetime64[ns]` column to float64 (GH12821)
• Bug in using NumPy ufunc with PeriodIndex to add or subtract integer raise IncompatibleFrequency. Note that using standard operator like + or - is recommended, because standard operators use more efficient path (GH13980)

• Bug in operations on NaT returning float instead of datetime64[ns] (GH12941)

• Bug in Series flexible arithmetic methods (like .add()) raises ValueError when axis=None (GH13894)

• Bug in DataFrame.to_csv() with MultiIndex columns in which a stray empty line was added (GH6618)

• Bug in DatetimeIndex, TimedeltaIndex and PeriodIndex.equals() may return True when input isn’t Index but contains the same values (GH13107)

• Bug in assignment against datetime with timezone may not work if it contains datetime near DST boundary (GH14146)

• Bug in pd.eval() and HDFStore query truncating long float literals with python 2 (GH14241)

• Bug in Index raises KeyError displaying incorrect column when column is not in the df and columns contains duplicate values (GH13822)

• Bug in Period and PeriodIndex creating wrong dates when frequency has combined offset aliases (GH13874)

• Bug in .to_string() when called with an integer line_width and index=False raises an Unbound-LocalError exception because idx referenced before assignment.

• Bug in eval() where the resolvers argument would not accept a list (GH14095)

• Bugs in stack, get_dummies, make_axis_dummies which don’t preserve categorical dtypes in (multi)indexes (GH13854)

• PeriodIndex can now accept list and array which contains pd.NaT (GH13430)

• Bug in df.groupby where .median() returns arbitrary values if grouped dataframe contains empty bins (GH13629)

• Bug in Index.copy() where name parameter was ignored (GH13430)

1.13 v0.18.1 (May 3, 2016)

This is a minor bug-fix release from 0.18.0 and includes a large number of bug fixes along with several new features, enhancements, and performance improvements. We recommend that all users upgrade to this version.

Highlights include:

• .groupby(...) has been enhanced to provide convenient syntax when working with .rolling(..), .expanding(..) and .resample(..) per group, see here

• pd.to_datetime() has gained the ability to assemble dates from a DataFrame, see here

• Method chaining improvements, see here.

• Custom business hour offset, see here.

• Many bug fixes in the handling of sparse, see here

• Expanded the Tutorials section with a feature on modern pandas, courtesy of @TomAugsburger. (GH13045).
What’s new in v0.18.1

- **New features**
  - Custom Business Hour
  - `.groupby(..)` syntax with window and resample operations
  - Method chaining improvements
    - `.where()` and `.mask()`
    - `.loc[]`, `.iloc[]`, `.ix[]`
    - `[]` indexing
  - Partial string indexing on `DateTimeIndex` when part of a `MultiIndex`
  - Assembling Datetimes
  - Other Enhancements
- **Sparse changes**
- **API changes**
  - `.groupby(..).nth()` changes
  - numpy function compatibility
  - Using `.apply` on groupby resampling
  - Changes in `read_csv` exceptions
  - `to_datetime` error changes
  - Other API changes
  - Deprecations
- **Performance Improvements**
- **Bug Fixes**

### 1.13.1 New features

#### 1.13.1.1 Custom Business Hour

The `CustomBusinessHour` is a mixture of `BusinessHour` and `CustomBusinessDay` which allows you to specify arbitrary holidays. For details, see Custom Business Hour (GH11514)

```python
In [1]: from pandas.tseries.offsets import CustomBusinessHour
In [2]: from pandas.tseries.holiday import USFederalHolidayCalendar
In [3]: bhour_us = CustomBusinessHour(calendar=USFederalHolidayCalendar())
```

Friday before MLK Day

```python
In [4]: dt = datetime(2014, 1, 17, 15)
```

(continues on next page)
Tuesday after MLK Day (Monday is skipped because it’s a holiday)

```python
In [6]: dt + bhour_us * 2
Out[6]: Timestamp('2014-01-20 09:00:00')
```

### 1.13.1.2 `.groupby()` syntax with window and resample operations

`.groupby()` has been enhanced to provide convenient syntax when working with `.rolling()`, `.expanding()` and `.resample()` per group, see (GH12486, GH12738).

You can now use `.rolling()` and `.expanding()` as methods on groupbys. These return another deferred object (similar to what `.rolling()` and `.expanding()` do on ungrouped pandas objects). You can then operate on these `RollingGroupby` objects in a similar manner.

Previously you would have to do this to get a rolling window mean per-group:

```python
                          'B': np.arange(40)})
In [8]: df.groupby('A').apply(lambda x: x.rolling(4).B.mean())
Out[9]:
   A
0  1   NaN
1  1   NaN
2  1   NaN
3  1   1.5
4  1   2.5
5  1   3.5
6  1   4.5
```

(continues on next page)
Now you can do:

```python
In [10]: df.groupby('A').rolling(4).B.mean()
Out[10]:
   A
0  0  NaN
  1  NaN
  2  NaN
  3  1.5
  4  2.5
  5  3.5
  6  4.5
... 
3  33  NaN
  34  NaN
  35  33.5
  36  34.5
  37  35.5
  38  36.5
  39  37.5
Name: B, Length: 40, dtype: float64
```

For `.resample()` type of operations, previously you would have to:

```python
In [11]: df = pd.DataFrame({'date': pd.date_range(start='2016-01-01',
                           ....:               periods=4,
                           ....:               freq='W'),
                           ....:               'group': [1, 1, 2, 2],
                           ....:               'val': [5, 6, 7, 8]}).set_index('date')

In [12]: df
Out[12]:
   group  val
date
2016-01-03  1   5
2016-01-10  1   6
2016-01-17  2   7
2016-01-24  2   8
```

```python
In [13]: df.groupby('group').apply(lambda x: x.resample('1D').ffill())
Out[13]:
   group  val
group date
1  2016-01-03  1   5
    2016-01-04  1   5
    2016-01-05  1   5
```
Now you can do:

```python
In [14]: df.groupby('group').resample('1D').ffill()
Out[14]:
       group  val
  group date
1  2016-01-03  1  5
   2016-01-04  1  5
   2016-01-05  1  5
   2016-01-06  1  5
   2016-01-07  1  5
   2016-01-08  1  5
   2016-01-09  1  5
... ... ...
2  2016-01-18  2  7
   2016-01-19  2  7
   2016-01-20  2  7
   2016-01-21  2  7
   2016-01-22  2  7
   2016-01-23  2  7
   2016-01-24  2  8
```

[16 rows x 2 columns]

1.13.1.3 Method chaining improvements

The following methods/indexers now accept a callable. It is intended to make these more useful in method chains, see the documentation. (GH11485, GH12533)

- `.where()` and `.mask()`
- `.loc[]`, `.iloc[]` and `.ix[]`
- `[]` indexing

`.where()` and `.mask()`

These can accept a callable for the condition and other arguments.
In [15]: df = pd.DataFrame({'A': [1, 2, 3],
                      'B': [4, 5, 6],
                      'C': [7, 8, 9]})

In [16]: df.where(lambda x: x > 4, lambda x: x + 10)
Out[16]:
   A  B  C
0  5 14  7
1 12  5  8
2 13  6  9

.loc[], .iloc[], .ix[]

These can accept a callable, and a tuple of callable as a slicer. The callable can return a valid boolean indexer or
anything which is valid for these indexer's input.

# callable returns bool indexer
In [17]: df.loc[lambda x: x.A >= 2, lambda x: x.sum() > 10]
Out[17]:
   B  C
0  5  8
1  6  9

# callable returns list of labels
In [18]: df.loc[lambda x: [1, 2], lambda x: ['A', 'B']]
Out[18]:
   A  B
0  2  5
1  3  6

[] indexing

Finally, you can use a callable in [] indexing of Series, DataFrame and Panel. The callable must return a valid input
for [] indexing depending on its class and index type.

In [19]: df[lambda x: 'A']
Out[19]:
   0  1
   1  2
   2  3
Name: A, dtype: int64

Using these methods / indexers, you can chain data selection operations without using temporary variable.

In [20]: bb = pd.read_csv('data/baseball.csv', index_col='id')

In [21]: (bb.groupby(['year', 'team'])
              .sum()
              .loc[lambda df: df.r > 100]
       )
Out[21]:

(continues on next page)
### 1.13.1.4 Partial string indexing on `DateTimeIndex` when part of a `MultiIndex`

Partial string indexing now matches on `DateTimeIndex` when part of a `MultiIndex` (GH10331)

```
In [22]: dft2 = pd.DataFrame(np.random.randn(20, 1),
                         columns=['A'],
                         index=pd.MultiIndex.from_product([pd.date_range('20130101', periods=10, freq='12H'), ['a', 'b']]))
```

```
In [23]: dft2
```

```
Out[23]:
A
2013-01-01 00:00:00 a   0.156998
   b   -0.571455
2013-01-01 12:00:00 a   1.057633
   b   -0.791489
2013-01-02 00:00:00 a   -0.524627
   b    0.071878
2013-01-02 12:00:00 a   1.910759
   b   -0.276646
```

(continues on next page)
On other levels

```
In [25]: idx = pd.IndexSlice

In [26]: dft2 = dft2.swaplevel(0, 1).sort_index()

In [27]: dft2
```

```
Out[27]:
    A
   a  2013-01-01 00:00:00  0.156998
       2013-01-01 12:00:00  1.057633
       2013-01-02 00:00:00 -0.524627
       2013-01-02 12:00:00  1.910759
       2013-01-03 00:00:00  0.513082
       2013-01-03 12:00:00  1.043945
       2013-01-04 00:00:00  1.459927
       ... ...  
   b  2013-01-02 12:00:00  0.787965
       2013-01-03 00:00:00 -0.546416
       2013-01-03 12:00:00  2.107785
       2013-01-04 00:00:00  1.015405
       2013-01-04 12:00:00 -0.675521
       2013-01-05 00:00:00  0.688972
       2013-01-05 12:00:00  1.924533
```

```
[20 rows x 1 columns]
```

```
In [28]: dft2.loc[idx[:, '2013-01-05'], :]
```

```
Out[28]:
    A
   a  2013-01-05 00:00:00  0.440266
      2013-01-05 12:00:00 -0.276646
   b  2013-01-05 00:00:00  0.688972
      2013-01-05 12:00:00  1.924533
```

```
[20 rows x 1 columns]
```

### 1.13.1.5 Assembling Datetimes

`pd.to_datetime()` has gained the ability to assemble datetimes from a passed in DataFrame or a dict. (GH8158).

```
In [29]: df = pd.DataFrame({'year': [2015, 2016],
                      'month': [2, 3],
                      'day': [4, 5],
                      'hour': [23, 12]})
```
Assembling using the passed frame.

```python
In [31]: pd.to_datetime(df)
Out[31]:
0 2015-02-04 02:00:00
1 2016-03-05 03:00:00
dtype: datetime64[ns]
```

You can pass only the columns that you need to assemble.

```python
In [32]: pd.to_datetime(df[['year', 'month', 'day']])
Out[32]:
0 2015-02-04
1 2016-03-05
dtype: datetime64[ns]
```

### 1.13.1.6 Other Enhancements

- `pd.read_csv()` now supports `delim_whitespace=True` for the Python engine (GH12958)
- `pd.read_csv()` now supports opening ZIP files that contains a single CSV, via extension inference or explicit `compression='zip'` (GH12175)
- `pd.read_csv()` now supports opening files using xz compression, via extension inference or explicit `compression='xz'` is specified; xz compressions is also supported by `DataFrame.to_csv` in the same way (GH11852)
- `pd.read_msgpack()` now always gives writeable ndarrays even when compression is used (GH12359).
- `pd.read_msgpack()` now supports serializing and de-serializing categoricals with msgpack (GH12573)
- `.to_json()` now supports `NDFrames` that contain categorical and sparse data (GH10778)
- `interpolate()` now supports `method='akima'` (GH7588).
- `pd.read_excel()` now accepts path objects (e.g. `pathlib.Path`, `py.path.local`) for the file path, in line with other `read_*` functions (GH12655)
- Added `.weekday_name` property as a component to `DatetimeIndex` and the `.dt` accessor. (GH11128)
- `Index.take` now handles `allow_fill` and `fill_value` consistently (GH12631)

```python
In [33]: idx = pd.Index([1., 2., 3., 4.], dtype='float')

# default, allow_fill=True, fill_value=None
In [34]: idx.take([2, -1])
Out[34]: Float64Index([3.0, 4.0], dtype='float64')
```

(continues on next page)
In [35]: idx.take([2, -1], fill_value=True)

Out[35]: Float64Index([3.0, nan], dtype='float64')

Index now supports .str.get_dummies() which returns MultiIndex, see Creating Indicator Variables (GH10008, GH10103)

In [36]: idx = pd.Index(['a|b', 'a|c', 'b|c'])

In [37]: idx.str.get_dummies('|')

Out[37]: MultiIndex(levels=[[0, 1], [0, 1], [0, 1]],
labels=[[1, 1, 0], [1, 0, 1], [0, 1, 1]],
names=['a', 'b', 'c'])

- pd.crosstab() has gained a normalize argument for normalizing frequency tables (GH12569). Examples in the updated docs here.
- .resample(..).interpolate() is now supported (GH12925)
- .isin() now accepts passed sets (GH12988)

1.13.2 Sparse changes

These changes conform sparse handling to return the correct types and work to make a smoother experience with indexing.

SparseArray.take now returns a scalar for scalar input, SparseArray for others. Furthermore, it handles a negative indexer with the same rule as Index (GH10560, GH12796)

In [38]: s = pd.SparseArray([np.nan, np.nan, 1, 2, 3, np.nan, 4, 5, np.nan, 6])

In [39]: s.take(0)

Out[39]: nan

In [40]: s.take([1, 2, 3])

[1.0, 2.0]

- Bug in SparseSeries[] indexing with Ellipsis raises KeyError (GH9467)
- Bug in SparseArray[] indexing with tuples are not handled properly (GH12966)
- Bug in SparseSeries.loc[] with list-like input raises TypeError (GH10560)
- Bug in SparseSeries.iloc[] with scalar input may raise IndexError (GH10560)
- Bug in SparseSeries.loc[], .iloc[] with slice returns SparseArray, rather than SparseSeries (GH10560)
- Bug in SparseDataFrame.loc[], .iloc[] may results in dense Series, rather than SparseSeries (GH12787)
- Bug in SparseArray addition ignores fill_value of right hand side (GH12910)
- Bug in SparseArray mod raises AttributeError (GH12910)
• Bug in SparseArray pow calculates 1 ** np.nan as np.nan which must be 1 (GH12910)
• Bug in SparseArray comparison output may incorrect result or raise ValueError (GH12971)
• Bug in SparseSeries.__repr__ raises TypeError when it is longer than max_rows (GH10560)
• Bug in SparseSeries.shape ignores fill_value (GH10452)
• Bug in SparseSeries and SparseArray may have different dtype from its dense values (GH12908)
• Bug in SparseSeries.reindex incorrectly handle fill_value (GH12797)
• Bug in SparseArray.to_frame() results in DataFrame, rather than SparseDataFrame (GH9850)
• Bug in SparseSeries.value_counts() does not count fill_value (GH6749)
• Bug in SparseArray.to_dense() does not preserve dtype (GH10648)
• Bug in SparseArray.to_dense() incorrectly handle fill_value (GH12797)
• Bug in pd.concat() of SparseSeries results in dense (GH10536)
• Bug in pd.concat() of SparseDataFrame incorrectly handle fill_value (GH9765)
• Bug in pd.concat() of SparseDataFrame may raise AttributeError (GH12174)
• Bug in SparseArray.shift() may raise NameError or TypeError (GH12908)

1.13.3 API changes

1.13.3.1 .groupby(..).nth() changes

The index in .groupby(..).nth() output is now more consistent when the as_index argument is passed (GH11039):

```python
In [41]: df = DataFrame({'A': ['a', 'b', 'a'],
                   'B': [1, 2, 3]})

In [42]: df
Out[42]:
   A  B
0  a  1
1  b  2
2  a  3

Previous Behavior:

In [3]: df.groupby('A', as_index=True)['B'].nth(0)
Out[3]:
   0  1
   1  2
Name: B, dtype: int64

In [4]: df.groupby('A', as_index=False)['B'].nth(0)
Out[4]:
   0  1
   1  2
Name: B, dtype: int64

New Behavior:
```
In [43]: df.groupby('A', as_index=True)['B'].nth(0)
Out[43]:
   A
a 1
b 2
Name: B, dtype: int64

In [44]: df.groupby('A', as_index=False)['B'].nth(0)
Out[44]:
   0 1
   1 2
Name: B, dtype: int64

Furthermore, previously, a .groupby would always sort, regardless if sort=False was passed with .nth().

In [45]: np.random.seed(1234)
In [46]: df = pd.DataFrame(np.random.randn(100, 2), columns=['a', 'b'])
In [47]: df['c'] = np.random.randint(0, 4, 100)

Previous Behavior:

In [4]: df.groupby('c', sort=True).nth(1)
Out[4]:
   a   b
c  
0 -0.334077  0.002118
1  0.036142 -2.074978
2 -0.720589  0.887163
3  0.859588 -0.636524

In [5]: df.groupby('c', sort=False).nth(1)
Out[5]:
   a   b
   c  
0 -0.334077  0.002118
1  0.036142 -2.074978
2 -0.720589  0.887163
3  0.859588 -0.636524

New Behavior:

In [48]: df.groupby('c', sort=True).nth(1)
Out[48]:
   a   b
   c  
0 -0.334077  0.002118
1  0.036142 -2.074978
2 -0.720589  0.887163
3  0.859588 -0.636524

In [49]: df.groupby('c', sort=False).nth(1)
   →
Out[49]:
   →
   a   b
   →
   c
(continues on next page)
1.13.3.2 numpy function compatibility

Compatibility between pandas array-like methods (e.g. `sum` and `take`) and their numpy counterparts has been greatly increased by augmenting the signatures of the pandas methods so as to accept arguments that can be passed in from numpy, even if they are not necessarily used in the pandas implementation (GH12644, GH12638, GH12687)

- `.searchsorted()` for Index and TimedeltaIndex now accept a sorter argument to maintain compatibility with numpy’s `searchsorted` function (GH12238)
- Bug in numpy compatibility of `np.round()` on a Series (GH12600)

An example of this signature augmentation is illustrated below:

```python
In [50]: sp = pd.SparseDataFrame([1, 2, 3])
In [51]: sp
Out[51]:
   0  1  2  3
0   0  1  2  3
```

Previous behaviour:

```python
In [2]: np.cumsum(sp, axis=0)
...: TypeError: cumsum() takes at most 2 arguments (4 given)
```

New behaviour:

```python
In [52]: np.cumsum(sp, axis=0)
Out[52]:
   0  1  2  3
0   0  1  2  3
1   3  6  9
2   6
```

1.13.3.3 Using `.apply` on groupby resampling

Using `.apply` on resampling groupby operations (using a `pd.TimeGrouper`) now has the same output types as similar `.apply` calls on other groupby operations. (GH11742).

```python
In [53]: df = pd.DataFrame({'date': pd.to_datetime(['10/10/2000', '11/10/2000']), 'value': [10, 13]})
In [54]: df
Out[54]:
   date  value
0  10/10  10
1  11/10  13
```

(continues on next page)
Previous behavior:

```python
In [1]: df.groupby(pd.TimeGrouper(key='date', freq='M')).apply(lambda x: x.value.
...:     .sum())
Out[1]:
...:
TypeError: cannot concatenate a non-NDFrame object

# Output is a Series
In [2]: df.groupby(pd.TimeGrouper(key='date', freq='M')).apply(lambda x: x[['value']].
...:     .sum())
Out[2]:
date
2000-10-31 value 10
2000-11-30 value 13
dtype: int64
```

New behavior:

```python
# Output is a Series
In [55]: df.groupby(pd.TimeGrouper(key='date', freq='M')).apply(lambda x: x.value.
...:     .sum())
Out[55]:
date
2000-10-31 10
2000-11-30 13
Freq: M, dtype: int64

# Output is a DataFrame
In [56]: df.groupby(pd.TimeGrouper(key='date', freq='M')).apply(lambda x: x[['value
...:     ']].sum())
Out[56]:
value
date
2000-10-31 10
2000-11-30 13
```

### 1.13.3.4 Changes in `read_csv` exceptions

In order to standardize the `read_csv` API for both the c and python engines, both will now raise an `EmptyDataError`, a subclass of `ValueError`, in response to empty columns or header (GH12493, GH12506)

Previous behaviour:

```python
In [1]: df = pd.read_csv(StringIO(''), engine='c')
...:
ValueError: No columns to parse from file

In [2]: df = pd.read_csv(StringIO(''), engine='python')
...:
StopIteration
```

New behaviour:
In [1]: df = pd.read_csv(StringIO(''), engine='c')
...
    pandas.io.common.EmptyDataError: No columns to parse from file

In [2]: df = pd.read_csv(StringIO(''), engine='python')
...
    pandas.io.common.EmptyDataError: No columns to parse from file

In addition to this error change, several others have been made as well:

- CParserError now sub-classes ValueError instead of just a Exception (GH12551)
- A CParserError is now raised instead of a generic Exception in read_csv when the c engine cannot parse a column (GH12506)
- A ValueError is now raised instead of a generic Exception in read_csv when the c engine encounters a NaN value in an integer column (GH12506)
- A ValueError is now raised instead of a generic Exception in read_csv when true_values is specified, and the c engine encounters an element in a column containing unencodable bytes (GH12506)
- pandas.parser.OverflowError exception has been removed and has been replaced with Python’s built-in OverflowError exception (GH12506)
- pd.read_csv() no longer allows a combination of strings and integers for the usecols parameter (GH12678)

1.13.3.5 to_datetime error changes

Bugs in pd.to_datetime() when passing a unit with convertible entries and errors='coerce' or non-convertible with errors='ignore'. Furthermore, an OutOfBoundsDatetime exception will be raised when an out-of-range value is encountered for that unit when errors='raise'. (GH11758, GH13052, GH13059)

Previous behaviour:

In [27]: pd.to_datetime(1420043460, unit='s', errors='coerce')
Out[27]: NaT

In [28]: pd.to_datetime(11111111, unit='D', errors='ignore')
OverflowError: Python int too large to convert to C long

In [29]: pd.to_datetime(11111111, unit='D', errors='raise')
OverflowError: Python int too large to convert to C long

New behaviour:

In [2]: pd.to_datetime(1420043460, unit='s', errors='coerce')
Out[2]: Timestamp('2014-12-31 16:31:00')

In [3]: pd.to_datetime(11111111, unit='D', errors='ignore')
Out[3]: 11111111

In [4]: pd.to_datetime(11111111, unit='D', errors='raise')
OutOfBoundsDatetime: cannot convert input with unit 'D'
1.13.3.6 Other API changes

- `.swaplevel()` for Series, DataFrame, Panel, and MultiIndex now features defaults for its first two parameters i and j that swap the two innermost levels of the index. (GH12934)
- `.searchsorted()` for Index and TimedeltaIndex now accept a sorter argument to maintain compatibility with numpy’s searchsorted function (GH12238)
- Period and PeriodIndex now raises IncompatibleFrequency error which inherits ValueError rather than raw ValueError (GH12615)
- Series.apply for category dtype now applies the passed function to each of the .categories (and not the .codes), and returns a category dtype if possible (GH12473)
- read_csv will now raise a TypeError if parse_dates is neither a boolean, list, or dictionary (matches the doc-string) (GH5636)
- The default for .query()/.eval() is now engine=None, which will use numexpr if it’s installed; otherwise it will fallback to the python engine. This mimics the pre-0.18.1 behavior if numexpr is installed (and which, previously, if numexpr was not installed, .query()/.eval() would raise). (GH12749)
- pd.show_versions() now includes pandas_datareader version (GH12740)
- Provide a proper __name__ and __qualname__ attributes for generic functions (GH12021)
- pd.concat(ignore_index=True) now uses RangeIndex as default (GH12695)
- pd.merge() and DataFrame.join() will show a UserWarning when merging/joining a single- with a multi-leveled dataframe (GH9455, GH12219)
- Compat with scipy > 0.17 for deprecated piecewise_polynomial interpolation method; support for the replacement from_derivatives method (GH12887)

1.13.3.7 Deprecations

- The method name Index.sym_diff() is deprecated and can be replaced by Index. symmetric_difference() (GH12591)
- The method name Categorical.sort() is deprecated in favor of Categorical.sort_values() (GH12882)

1.13.4 Performance Improvements

- Improved speed of SAS reader (GH12656, GH12961)
- Performance improvements in .groupby().cumcount() (GH11039)
- Improved memory usage in pd.read_csv() when using skiprows=an_integer (GH13005)
- Improved performance of DataFrame.to_sql when checking case sensitivity for tables. Now only checks if table has been created correctly when table name is not lower case. (GH12876)
- Improved performance of Period construction and time series plotting (GH12903, GH11831).
- Improved performance of .str.encode() and .str.decode() methods (GH13008)
- Improved performance of to_numeric if input is numeric dtype (GH12777)
- Improved performance of sparse arithmetic with IntIndex (GH13036)
1.13.5 Bug Fixes

- The `usecols` parameter in `pd.read_csv` is now respected even when the lines of a CSV file are not even (GH12203)

- Bug in `groupby.transform(...)` when `axis=1` is specified with a non-monotonic ordered index (GH12713)

- Bug in `Period` and `PeriodIndex` creation raises `KeyError` if `freq="Minute"` is specified. Note that “Minute” freq is deprecated in v0.17.0, and recommended to use `freq="T"` instead (GH11854)

- Bug in `.resample(...).count()` with a `PeriodIndex` always raising a `TypeError` (GH12774)

- Bug in `.resample(...)` with a `PeriodIndex` casting to a `DatetimeIndex` when empty (GH12868)

- Bug in printing data which contains `Period` with different `freq` raises `ValueError` (GH12615)

- Bug in `Series` construction with `Categorical` and `dtype='category'` is specified (GH12574)

- Bugs in concatenation with a coercable dtype was too aggressive, resulting in different dtypes in output formatting when an object was longer than `display.max_rows` (GH12411, GH12045, GH11594, GH10571, GH12211)

- Bug in `float_format` option with option not being validated as a callable. (GH12706)

- Bug in `GroupBy.filter` when `dropna=False` and no groups fulfilled the criteria (GH12768)

- Bug in `__name__` of ` cum*` functions (GH12021)

- Bug in `.astype()` of a `Float64Inde/Int64Index` to an `Int64Index` (GH12881)

- Bug in roundtripping an integer based index in `.to_json()/read_json()` when `orient='index'` (the default) (GH12866)

- Bug in plotting `Categorical` dtypes cause error when attempting stacked bar plot (GH13019)

- Compat with >= numpy 1.11 for `NaT` comparisons (GH12969)

- Bug in `.drop()` with a non-unique `MultiIndex`. (GH12701)

- Bug in `.concat` of `datetime` tz-aware and naive DataFrames (GH12467)

- Bug in correctly raising a `ValueError` in `.resample(...).fillna(...)` when passing a non-string (GH12952)

- Bug fixes in various encoding and header processing issues in `pd.read_sas()` (GH12659, GH12654, GH12647, GH12809)

- Bug in `pd.crosstab()` where would silently ignore `aggfunc` if `values=None` (GH12569).

- Potential segfault in `DataFrame.to_json` when serialising `datetime.time` (GH11473).

- Potential segfault in `DataFrame.to_json` when attempting to serialise 0d array (GH11299).

- Segfault in `to_json` when attempting to serialise a `DataFrame` or `Series` with non-ndarray values; now supports serialization of `category`, `sparse`, and `datetime64[ns, tz]` dtypes (GH10778).

- Bug in `DataFrame.to_json` with unsupported dtype not passed to default handler (GH12554).

- Bug in `.align` not returning the sub-class (GH12983)

- Bug in aligning a `Series` with a `DataFrame` (GH13037)

- Bug in `ABCPanel` in which `Panel4D` was not being considered as a valid instance of this generic type (GH12810)
- Bug in consistency of .name on .groupby().apply(). cases (GH12363)
- Bug in Timestamp.__repr__ that caused pprint to fail in nested structures (GH12622)
- Bug in Timedelta.min and Timedelta.max, the properties now report the true minimum/maximum timedeltas as recognized by pandas. See the documentation. (GH12727)
- Bug in .quantile() with interpolation may coerce to float unexpectedly (GH12772)
- Bug in .quantile() with empty Series may return scalar rather than empty Series (GH12772)
- Bug in .loc with out-of-bounds in a large indexer would raise IndexError rather than KeyError (GH12527)
- Bug in resampling when using a TimedeltaIndex and .asfreq(), would previously not include the final fencepost (GH12926)
- Bug in equality testing with a Categorical in a DataFrame (GH12564)
- Bug in GroupBy.first(), .last() returns incorrect row when TimeGrouper is used (GH7453)
- Bug in pd.read_csv() with the c engine when specifying skiprows with newlines in quoted items (GH10911, GH12775)
- Bug in DataFrame timezone lost when assigning tz-aware datetime Series with alignment (GH12981)
- Bug in .value_counts() when normalize=True and dropna=True where nulls still contributed to the normalized count (GH12558)
- Bug in Series.value_counts() loses name if its dtype is category (GH12835)
- Bug in Series.value_counts() loses timezone info (GH12835)
- Bug in Series.value_counts(normalize=True) with Categorical raises UnboundLocalError (GH12835)
- Bug in Panel.fillna() ignoring inplace=True (GH12633)
- Bug in pd.read_csv() when specifying names, usecols, and parse_dates simultaneously with the c engine (GH9755)
- Bug in pd.read_csv() when specifying delim_whitespace=True and lineterminator simultaneously with the c engine (GH12912)
- Bug in Series.rename, DataFrame.rename and DataFrame.rename_axis not treating Series as mappings to relabel (GH12623).
- Clean in .rolling.min and .rolling.max to enhance dtype handling (GH12373)
- Bug in groupby where complex types are coerced to float (GH12902)
- Bug in Series.map raises TypeError if its dtype is category or tz-aware datetime (GH12473)
- Bugs on 32bit platforms for some test comparisons (GH12972)
- Bug in index coercion when falling back from RangeIndex construction (GH12893)
- Better error message in window functions when invalid argument (e.g. a float window) is passed (GH12669)
- Bug in slicing subclassed DataFrame defined to return subclassed Series may return normal Series (GH11559)
- Bug in .str accessor methods may raise ValueError if input has name and the result is DataFrame or MultiIndex (GH12617)
- Bug in DataFrame.last_valid_index() and DataFrame.first_valid_index() on empty frames (GH12800)
• Bug in CategoricalIndex.get_loc returns different result from regular Index (GH12531)
• Bug in PeriodIndex.resample where name not propagated (GH12769)
• Bug in date_range closed keyword and timezones (GH12684).
• Bug in pd.concat raises AttributeError when input data contains tz-aware datetime and timedelta (GH12620)
• Bug in pd.concat did not handle empty Series properly (GH11082)
• Bug in .plot.bar alignment when width is specified with int (GH12979)
• Bug in fill_value is ignored if the argument to a binary operator is a constant (GH12723)
• Bug in pd.read_html() when using bs4 flavor and parsing table with a header and only one column (GH9178)
• Bug in .pivot_table when margins=True and dropna=True where nulls still contributed to margin count (GH12577)
• Bug in .pivot_table when dropna=False where table index/column names disappear (GH12133)
• Bug in pd.crosstab() when margins=True and dropna=False which raised (GH12642)
• Bug in Series.name when name attribute can be a hashable type (GH12610)
• Bug in .describe() resets categorical columns information (GH11558)
• Bug where loffset argument was not applied when calling resample().count() on a timeseries (GH12725)
• pd.read_excel() now accepts column names associated with keyword argument names (GH12870)
• Bug in pd.to_numeric() with Index returns np.ndarray, rather than Index (GH12777)
• Bug in pd.to_numeric() with datetime-like may raise TypeError (GH12777)
• Bug in pd.to_numeric() with scalar raises ValueError (GH12777)

1.14 v0.18.0 (March 13, 2016)

This is a major release from 0.17.1 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Warning: pandas >= 0.18.0 no longer supports compatibility with Python version 2.6 and 3.3 (GH7718, GH11273)

Warning: numexpr version 2.4.4 will now show a warning and not be used as a computation back-end for pandas because of some buggy behavior. This does not affect other versions (>= 2.1 and >= 2.4.6). (GH12489)

Highlights include:
• Moving and expanding window functions are now methods on Series and DataFrame, similar to .groupby, see here.
• Adding support for a RangeIndex as a specialized form of the Int64Index for memory savings, see here.
• API breaking change to the .resample method to make it more .groupby like, see here.
• Removal of support for positional indexing with floats, which was deprecated since 0.14.0. This will now raise a TypeError, see here.
• The .to_xarray() function has been added for compatibility with the xarray package, see here.
• The read_sas function has been enhanced to read sas7bdat files, see here.
• Addition of the .str.extractall() method, and API changes to the .str.extract() method and .str.cat() method.
• pd.test() top-level nose test runner is available (GH4327).

Check the API Changes and deprecations before updating.

What’s new in v0.18.0

• New features
  – Window functions are now methods
  – Changes to rename
  – Range Index
  – Changes to str.extract
  – Addition of str.extractall
  – Changes to str.cat
  – Datetimelike rounding
  – Formatting of Integers in FloatIndex
  – Changes to dtype assignment behaviors
  – to_xarray
  – Latex Representation
  – pd.read_sas() changes
  – Other enhancements

• Backwards incompatible API changes
  – NaT and Timedelta operations
  – Changes to msgpack
  – Signature change for .rank
  – Bug in QuarterBegin with n=0
  – Resample API
    * Downsampling
    * Upsampling
    * Previous API will work but with deprecations
  – Changes to eval
  – Other API Changes
  – Deprecations
1.14.1 New features

1.14.1.1 Window functions are now methods

Window functions have been refactored to be methods on Series/DataFrame objects, rather than top-level functions, which are now deprecated. This allows these window-type functions, to have a similar API to that of .groupby. See the full documentation here (GH11603, GH12373)

```python
In [1]: np.random.seed(1234)
In [2]: df = pd.DataFrame({'A': range(10), 'B': np.random.randn(10)})
In [3]: df
Out[3]:
   A   B
0  0  0.471435
1  1 -1.190976
2  2  1.432707
3  3 -0.312652
4  4 -0.720589
5  5  0.887163
6  6  0.859588
7  7 -0.636524
8  8  0.015696
9  9 -2.242685
```

Previous Behavior:

```python
In [8]: pd.rolling_mean(df, window=3)
FutureWarning: pd.rolling_mean is deprecated for DataFrame and will be removed in a future version, replace with DataFrame.rolling(window=3, center=False).mean()
Out[8]:
    A   B
0  NaN  NaN
1  NaN  NaN
2  1  0.237722
3  2 -0.023640
4  3  0.133155
5  4 -0.048693
6  5  0.342054
7  6  0.370076
8  7  0.079587
9  8 -0.954504
```

New Behavior:

```python
In [4]: r = df.rolling(window=3)
```
These show a descriptive repr

```
In [5]: r
Out[5]: Rolling [window=3, center=False, axis=0]
```

with tab-completion of available methods and properties.

```
In [9]: r.
   ...: r.A r.agg r.apply r.count r.exclusions r.max r.
   ...: r.median r.name r.skew r.sum
   ...: r.B r.aggregate r.corr r.cov r.kurt r.mean r.
   ...: r.min r.quantile r.std r.var
```

The methods operate on the `Rolling` object itself

```
In [6]: r.mean()
Out[6]:
   A    B
  ---  ---
  0  NaN  NaN
  1 NaN   NaN
  2  1.0  0.237722
  3  2.0 -0.023640
  4  3.0  0.133155
  5  4.0 -0.048693
  6  5.0  0.342054
  7  6.0  0.370076
  8  7.0  0.079587
  9  8.0 -0.954504
```

They provide `getitem` accessors

```
In [7]: r['A'].mean()
Out[7]:
   0  NaN
   1  NaN
   2  1.0
   3  2.0
   4  3.0
   5  4.0
   6  5.0
   7  6.0
   8  7.0
   9  8.0
Name: A, dtype: float64
```

And multiple aggregations

```
In [8]: r.agg({'A' : ['mean','std'],
   ...: 'B' : ['mean','std']})
Out[8]:
   A         B
  ---  ---
  0 NaN    NaN   NaN   NaN
  1 NaN    NaN   NaN   NaN
  2  1.0   0.237722  1.327364
  3  2.0 -0.023640  1.335505
  4  3.0  0.133155  1.143778
```

(continues on next page)
5 4.0 1.0 -0.048693 0.835747
6 5.0 1.0 0.342054 0.920379
7 6.0 1.0 0.370076 0.871850
8 7.0 1.0 0.079587 0.750099
9 8.0 1.0 -0.954504 1.162285

1.14.1.2 Changes to rename

Series.rename and NDFrame.rename_axis can now take a scalar or list-like argument for altering the Series or axis name, in addition to their old behaviors of altering labels. (GH9494, GH11965)

```
In [9]: s = pd.Series(np.random.randn(5))

In [10]: s.rename('newname')
Out[10]:
0    1.150036
1     0.991946
2     0.953324
3    -2.021255
4    -0.334077
Name: newname, dtype: float64

In [11]: df = pd.DataFrame(np.random.randn(5, 2))

In [12]: (df.rename_axis("indexname")
       ....: .rename_axis("columns_name", axis="columns")
       ....:)
Out[12]:
       columns_name       0  1
   indexname
0           0.002118  0.405453
1           0.289092  1.321158
2          -1.546906 -0.202646
3           -0.655969  0.193421
4            0.553439  1.318152
```

The new functionality works well in method chains. Previously these methods only accepted functions or dicts mapping a label to a new label. This continues to work as before for function or dict-like values.

1.14.1.3 Range Index

A RangeIndex has been added to the Int64Index sub-classes to support a memory saving alternative for common use cases. This has a similar implementation to the python range object (xrange in python 2), in that it only stores the start, stop, and step values for the index. It will transparently interact with the user API, converting to Int64Index if needed.

This will now be the default constructed index for NDFrame objects, rather than previous an Int64Index. (GH939, GH12070, GH12071, GH12109, GH12888)

Previous Behavior:

```
In [3]: s = pd.Series(range(1000))

In [4]: s.index
```

(continues on next page)
Out[4]:
Int64Index([ 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, ...
         990, 991, 992, 993, 994, 995, 996, 997, 998, 999], dtype='int64',
length=1000)

In [6]: s.index.nbytes
Out[6]: 8000

New Behavior:

In [13]: s = pd.Series(range(1000))
In [14]: s.index
Out[14]: RangeIndex(start=0, stop=1000, step=1)
In [15]: s.index.nbytes
Out[15]: 80

1.14.1.4 Changes to str.extract

The `.str.extract` method takes a regular expression with capture groups, finds the first match in each subject string, and returns the contents of the capture groups (GH11386).

In v0.18.0, the `expand` argument was added to extract.

- **expand=False**: it returns a Series, Index, or DataFrame, depending on the subject and regular expression pattern (same behavior as pre-0.18.0).
- **expand=True**: it always returns a DataFrame, which is more consistent and less confusing from the perspective of a user.

Currently the default is `expand=None` which gives a `FutureWarning` and uses `expand=False`. To avoid this warning, please explicitly specify `expand`.

In [1]: pd.Series(['a1', 'b2', 'c3']).str.extract('[ab](\d)', expand=None)
FutureWarning: currently extract(expand=None) means expand=False (return Index/Series/DataFrame) but in a future version of pandas this will be changed to expand=True (return DataFrame)
Out[1]:
       0  1
0      1  NaN
1      2  NaN
dtype: object

Extracting a regular expression with one group returns a Series if `expand=False`.

In [16]: pd.Series(['a1', 'b2', 'c3']).str.extract('[ab](\d)', expand=False)
Out[16]:
       0  1  2
0      1  NaN
1      2  NaN
dtype: object

It returns a DataFrame with one column if `expand=True`.

1.14. v0.18.0 (March 13, 2016)
Calling on an Index with a regex with exactly one capture group returns an Index if expand=False.

In [18]: s = pd.Series(['a1', 'b2', 'c3'], ['A11', 'B22', 'C33'])

In [19]: s.index
Out[19]: Index(['A11', 'B22', 'C33'], dtype='object')

In [20]: s.index.str.extract('(?P<letter>[a-zA-Z])', expand=False)
Out[20]: Index(['A', 'B', 'C'], dtype='object', name='letter')

It returns a DataFrame with one column if expand=True.

In [21]: s.index.str.extract('(?P<letter>[a-zA-Z])', expand=True)
Out[21]:
   letter
0    A
1    B
2    C

Calling on an Index with a regex with more than one capture group raises ValueError if expand=False.

>>> s.index.str.extract('(?P<letter>[a-zA-Z])([0-9]+)', expand=False)
ValueError: only one regex group is supported with Index

It returns a DataFrame if expand=True.

In [22]: s.index.str.extract('(?P<letter>[a-zA-Z])([0-9]+)', expand=True)
Out[22]:
   letter  1
0    A   11
1    B   22
2    C   33

In summary, extract (expand=True) always returns a DataFrame with a row for every subject string, and a column for every capture group.

1.14.1.5 Addition of str.extractall

The .str.extractall method was added (GH11386). Unlike extract, which returns only the first match.

In [23]: s = pd.Series(['ala2', 'b1', 'c1'], ['A', 'B', 'C'])

In [24]: s
Out[24]:
     A    ala2
     B     b1
     C      c1
    dtype: object

(continues on next page)
The `extractall` method returns all matches.

```
In [26]: s.str.extractall("(?P<letter>[ab])(?P<digit>\d)")
```

```
Out[26]:
      letter digit    match
     A      0   a    1
     1      1   a    2
     B      0   b    1
```

### 1.14.1.6 Changes to `str.cat`

The method `.str.cat()` concatenates the members of a Series. Before, if NaN values were present in the Series, calling `.str.cat()` on it would return NaN, unlike the rest of the Series.``.str.* API. This behavior has been amended to ignore NaN values by default. (GH11435).

A new, friendlier `ValueError` is added to protect against the mistake of supplying the `sep` as an arg, rather than as a kwarg. (GH11334).

```
In [27]: pd.Series(['a','b',np.nan,'c']).str.cat(sep=' ')
```

```
' a  b  c'
```

```
In [28]: pd.Series(['a','b',np.nan,'c']).str.cat(sep=' ', na_rep='?')
```

```
' a  b  ?  c'
```

```
In [2]: pd.Series(['a','b',np.nan,'c']).str.cat(' ')
ValueError: Did you mean to supply a `sep` keyword?
```

### 1.14.1.7 Datetimelike rounding

`DatetimeIndex`, `Timestamp`, `TimedeltaIndex`, `Timedelta` have gained the `.round()`, `.floor()` and `.ceil()` method for datetimelike rounding, flooring and ceiling. (GH4314, GH11963)

Naive datetimes

```
In [29]: dr = pd.date_range('20130101 09:12:56.1234', periods=3)
```

```
In [30]: dr
Out[30]:
dtype=’datetime64[ns]’, freq=’D’)
```

```
In [31]: dr.round(’s’)
```
DatetimeIndex(['2013-01-01 09:12:56', '2013-01-02 09:12:56',
  '2013-01-03 09:12:56'],
  dtype='datetime64[ns]', freq=None)

# Timestamp scalar
In [32]: dr[0]
Out[32]: Timestamp('2013-01-01 09:12:56.123400', freq='D')

In [33]: dr[0].round('10s')
Out[33]: Timestamp('2013-01-01 09:13:00')

Tz-aware are rounded, floored and ceiled in local times

In [34]: dr = dr.tz_localize('US/Eastern')

In [35]: dr
Out[35]: DatetimeIndex(['2013-01-01 09:12:56-05:00',
  '2013-01-02 09:12:56-05:00',
  '2013-01-03 09:12:56-05:00'],
  dtype='datetime64[ns, US/Eastern]', freq='D')

In [36]: dr.round('s')
Out[36]: DatetimeIndex(['2013-01-01 09:12:56-05:00', '2013-01-02 09:12:56-05:00',
  '2013-01-03 09:12:56-05:00'],
  dtype='datetime64[ns, US/Eastern]', freq=None)

Timedeltas

In [37]: t = timedelta_range('1 days 2 hr 13 min 45 us',periods=3,freq='d')

In [38]: t
Out[38]: TimedeltaIndex(['1 days 02:13:00.000045', '2 days 02:13:00.000045',
  '3 days 02:13:00.000045'],
  dtype='timedelta64[ns]', freq='D')

In [39]: t.round('10min')
Out[39]: TimedeltaIndex(['1 days 02:10:00', '2 days 02:10:00', '3 days 02:10:00'],
  dtype='timedelta64[ns]', freq=None)

# Timedelta scalar
In [40]: t[0]
Out[40]: Timedelta('1 days 02:13:00.000045')

In [41]: t[0].round('2h')
Out[41]: Timedelta('1 days 02:00:00')

In addition, .round(), .floor() and .ceil() will be available thru the .dt accessor of Series.
In [42]: s = pd.Series(dr)

In [43]: s
Out[43]:
0  2013-01-01 09:12:56.123400-05:00
1  2013-01-02 09:12:56.123400-05:00
2  2013-01-03 09:12:56.123400-05:00
dtype: datetime64[ns, US/Eastern]

In [44]: s.dt.round('D')
Out[44]:
\[
\begin{array}{l}
0  2013-01-01 00:00:00-05:00 \\
1  2013-01-02 00:00:00-05:00 \\
2  2013-01-03 00:00:00-05:00 \\
\end{array}
\]
dtype: datetime64[ns, US/Eastern]

1.14.1.8 Formatting of Integers in FloatIndex

Integers in FloatIndex, e.g. 1., are now formatted with a decimal point and a 0 digit, e.g. 1.0 (GH11713) This change not only affects the display to the console, but also the output of IO methods like .to_csv or .to_html.

Previous Behavior:

In [2]: s = pd.Series([1,2,3], index=np.arange(3.))

In [3]: s
Out[3]:
0  1
1  2
2  3
dtype: int64

In [4]: s.index
Out[4]: Float64Index([0.0, 1.0, 2.0], dtype='float64')

In [5]: print(s.to_csv(path=None))
0,1
1,2
2,3

New Behavior:

In [45]: s = pd.Series([1,2,3], index=np.arange(3.))

In [46]: s
Out[46]:
0.0  1
1.0  2
2.0  3
dtype: int64

In [47]: s.index
Out[47]: Float64Index([0.0, 1.0, 2.0], dtype='float64')

(continues on next page)
In [48]: print(s.to_csv(path=None))
→0,1
1.0,2
2.0,3

1.14.1.9 Changes to dtype assignment behaviors

When a DataFrame’s slice is updated with a new slice of the same dtype, the dtype of the DataFrame will now remain the same. (GH10503)

Previous Behavior:

In [5]: df = pd.DataFrame({'a': [0, 1, 1],
                      'b': pd.Series([100, 200, 300], dtype='uint32')})

In [7]: df.dtypes
Out[7]:
a     int64
b    uint32
dtype: object

In [8]: ix = df['a'] == 1
In [9]: df.loc[ix, 'b'] = df.loc[ix, 'b']
In [11]: df.dtypes
Out[11]:
a     int64
b    uint32
dtype: object

New Behavior:

In [49]: df = pd.DataFrame({'a': [0, 1, 1],
                      'b': pd.Series([100, 200, 300], dtype='uint32')})

In [50]: df.dtypes
Out[50]:
a     int64
b    uint32
dtype: object

In [51]: ix = df['a'] == 1
In [52]: df.loc[ix, 'b'] = df.loc[ix, 'b']
In [53]: df.dtypes
Out[53]:
a     int64
b    uint32
dtype: object

When a DataFrame’s integer slice is partially updated with a new slice of floats that could potentially be downcasted to integer without losing precision, the dtype of the slice will be set to float instead of integer.
Previous Behavior:

```python
In [4]: df = pd.DataFrame(np.array(range(1,10)).reshape(3,3),
                      columns=list('abc'),
                      index=[[4,4,8], [8,10,12]])

In [5]: df
Out[5]:
     a  b  c
4  8  1  2
10 4  5  6
  8 12  7  8

In [7]: df.ix[4, 'c'] = np.array([0., 1.])

In [8]: df
Out[8]:
     a  b  c
4  8  1  2
10 4  5  1
  8 12  7  9
```

New Behavior:

```python
In [54]: df = pd.DataFrame(np.array(range(1,10)).reshape(3,3),
                      columns=list('abc'),
                      index=[[4,4,8], [8,10,12]])

In [55]: df
Out[55]:
     a  b  c
4  8  1  2
10 4  5  6
  8 12  7  9

In [56]: df.loc[4, 'c'] = np.array([0., 1.])

In [57]: df
Out[57]:
     a  b  c
4  8  1  2 0.0
10 4  5  1.0
  8 12  7  9.0
```

1.14.1.10 to_xarray

In a future version of pandas, we will be deprecating Panel and other > 2 ndim objects. In order to provide for continuity, all NDFrame objects have gained the .to_xarray() method in order to convert to xarray objects, which has a pandas-like interface for > 2 ndim. (GH11972)

See the xarray full-documentation here.

```python
In [1]: p = Panel(np.arange(2*3*4).reshape(2,3,4))

In [2]: p.to_xarray()
Out[2]:
(continues on next page)```
<xarray.DataArray (items: 2, major_axis: 3, minor_axis: 4)>
array([[ 0,  1,  2,  3],
       [ 4,  5,  6,  7],
       [ 8,  9, 10, 11]],
       [[12, 13, 14, 15],
        [16, 17, 18, 19],
        [20, 21, 22, 23]])
Coordinates:
* items  (items) int64 0 1
* major_axis (major_axis) int64 0 1 2
* minor_axis (minor_axis) int64 0 1 2 3

1.14.1.11 Latex Representation

DataFrame has gained a .__repr_latex__() method in order to allow for conversion to latex in a ipython/jupyter notebook using nbconvert. (GH11778)

Note that this must be activated by setting the option pd.display.latex.repr=True (GH12182)

For example, if you have a jupyter notebook you plan to convert to latex using nbconvert, place the statement pd.display.latex.repr=True in the first cell to have the contained DataFrame output also stored as latex.

The options display.latex.escape and display.latex.longtable have also been added to the configuration and are used automatically by the to_latex method. See the available options docs for more info.

1.14.1.12 pd.read_sas() changes

read_sas has gained the ability to read SAS7BDAT files, including compressed files. The files can be read in entirety, or incrementally. For full details see here. (GH4052)

1.14.1.13 Other enhancements

- Handle truncated floats in SAS xport files (GH11713)
- Added option to hide index in Series.to_string (GH11729)
- read_excel now supports s3 urls of the format s3://bucketname/filename (GH11447)
- add support for AWS_S3_HOST env variable when reading from s3 (GH12198)
- A simple version of Panel.round() is now implemented (GH11763)
- For Python 3.x, round(DataFrame), round(Series), round(Panel) will work (GH11763)
- sys.getsizeof(obj) returns the memory usage of a pandas object, including the values it contains (GH11597)
- Series gained an is_unique attribute (GH11946)
- DataFrame.quantile and Series.quantile now accept interpolation keyword (GH10174).
- Added DataFrame.style.format for more flexible formatting of cell values (GH11692)
- DataFrame.select_dtypes now allows the np.float16 typecode (GH11990)
- pivot_table() now accepts most iterables for the values parameter (GH12017)
• Added Google BigQuery service account authentication support, which enables authentication on remote servers. (GH11881, GH12572). For further details see here
• HDFStore is now iterable: for k in store is equivalent to for k in store.keys() (GH12221).
• Add missing methods/fields to .dt for Period (GH8848)
• The entire codebase has been PEP-ified (GH12096)

1.14.2 Backwards incompatible API changes

• the leading whitespaces have been removed from the output of .to_string(index=False) method (GH11833)
• the out parameter has been removed from the Series.round() method. (GH11763)
• DataFrame.round() leaves non-numeric columns unchanged in its return, rather than raises. (GH11885)
• DataFrame.head(0) and DataFrame.tail(0) return empty frames, rather than self. (GH11937)
• Series.head(0) and Series.tail(0) return empty series, rather than self. (GH11937)
• to_msgpack and read_msgpack encoding now defaults to 'utf-8'. (GH12170)
• the order of keyword arguments to text file parsing functions (.read_csv(), .read_table(), .read_fwf()) changed to group related arguments. (GH11555)
• NaTType.isoformat now returns the string 'NaT' to allow the result to be passed to the constructor of Timestamp. (GH12300)

1.14.2.1 NaT and Timedelta operations

NaT and Timedelta have expanded arithmetic operations, which are extended to Series arithmetic where applicable. Operations defined for datetime64[ns] or timedelta64[ns] are now also defined for NaT (GH11564). NaT now supports arithmetic operations with integers and floats.

```
In [58]: pd.NaT * 1
Out[58]: NaT

In [59]: pd.NaT * 1.5
Out[59]: NaT

In [60]: pd.NaT / 2
Out[60]: NaT

In [61]: pd.NaT * np.nan
Out[61]: NaT
```

NaT defines more arithmetic operations with datetime64[ns] and timedelta64[ns].

```
In [62]: pd.NaT / pd.NaT
Out[62]: nan

In [63]: pd.Timedelta('1s') / pd.NaT
Out[63]: nan
```

NaT may represent either a datetime64[ns] null or a timedelta64[ns] null. Given the ambiguity, it is treated as a timedelta64[ns], which allows more operations to succeed.
pandas: powerful Python data analysis toolkit, Release 0.23.2

In [64]: pd.NaT + pd.NaT
Out[64]: NaT

# same as
In [65]: pd.Timedelta('1s') + pd.Timedelta('1s')
Out[65]: Timedelta('0 days 00:00:02')

as opposed to

In [3]: pd.Timestamp('19900315') + pd.Timestamp('19900315')
TypeError: unsupported operand type(s) for +: 'Timestamp' and 'Timestamp'

However, when wrapped in a Series whose dtype is datetime64[ns] or timedelta64[ns], the dtype information is respected.

In [1]: pd.Series([pd.NaT], dtype='<M8[ns]') + pd.Series([pd.NaT], dtype='<M8[ns]')
TypeError: can only operate on a datetimes for subtraction,
but the operator [__add__] was passed

In [66]: pd.Series([pd.NaT], dtype='<m8[ns]') + pd.Series([pd.NaT], dtype='<m8[ns]')
Out[66]:
0  NaT
dtype: timedelta64[ns]

Timedelta division by floats now works.

In [67]: pd.Timedelta('1s') / 2.0
Out[67]: Timedelta('0 days 00:00:00.500000')

Subtraction by Timedelta in a Series by a Timestamp works (GH11925)

In [68]: ser = pd.Series(pd.timedelta_range('1 day', periods=3))

In [69]: ser
Out[69]:
0  1 days
1  2 days
2  3 days
dtype: timedelta64[ns]

In [70]: pd.Timestamp('2012-01-01') - ser
Out[70]:
0  2011-12-31
1  2011-12-30
2  2011-12-29
dtype: datetime64[ns]

NaT.isoformat() now returns 'NaT'. This change allows pd.Timestamp to rehydrate any timestamp like object from its isoformat (GH12300).

1.14.2.2 Changes to msgpack

Forward incompatible changes in msgpack writing format were made over 0.17.0 and 0.18.0; older versions of pandas cannot read files packed by newer versions (GH12129, GH10527)

Bugs in to_msgpack and read_msgpack introduced in 0.17.0 and fixed in 0.18.0, caused files packed in Python 2 unreadable by Python 3 (GH12142). The following table describes the backward and forward compat of msgpacks.

202 Chapter 1. What's New
Warning:

<table>
<thead>
<tr>
<th>Packed with</th>
<th>Can be unpacked with</th>
</tr>
</thead>
<tbody>
<tr>
<td>pre-0.17 / Python 2</td>
<td>any</td>
</tr>
<tr>
<td>pre-0.17 / Python 3</td>
<td>any</td>
</tr>
<tr>
<td>0.17 / Python 2</td>
<td>• ==0.17 / Python 2</td>
</tr>
<tr>
<td></td>
<td>• &gt;=0.18 / any Python</td>
</tr>
<tr>
<td>0.17 / Python 3</td>
<td>&gt;=0.18 / any Python</td>
</tr>
<tr>
<td>0.18</td>
<td>&gt;= 0.18</td>
</tr>
</tbody>
</table>

0.18.0 is backward-compatible for reading files packed by older versions, except for files packed with 0.17 in Python 2, in which case only they can only be unpacked in Python 2.

1.14.2.3 Signature change for .rank

Series.rank and DataFrame.rank now have the same signature (GH11759)

Previous signature

```python
In [3]: pd.Series([0,1]).rank(method='average', na_option='keep',
                  ascending=True, pct=False)
Out[3]:
          0
0 1
1 2
dtype: float64
```

```python
In [4]: pd.DataFrame([0,1]).rank(axis=0, numeric_only=None,
                              method='average', na_option='keep',
                              ascending=True, pct=False)
Out[4]:
     0
  0 1
  1 2
```

New signature

```python
In [71]: pd.Series([0,1]).rank(axis=0, method='average', numeric_only=None,
                              ....: na_option='keep', ascending=True, pct=False)
Out[71]:
          0
0 1.0
1 2.0
dtype: float64
```

```python
In [72]: pd.DataFrame([0,1]).rank(axis=0, method='average', numeric_only=None,
                              ....: na_option='keep', ascending=True, pct=False)
```

1.14. v0.18.0 (March 13, 2016)
1.14.2.4 Bug in QuarterBegin with n=0

In previous versions, the behavior of the QuarterBegin offset was inconsistent depending on the date when the \( n \) parameter was 0. (GH11406)

The general semantics of anchored offsets for \( n=0 \) is to not move the date when it is an anchor point (e.g., a quarter start date), and otherwise roll forward to the next anchor point.

```python
In [73]: d = pd.Timestamp('2014-02-01')
In [74]: d
Out[74]: Timestamp('2014-02-01 00:00:00')
In [75]: d + pd.offsets.QuarterBegin(n=0, startingMonth=2)
Out[75]: Timestamp('2014-02-01 00:00:00')

In [76]: d + pd.offsets.QuarterBegin(n=0, startingMonth=1)
Out[76]: Timestamp('2014-04-01 00:00:00')
```

For the QuarterBegin offset in previous versions, the date would be rolled backwards if date was in the same month as the quarter start date.

```python
In [3]: d = pd.Timestamp('2014-02-15')
In [4]: d + pd.offsets.QuarterBegin(n=0, startingMonth=2)
Out[4]: Timestamp('2014-02-01 00:00:00')
```

This behavior has been corrected in version 0.18.0, which is consistent with other anchored offsets like MonthBegin and YearBegin.

```python
In [77]: d = pd.Timestamp('2014-02-15')
In [78]: d + pd.offsets.QuarterBegin(n=0, startingMonth=2)
Out[78]: Timestamp('2014-05-01 00:00:00')
```

1.14.2.5 Resample API

Like the change in the window functions API above, .resample(...) is changing to have a more groupby-like API. (GH11732, GH12702, GH12202, GH12332, GH12334, GH12348, GH12448).

```python
In [79]: np.random.seed(1234)
In [80]: df = pd.DataFrame(np.random.rand(10,4),
                                 columns=list('ABCD'),
                                 index=pd.date_range('2010-01-01 09:00:00', periods=10, freq='s'))
In [81]: df
Out[81]:
       A         B         C         D
2010-01-01 09:00:00  0.191519  0.622109  0.437728  0.785359
2010-01-01 09:00:01  0.779976  0.272593  0.276464  0.801872
2010-01-01 09:00:02  0.958139  0.875933  0.357817  0.500995
2010-01-01 09:00:03  0.683463  0.712702  0.370251  0.561196
(continues on next page)
Previous API:

You would write a resampling operation that immediately evaluates. If a how parameter was not provided, it would default to how='mean'.

```
In [6]: df.resample('2s')
Out[6]:
     A     B     C     D
2010-01-01 09:00:00 0.485748 0.447351 0.357096 0.793615
2010-01-01 09:00:02 0.820801 0.794317 0.364034 0.531096
2010-01-01 09:00:04 0.433985 0.314582 0.424104 0.625733
2010-01-01 09:00:06 0.624988 0.609738 0.633165 0.612452
2010-01-01 09:00:08 0.510470 0.534317 0.573201 0.806949
```

You could also specify a how directly

```
In [7]: df.resample('2s', how='sum')
Out[7]:
     A     B     C     D
2010-01-01 09:00:00 0.971495 0.894701 0.714192 1.587231
2010-01-01 09:00:02 1.641602 1.588635 0.728068 1.062191
2010-01-01 09:00:04 0.867969 0.629165 0.633165 0.612452
2010-01-01 09:00:06 1.249976 1.219477 1.266330 1.224904
2010-01-01 09:00:08 1.020940 1.068634 1.146402 1.613897
```

New API:

Now, you can write `df.resample(...)` as a 2-stage operation like `df.groupby(...).`, which yields a Resampler.

```
In [82]: r = df.resample('2s')
In [83]: r
Out[83]: DatetimeIndexResampler [freq=<2 * Seconds>, axis=0, closed=left, label=left, →convention=start, base=0]
```

Downsampling

You can then use this object to perform operations. These are downsampling operations (going from a higher frequency to a lower one).

```
In [84]: r.mean()
Out[84]:
     A     B     C     D
2010-01-01 09:00:00 0.485748 0.447351 0.357096 0.793615
2010-01-01 09:00:02 0.820801 0.794317 0.364034 0.531096
2010-01-01 09:00:04 0.433985 0.314582 0.424104 0.625733
2010-01-01 09:00:06 0.624988 0.609738 0.633165 0.612452
2010-01-01 09:00:08 0.510470 0.534317 0.573201 0.806949
```
Furthermore, resample now supports `getitem` operations to perform the resample on specific columns.

```python
In [86]: r[['A','C']].mean()
Out[86]:
A    C
2010-01-01 09:00:00 0.485748 0.357096
2010-01-01 09:00:02 0.820801 0.364034
2010-01-01 09:00:04 0.433985 0.424104
2010-01-01 09:00:06 0.624988 0.633165
2010-01-01 09:00:08 0.510470 0.573201
```

and `.aggregate` type operations.

```python
In [87]: r.agg({'A' : 'mean', 'B' : 'sum'})
Out[87]:
A   B
2010-01-01 09:00:00 0.485748 0.894701
2010-01-01 09:00:02 0.820801 1.588635
2010-01-01 09:00:04 0.433985 0.633165
2010-01-01 09:00:06 0.624988 1.219477
2010-01-01 09:00:08 0.510470 1.068634
```

These accessors can of course, be combined

```python
In [88]: r[['A','B']].agg(['mean','sum'])
Out[88]:
A      B
mean   sum
2010-01-01 09:00:00 0.485748 0.971495 0.447351 0.894701
2010-01-01 09:00:02 0.820801 1.641602 0.794317 1.588635
2010-01-01 09:00:04 0.433985 0.867969 0.314582 0.633165
2010-01-01 09:00:06 0.624988 1.249976 0.609738 1.219477
2010-01-01 09:00:08 0.510470 1.020940 0.534317 1.068634
```

### Upsampling

Upsampling operations take you from a lower frequency to a higher frequency. These are now performed with the `Resampler` objects with `backfill()`, `ffill()`, `fillna()` and `asfreq()` methods.

```python
In [89]: s = pd.Series(np.arange(5,dtype='int64'),
          index=date_range('2010-01-01', periods=5, freq='Q'))

In [90]: s
Out[90]:
2010-03-31  0
(continues on next page)
```
Previously

```python
In [6]: s.resample('M', fill_method='ffill')
Out[6]:
2010-03-31  0
2010-04-30  0
2010-05-31  0
2010-06-30  1
2010-07-31  1
2010-08-31  1
2010-09-30  2
2010-10-31  2
2010-11-30  2
2010-12-31  3
2011-01-31  3
2011-02-28  3
2011-03-31  4
Freq: M, dtype: int64
```

New API

```python
In [91]: s.resample('M').ffill()
Out[91]:
2010-03-31  0
2010-04-30  0
2010-05-31  0
2010-06-30  1
2010-07-31  1
2010-08-31  1
2010-09-30  2
2010-10-31  2
2010-11-30  2
2010-12-31  3
2011-01-31  3
2011-02-28  3
2011-03-31  4
Freq: M, dtype: int64
```

**Note:** In the new API, you can either downsample OR upsample. The prior implementation would allow you to pass an aggregator function (like `mean`) even though you were upsampling, providing a bit of confusion.

**Previous API will work but with deprecations**

**Warning:** This new API for resample includes some internal changes for the prior-to-0.18.0 API, to work with a deprecation warning in most cases, as the resample operation returns a deferred object. We can intercept operations...
and just do what the (pre 0.18.0) API did (with a warning). Here is a typical use case:

```
In [4]: r = df.resample('2s')

In [6]: r*10
```

```
pandas/tseries/resample.py:80: FutureWarning: .resample() is now a deferred operation
  use .resample(...).mean() instead of .resample(...)
```

```
Out[6]:
          A         B         C         D
2010-01-01 09:00:00 4.857476 4.473507 3.570960 7.936154
2010-01-01 09:00:02 8.208011 7.943173 3.640340 5.310957
2010-01-01 09:00:04 4.339846 3.145823 4.241039 6.257326
2010-01-01 09:00:06 6.249881 6.097384 6.331650 6.124518
2010-01-01 09:00:08 5.104699 5.343172 5.732009 8.069486
```

However, getting and assignment operations directly on a `Resampler` will raise a `ValueError`:

```
In [7]: r.iloc[0] = 5
ValueError: .resample() is now a deferred operation
  use .resample(...).mean() instead of .resample(...)
```

There is a situation where the new API can not perform all the operations when using original code. This code is intending to resample every 2s, take the `mean` AND then take the `min` of those results.

```
In [4]: df.resample('2s').min()
```

```
Out[4]:
          A         B         C         D
2010-01-01 09:00:00 0.433985 0.314582 0.357096 0.531096
dtype: float64
```

The new API will:

```
In [92]: df.resample('2s').min()
```

```
Out[92]:
          A         B         C         D
2010-01-01 09:00:00 0.191519 0.272593 0.276464 0.785359
2010-01-01 09:00:02 0.683463 0.712702 0.357817 0.500995
2010-01-01 09:00:04 0.364886 0.013768 0.075381 0.368824
2010-01-01 09:00:06 0.316836 0.568099 0.397203 0.436173
2010-01-01 09:00:08 0.218792 0.143767 0.442141 0.704581
dtype: float64
```

The good news is the return dimensions will differ between the new API and the old API, so this should loudly raise an exception.

To replicate the original operation

```
In [93]: df.resample('2s').mean().min()
```

```
Out[93]:
          A         B         C         D
0 0.433985 0.314582 0.357096 0.531096
dtype: float64
```
1.14.2.6 Changes to eval

In prior versions, new columns assignments in an eval expression resulted in an inplace change to the DataFrame. (GH9297, GH8664, GH10486)

```
In [94]: df = pd.DataFrame({'a': np.linspace(0, 10, 5), 'b': range(5)})
```

```
In [95]: df
Out[95]:
   a  b
0  0  0
1  2.5 1
2  5.0 2
3  7.5 3
4 10.0 4
```

```
In [12]: df.eval('c = a + b')

FutureWarning: eval expressions containing an assignment currently default to operating inplace.
This will change in a future version of pandas, use inplace=True to avoid this warning.
```

```
In [13]: df
Out[13]:
    a  b  c
0  0.0 0  0.0
1  2.5 1  3.5
2  5.0 2  7.0
3  7.5 3 10.5
4 10.0 4 14.0
```

In version 0.18.0, a new inplace keyword was added to choose whether the assignment should be done inplace or return a copy.

```
In [96]: df
Out[96]:
   a  b  c
0  0.0 0  0.0
1  2.5 1  3.5
2  5.0 2  7.0
3  7.5 3 10.5
4 10.0 4 14.0
```

```
In [97]: df.eval('d = c - b', inplace=False)

 In [98]: df
```

(continues on next page)
In [99]: df.eval('d = c - b', inplace=True)

In [100]: df
Out[100]:
<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>1</td>
<td>2.5</td>
<td>1.0</td>
<td>3.5</td>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
<td>5.0</td>
<td>2.0</td>
<td>7.0</td>
<td>5.0</td>
</tr>
<tr>
<td>3</td>
<td>7.5</td>
<td>3.0</td>
<td>10.5</td>
<td>7.5</td>
</tr>
<tr>
<td>4</td>
<td>10.0</td>
<td>4.0</td>
<td>14.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Warning: For backwards compatibility, inplace defaults to True if not specified. This will change in a future version of pandas. If your code depends on an inplace assignment you should update to explicitly set inplace=True.

The inplace keyword parameter was also added the query method.

In [101]: df.query('a > 5')
Out[101]:
<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>7.5</td>
<td>3.0</td>
<td>10.5</td>
<td>7.5</td>
</tr>
<tr>
<td>4</td>
<td>10.0</td>
<td>4.0</td>
<td>14.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>

In [102]: df.query('a > 5', inplace=True)

In [103]: df
Out[103]:
<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>7.5</td>
<td>3.0</td>
<td>10.5</td>
<td>7.5</td>
</tr>
<tr>
<td>4</td>
<td>10.0</td>
<td>4.0</td>
<td>14.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Warning: Note that the default value for inplace in a query is False, which is consistent with prior versions.

eval has also been updated to allow multi-line expressions for multiple assignments. These expressions will be evaluated one at a time in order. Only assignments are valid for multi-line expressions.

In [104]: df
Out[104]:
<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>7.5</td>
<td>3.0</td>
<td>10.5</td>
<td>7.5</td>
</tr>
<tr>
<td>4</td>
<td>10.0</td>
<td>4.0</td>
<td>14.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>

In [105]: df.eval(""
......: e = d + a
......: f = e - 22
......: g = f / 2.0"", inplace=True)
1.14.2.7 Other API Changes

- `DataFrame.between_time` and `Series.between_time` now only parse a fixed set of time strings. Parsing of date strings is no longer supported and raises a `ValueError`. (GH11818)

```python
In [107]: s = pd.Series(range(10), pd.date_range('2015-01-01', freq='H', periods=10))
In [108]: s.between_time('7:00am', '9:00am')
Out [108]:
2015-01-01 07:00:00    7
2015-01-01 08:00:00    8
2015-01-01 09:00:00    9
Freq: H, dtype: int64
```

This will now raise,

```python
In [2]: s.between_time('20150101 07:00:00','20150101 09:00:00')
ValueError: Cannot convert arg ['20150101 07:00:00'] to a time.
```

- `.memory_usage()` now includes values in the index, as does `memory_usage` in `.info()` (GH11597)
- `DataFrame.to_latex()` now supports non-ascii encodings (e.g., `utf-8`) in Python 2 with the parameter `encoding` (GH7061)
- `pandas.merge()` and `DataFrame.merge()` will show a specific error message when trying to merge with an object that is not of type `DataFrame` or a subclass (GH12081)
- `DataFrame.unstack` and `Series.unstack` now take `fill_value` keyword to allow direct replacement of missing values when an unstack results in missing values in the resulting `DataFrame`. As an added benefit, specifying `fill_value` will preserve the data type of the original stacked data. (GH9746)
- As part of the new API for `window functions` and `resampling`, aggregation functions have been clarified, raising more informative error messages on invalid aggregations. (GH9052). A full set of examples are presented in `groupby`.
- Statistical functions for `NDFrame` objects (like `sum()`, `mean()`, `min()`) will now raise if non-numpy-compatible arguments are passed in for **kwargs (GH12301)
- `.to_latex` and `.to_html` gain a `decimal` parameter like `.to_csv`; the default is `', '` (GH12031)
- More helpful error message when constructing a `DataFrame` with empty data but with indices (GH8020)
- `.describe()` will now properly handle bool dtype as a categorical (GH6625)
- More helpful error message with an invalid .transform with user defined input (GH10165)
- Exponentially weighted functions now allow specifying alpha directly (GH10789) and raise `ValueError` if parameters violate $0 < \alpha \leq 1$ (GH12492)
1.14.2.8 Deprecations

- The functions `pd.rolling_*`, `pd.expanding_*`, and `pd.ewm*` are deprecated and replaced by the corresponding method call. Note that the new suggested syntax includes all of the arguments (even if default) (GH11603)

```python
In [1]: s = pd.Series(range(3))
In [2]: pd.rolling_mean(s,window=2,min_periods=1)
   FutureWarning: pd.rolling_mean is deprecated for Series and
   will be removed in a future version, replace with
   Series.rolling(min_periods=1,window=2,center=False).mean()
Out[2]:
   0    0.0
   1    0.5
   2    1.5
   dtype: float64
```

In [3]: `pd.rolling_cov(s, s, window=2)
   FutureWarning: pd.rolling_cov is deprecated for Series and
   will be removed in a future version, replace with
   Series.rolling(window=2).cov(other=<Series>)
Out[3]:
   0   NaN
   1    0.5
   2    0.5
   dtype: float64

- The `freq` and `how` arguments to the `.rolling`, `.expanding`, and `.ewm` (new) functions are deprecated, and will be removed in a future version. You can simply resample the input prior to creating a window function. (GH11603).

For example, instead of `s.rolling(window=5,freq='D').max()` to get the max value on a rolling 5 Day window, one could use `s.resample('D').mean().rolling(window=5).max()`, which first resamples the data to daily data, then provides a rolling 5 day window.

- `pd.tseries.frequencies.get_offset_name` function is deprecated. Use offset’s `.freqstr` property as alternative (GH11912)
- `pandas.stats.fama_macbeth` routines are deprecated and will be removed in a future version (GH6077)
- `pandas.stats.ols`, `pandas.stats.plm` and `pandas.stats.var` routines are deprecated and will be removed in a future version (GH6077)
- show a FutureWarning rather than a DeprecationWarning on using long-time deprecated syntax in HDFStore.select, where the where clause is not a string-like (GH12027)
- The `pandas.options.display.mpl_style` configuration has been deprecated and will be removed in a future version of pandas. This functionality is better handled by matplotlib’s style sheets (GH11783).

1.14.2.9 Removal of deprecated float indexers

In GH4892 indexing with floating point numbers on a non-Float64Index was deprecated (in version 0.14.0). In 0.18.0, this deprecation warning is removed and these will now raise a TypeError. (GH12165, GH12333)

```python
In [109]: s = pd.Series([1, 2, 3], index=[4, 5, 6])
In [110]: s
```
Out[110]:
4 1
5 2
6 3
dtype: int64

In [111]: s2 = pd.Series([1, 2, 3], index=list('abc'))

In [112]: s2
Out[112]:
a 1
b 2
c 3
dtype: int64

Previous Behavior:

# this is label indexing
In [2]: s[5.0]
FutureWarning: scalar indexers for index type Int64Index should be integers and not floating point
Out[2]: 2

# this is positional indexing
In [3]: s.iloc[1.0]
FutureWarning: scalar indexers for index type Int64Index should be integers and not floating point
Out[3]: 2

# this is label indexing
In [4]: s.loc[5.0]
FutureWarning: scalar indexers for index type Int64Index should be integers and not floating point
Out[4]: 2

# .ix would coerce 1.0 to the positional 1, and index
In [5]: s2.ix[1.0] = 10
FutureWarning: scalar indexers for index type Index should be integers and not floating point

In [6]: s2
Out[6]:
a 1
b 10
c 3
dtype: int64

New Behavior:

For iloc, getting & setting via a float scalar will always raise.

In [3]: s.iloc[2.0]
TypeError: cannot do label indexing on <class 'pandas.indexes.numeric.Int64Index'> with these indexers [2.0] of <type 'float'>

Other indexers will coerce to a like integer for both getting and setting. The FutureWarning has been dropped for .loc,.ix and [].
and setting

```python
In [115]: s_copy = s.copy()
In [116]: s_copy[5.0] = 10
In [117]: s_copy
Out[117]:
4   1
5  10
6   3
dtype: int64
```

```python
In [118]: s_copy = s.copy()
In [119]: s_copy.loc[5.0] = 10
In [120]: s_copy
Out[120]:
4   1
5  10
6   3
dtype: int64
```

Positional setting with `.ix` and a float indexer will ADD this value to the index, rather than previously setting the value by position.

```python
In [3]: s2.ix[1.0] = 10
In [4]: s2
Out[4]:
a   1
b   2
c   3
1.0 10
dtype: int64
```

Slicing will also coerce integer-like floats to integers for a non-`Float64Index`.

```python
In [121]: s.loc[5.0:6]
Out[121]:
5   2
6   3
dtype: int64
```

Note that for floats that are NOT coercible to ints, the label based bounds will be excluded

```python
In [122]: s.loc[5.1:6]
Out[122]:
6   3
dtype: int64
```

Float indexing on a `Float64Index` is unchanged.
In [123]: s = pd.Series([1, 2, 3], index=np.arange(3.))

In [124]: s[1.0]
Out[124]: 2

In [125]: s[1.0:2.5]
Out[125]:
1.0  2
2.0  3
dtype: int64

1.14.2.10 Removal of prior version deprecations/changes

- Removal of `rolling_corr_pairwise` in favor of `rolling().corr(pairwise=True)` (GH4950)
- Removal of `expanding_corr_pairwise` in favor of `expanding().corr(pairwise=True)` (GH4950)
- Removal of `DataMatrix` module. This was not imported into the pandas namespace in any event (GH12111)
- Removal of `cols` keyword in favor of `subset` in `DataFrame.duplicated()` and `DataFrame.drop_duplicates()` (GH6680)
- Removal of the `read_frame` and `frame_query` (both aliases for `pd.read_sql`) and `write_frame` (alias of `to_sql`) functions in the `pd.io.sql` namespace, deprecated since 0.14.0 (GH6292).
- Removal of the `order` keyword from `.factorize()` (GH6930)

1.14.3 Performance Improvements

- Improved performance of `andrews_curves` (GH11534)
- Improved huge `DatetimeIndex`, `PeriodIndex` and `TimedeltaIndex`'s ops performance including `NaT` (GH10277)
- Improved performance of `pandas.concat` (GH11958)
- Improved performance of `StataReader` (GH11591)
- Improved performance in construction of `Categoricals` with `Series` of datetimes containing `NaT` (GH12077)
- Improved performance of ISO 8601 date parsing for dates without separators (GH11899), leading zeros (GH11871) and with whitespace preceding the time zone (GH9714)

1.14.4 Bug Fixes

- Bug in `GroupBy.size` when data-frame is empty. (GH11699)
- Bug in `Period.end_time` when a multiple of time period is requested (GH11738)
- Regression in `.clip` with tz-aware datetimes (GH11838)
- Bug in `date_range` when the boundaries fell on the frequency (GH11804, GH12409)
- Bug in consistency of passing nested dicts to `.groupby(...)`.agg(...) (GH9052)
- Accept unicode in `Timedelta` constructor (GH11995)
• Bug in value label reading for StataReader when reading incrementally (GH12014)
• Bug in vectorized DateOffset when n parameter is 0 (GH11370)
• Compat for numpy 1.11 w.r.t. NaT comparison changes (GH12049)
• Bug in read_csv when reading from a StringIO in threads (GH11790)
• Bug in not treating NaT as a missing value in datetimelikes when factorizing & with Categoricals (GH12077)
• Bug in getitem when the values of a Series were tz-aware (GH12089)
• Bug in Series.str.get_dummies when one of the variables was ‘name’ (GH12180)
• Bug in pd.concat while concatenating tz-aware NaT series. (GH11693, GH11755, GH12217)
• Bug in pd.read_stata with version <= 108 files (GH12232)
• Bug in Series.resample using a frequency of Nano when the index is a DatetimeIndex and contains non-zero nanosecond parts (GH12037)
• Bug in resampling with .nunique and a sparse index (GH12352)
• Removed some compiler warnings (GH12471)
• Work around compat issues with boto in python 3.5 (GH11915)
• Bug in NaT subtraction from Timestamp or DatetimeIndex with timezones (GH11718)
• Bug in subtraction of Series of a single tz-aware Timestamp (GH12290)
• Use compat iterators in PY2 to support .next() (GH12299)
• Bug in Timedelta.round with negative values (GH11690)
• Bug in .loc against CategoricalIndex may result in normal Index (GH11586)
• Bug in DataFrame.info when duplicated column names exist (GH11761)
• Bug in .copy of datetime tz-aware objects (GH11794)
• Bug in Series.apply and Series.map where timedelta64 was not boxed (GH11349)
• Bug in DataFrame.set_index() with tz-aware Series (GH12358)
• Bug in subclasses of DataFrame where AttributeError did not propagate (GH11808)
• Bug groupby on tz-aware data where selection not returning Timestamp (GH11616)
• Bug in pd.read_clipboard and pd.to_clipboard functions not supporting Unicode; upgrade included pyperclip to v1.5.15 (GH9263)
• Bug in DataFrame.query containing an assignment (GH8664)
• Bug in from_msgpack where __contains__() fails for columns of the unpacked DataFrame, if the DataFrame has object columns. (GH11880)
• Bug in .resample on categorical data with TimedeltaIndex (GH12169)
• Bug in timezone info lost when broadcasting scalar datetime to DataFrame (GH11682)
• Bug in Index creation from Timestamp with mixed tz coerces to UTC (GH11488)
• Bug in to_numeric where it does not raise if input is more than one dimension (GH11776)
• Bug in parsing timezone offset strings with non-zero minutes (GH11708)
• Bug in df.plot using incorrect colors for bar plots under matplotlib 1.5+ (GH11614)
• Bug in the `groupbyplot` method when using keyword arguments (GH11805).
• Bug in `DataFrame.duplicated` and `drop_duplicates` causing spurious matches when setting `keep=False` (GH11864)
• Bug in `.loc` result with duplicated key may have `Index` with incorrect dtype (GH11497)
• Bug in `pd.rolling_median` where memory allocation failed even with sufficient memory (GH11696)
• Bug in `DataFrame.style` with spurious zeros (GH12134)
• Bug in `DataFrame.style` with integer columns not starting at 0 (GH12125)
• Bug in `.style.bar` may not rendered properly using specific browser (GH11678)
• Bug in rich comparison of `Timedelta` with a `numpy.array` of `Timedelta` that caused an infinite recursion (GH11835)
• Bug in `DataFrame.round` dropping column index name (GH11986)
• Bug in `.replace` while replacing value in mixed dtype DataFrame (GH11698)
• Bug in `.loc` prevents copying name of passed `Index`, when a new name is not provided (GH11193)
• Bug in `read_excel` failing to read any non-empty sheets when empty sheets exist and `sheetname=None` (GH11711)
• Bug in `read_excel` failing to raise `NotImplemented` error when keywords `parse_dates` and `date_parser` are provided (GH11544)
• Bug in `read_sql` with `pymysql` connections failing to return chunked data (GH11522)
• Bug in `.to_csv` ignoring formatting parameters `decimal`, `na_rep`, `float_format` for float indexes (GH11553)
• Bug in `Int64Index` and `Float64Index` preventing the use of the modulo operator (GH9244)
• Bug in `MultiIndex.drop` for not lexsorted multi-indexes (GH12078)
• Bug in `DataFrame` when masking an empty DataFrame (GH11859)
• Bug in `.plot` potentially modifying the `colors` input when the number of columns didn’t match the number of series provided (GH12039).
• Bug in `Series.plot` failing when index has a `CustomBusinessDay` frequency (GH7222).
• Bug in `.to_sql` for `datetime.time` values with sqlite fallback (GH8341)
• Bug in `read_excel` failing to read data with one column when `squeeze=True` (GH12157)
• Bug in `read_excel` failing to read one empty column (GH12292, GH9002)
• Bug in `.groupby` where a `KeyError` was not raised for a wrong column if there was only one row in the dataframe (GH11741)
• Bug in `.read_csv` with `dtype` specified on empty data producing an error (GH12048)
• Bug in `.read_csv` where strings like '2E' are treated as valid floats (GH12237)
• Bug in building `pandas` with debugging symbols (GH12123)
• Removed `millisecond` property of `DatetimeIndex`. This would always raise a `ValueError` (GH12019).
• Bug in `Series` constructor with read-only data (GH11502)
• Removed `pandas.util.testing.choice()`. Should use `np.random.choice()`, instead. (GH12386)
• Bug in `.loc` setitem indexer preventing the use of a TZ-aware DatetimeIndex (GH12050)
• Bug in `.style` indexes and multi-indexes not appearing (GH11655)
• Bug in `to_msgpack` and `from_msgpack` which did not correctly serialize or deserialize NaT (GH12307).
• Bug in `.skew` and `.kurt` due to roundoff error for highly similar values (GH11974)
• Bug in `Timestamp` constructor where microsecond resolution was lost if HHMMSS were not separated with `:` (GH10041)
• Bug in `buffer_rd_bytes` src->buffer could be freed more than once if reading failed, causing a segfault (GH12098)
• Bug in `crosstab` where arguments with non-overlapping indexes would return a `KeyError` (GH10291)
• Bug in `DataFrame.apply` in which reduction was not being prevented for cases in which `dtype` was not a `numpy` dtype (GH12244)
• Bug when initializing categorical series with a scalar value. (GH12336)
• Bug when specifying a UTC `DatetimeIndex` by setting `utc=True` in `.to_datetime` (GH11934)
• Bug when increasing the buffer size of CSV reader in `read_csv` (GH12494)
• Bug when setting columns of a `DataFrame` with duplicate column names (GH12344)

1.15 v0.17.1 (November 21, 2015)

Note: We are proud to announce that pandas has become a sponsored project of the (NumFOCUS organization). This will help ensure the success of development of pandas as a world-class open-source project.

This is a minor bug-fix release from 0.17.0 and includes a large number of bug fixes along several new features, enhancements, and performance improvements. We recommend that all users upgrade to this version.

Highlights include:

• Support for Conditional HTML Formatting, see here
• Releasing the GIL on the csv reader & other ops, see here
• Fixed regression in `DataFrame.drop_duplicates` from 0.16.2, causing incorrect results on integer values (GH11376)

What's new in v0.17.1

• New features
  – Conditional HTML Formatting
• Enhancements
• API changes
  – Deprecations
• Performance Improvements
• Bug Fixes
1.15.1 New features

1.15.1.1 Conditional HTML Formatting

**Warning:** This is a new feature and is under active development. We’ll be adding features and possibly making breaking changes in future releases. Feedback is welcome.

We’ve added experimental support for conditional HTML formatting: the visual styling of a DataFrame based on the data. The styling is accomplished with HTML and CSS. Accesses the styler class with the `pandas.DataFrame.style`, attribute, an instance of Styler with your data attached.

Here’s a quick example:

```python
In [1]: np.random.seed(123)
In [2]: df = DataFrame(np.random.randn(10, 5), columns=list('abcde'))
In [3]: html = df.style.background_gradient(cmap='viridis', low=.5)
```

We can render the HTML to get the following table.

Styler interacts nicely with the Jupyter Notebook. See the documentation for more.

1.15.2 Enhancements

- DatetimeIndex now supports conversion to strings with `astype(str)` (GH10442)
- Support for compression (gzip/bz2) in `pandas.DataFrame.to_csv()` (GH7615)
- `pd.read_*` functions can now also accept `pathlib.Path` or `py._path.local.LocalPath` objects for the `filepath_or_buffer` argument. (GH1033) - The DataFrame and Series functions `.to_csv()`, `.to_html()` and `.to_latex()` can now handle paths beginning with tildes (e.g. ~/Documents/) (GH11438)
- DataFrame now uses the fields of a namedtuple as columns, if columns are not supplied (GH11181)
- `DataFrame.itertuples()` now returns namedtuple objects, when possible. (GH11269, GH11625)
- Added `axvlines_kwds` to parallel coordinates plot (GH10709)
- Option to `.info()` and `.memory_usage()` to provide for deep introspection of memory consumption. Note that this can be expensive to compute and therefore is an optional parameter. (GH11595)

```python
In [4]: df = DataFrame({'A' : ['foo']]*1000)
In [5]: df['B'] = df['A'].astype('category')

# shows the '+' as we have object dtypes
In [6]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 2 columns):
A 1000 non-null object
B 1000 non-null category
dtypes: category(1), object(1)
memory usage: 9.0+ KB
```

(continues on next page)
# Chapter 1. What's New

---

# we have an accurate memory assessment (but can be expensive to compute this)

```
In [7]: df.info(memory_usage='deep')
```

```python
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 2 columns):
A 1000 non-null object  
B 1000 non-null category  
dtypes: category(1), object(1)  
memory usage: 75.4 KB
```

- **Index** now has a `fillna` method (GH10089)

```
In [8]: pd.Index([1, np.nan, 3]).fillna(2)
Out[8]: Float64Index([1.0, 2.0, 3.0], dtype='float64')
```

- Series of type **category** now make `.str.<...>` and `.dt.<...>` accessor methods / properties available, if the categories are of that type. (GH10661)

```
In [9]: s = pd.Series(list('aabb')).astype('category')
In [10]: s
Out[10]:
0   a
1   a
2   b
3   b
dtype: category
Categories (2, object): [a, b]
In [11]: s.str.contains("a")
```

```
True  
0 1 2 3
```

```
In [12]: date = pd.Series(pd.date_range('1/1/2015', periods=5)).astype('category')
In [13]: date
Out[13]:
0   2015-01-01
1   2015-01-02
2   2015-01-03
3   2015-01-04
4   2015-01-05
```

```
```

```
In [14]: date.dt.day
```

(continues on next page)
• **pivot_table** now has a `margins_name` argument so you can use something other than the default of ‘All’ (GH3335)

• Implement export of `datetime64[ns, tz]` dtypes with a fixed HDF5 store (GH11411)

• Pretty printing sets (e.g. in DataFrame cells) now uses set literal syntax (`{x, y}`) instead of Legacy Python syntax (`set([x, y])`) (GH11215)

• Improve the error message in pandas.io.gbq.to_gbq() when a streaming insert fails (GH11285) and when the DataFrame does not match the schema of the destination table (GH11359)

### 1.15.3 API changes

• raise `NotImplementedError` in `Index.shift` for non-supported index types (GH8038)

• `min` and `max` reductions on `datetime64` and `timedelta64` typed series now result in `NaT` and not `nan` (GH11245).

• Indexing with a null key will raise a `TypeError`, instead of a `ValueError` (GH11356)

• `Series.ptp` will now ignore missing values by default (GH11163)

#### 1.15.3.1 Deprecations

• The pandas.io.ga module which implements google-analytics support is deprecated and will be removed in a future version (GH11308)

• Deprecate the `engine` keyword in `.to_csv()`, which will be removed in a future version (GH11274)

### 1.15.4 Performance Improvements

• Checking monotonic-ness before sorting on an index (GH11080)

• `Series.dropna` performance improvement when its dtype can’t contain `NaN` (GH11159)

• Release the GIL on most datetime field operations (e.g. `DatetimeIndex.year`, `Series.dt.year`), normalization, and conversion to and from `Period`, `DatetimeIndex.to_period` and `PeriodIndex.to_timestamp` (GH11263)

• Release the GIL on some rolling algos: `rolling_median`, `rolling_mean`, `rolling_max`, `rolling_min`, `rolling_var`, `rolling_kurt`, `rolling_skew` (GH11450)

• Release the GIL when reading and parsing text files in `read_csv`, `read_table` (GH11272)

• Improved performance of `rolling_median` (GH11450)

• Improved performance of `to_excel` (GH11352)

• Performance bug in repr of `Categorical` categories, which was rendering the strings before chopping them for display (GH11305)
• Performance improvement in `Categorical.remove_unused_categories`, (GH11643).
• Improved performance of `Series` constructor with no data and `DatetimeIndex` (GH11433)
• Improved performance of `shift`, `cumprod`, and `cumsum with groupby` (GH4095)

1.15.5 Bug Fixes

• `SparseArray.__iter__()` now does not cause `PendingDeprecationWarning` in `Python 3.5` (GH11622)
• Regression from 0.16.2 for output formatting of long floats/nan, restored in (GH11302)
• `Series.sort_index()` now correctly handles the `inplace` option (GH11402)
• Incorrectly distributed .c file in the build on PyPi when reading a csv of floats and passing `na_values=<a scalar>` would show an exception (GH11374)
• Bug in `.to_latex()` output broken when the index has a name (GH10660)
• Bug in HDFStore.append with strings whose encoded length exceeded the max unencoded length (GH11234)
• Bug in merging `datetime64[ns, tz]` dtypes (GH11405)
• Bug in HDFStore.select when comparing with a numpy scalar in a where clause (GH11283)
• Bug in using DataFrame.ix with a multi-index indexer (GH11372)
• Bug in `date_range` with ambiguous endpoints (GH11626)
• Prevent adding new attributes to the accessors `.str`, `.dt` and `.cat`. Retrieving such a value was not possible, so error out on setting it. (GH10673)
• Bug in tz-conversions with an ambiguous time and `.dt` accessors (GH11295)
• Bug in output formatting when using an index of ambiguous times (GH11619)
• Bug in comparisons of Series vs list-likes (GH11339)
• Bug in DataFrame.replace with a `datetime64[ns, tz]` and a non-compat `to_replace` (GH11326, GH11153)
• Bug in `isnull` where `numpy.datetime64('NaT')` in a `numpy.array` was not determined to be null(GH11206)
• Bug in list-like indexing with a mixed-integer Index (GH11320)
• Bug in `pivot_table` with `margins=True` when indexes are of `Categorical` dtype (GH10993)
• Bug in DataFrame.plot cannot use hex strings colors (GH10299)
• Regression in `DataFrame.drop_duplicates` from 0.16.2, causing incorrect results on integer values (GH11376)
• Bug in `pd.eval` where unary ops in a list error (GH11235)
• Bug in `squeeze()` with zero length arrays (GH11230, GH8999)
• Bug in `describe()` dropping column names for hierarchical indexes (GH11517)
• Bug in `DataFrame.pct_change()` not propagating axis keyword on `.fillna` method (GH11150)
• Bug in `.to_csv()` when a mix of integer and string column names are passed as the `columns` parameter (GH11637)
• Bug in indexing with a range, (GH11652)
• Bug in inference of numpy scalars and preserving dtype when setting columns (GH11638)
• Bug in `to_sql` using unicode column names giving UnicodeEncodeError with (GH11431).
• Fix regression in setting of `xticks` in `plot` (GH11529).
• Bug in `holiday.dates` where observance rules could not be applied to holiday and doc enhancement (GH11477, GH11533)
• Fix plotting issues when having plain `Axes` instances instead of `SubplotAxes` (GH11520, GH11556).
• Bug in `DataFrame.to_latex()` produces an extra rule when `header=False` (GH7124)
• Bug in `df.groupby(...).apply(func)` when a func returns a `Series` containing a new datetimelike column (GH11324)
• Bug in `pandas.json` when file to load is big (GH11344)
• Bugs in `to_excel` with duplicate columns (GH11007, GH10982, GH10970)
• Fixed a bug that prevented the construction of an empty series of dtype `datetime64[ns, tz]` (GH11245).
• Bug in `read_excel` with multi-index containing integers (GH11317)
• Bug in `to_excel` with openpyxl 2.2+ and merging (GH11408)
• Bug in `DataFrame.to_dict()` produces a `np.datetime64` object instead of `Timestamp` when only datetime is present in data (GH11327)
• Bug in `DataFrame.corr()` raises exception when computes Kendall correlation for DataFrames with boolean and not boolean columns (GH11560)
• Bug in the link-time error caused by `C inline` functions on FreeBSD 10+ (with clang) (GH10510)
• Bug in `DataFrame.to_csv` in passing through arguments for formatting MultiIndexes, including `date_format` (GH7791)
• Bug in `DataFrame.join()` with `how='right'` producing a `TypeError` (GH11519)
• Bug in `Series.quantile` with empty list results has `Index` with `object` dtype (GH11588)
• Bug in `pd.merge` results in empty `Int64Index` rather than `Index(dtype=object)` when the merge result is empty (GH11588)
• Bug in `Categorical.remove_unused_categories` when having `NaN` values (GH11599)
• Bug in `DataFrame.to_sparse()` loses column names for MultiIndexes (GH11600)
• Bug in `DataFrame.round()` with non-unique column index producing a Fatal Python error (GH11611)
• Bug in `DataFrame.round()` with `decimals` being a non-unique indexed Series producing extra columns (GH11618)

### 1.16 v0.17.0 (October 9, 2015)

This is a major release from 0.16.2 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

**Warning:** pandas >= 0.17.0 will no longer support compatibility with Python version 3.2 (GH9118)
Warning: The pandas.io.data package is deprecated and will be replaced by the pandas-datareader package. This will allow the data modules to be independently updated to your pandas installation. The API for pandas-datareader v0.1.1 is exactly the same as in pandas v0.17.0 (GH8961, GH10861).

After installing pandas-datareader, you can easily change your imports:

```python
from pandas.io import data, wb
```

becomes

```python
from pandas_datareader import data, wb
```

Highlights include:

- Release the Global Interpreter Lock (GIL) on some cython operations, see [here](#).
- Plotting methods are now available as attributes of the `.plot` accessor, see [here](#).
- The sorting API has been revamped to remove some long-time inconsistencies, see [here](#).
- Support for a `datetime64[ns]` with timezones as a first-class dtype, see [here](#).
- The default for `to_datetime` will now be to `raise` when presented with unparsable formats, previously this would return the original input. Also, date parse functions now return consistent results. See [here](#).
- The default for `dropna` in HDFStore has changed to `False`, to store by default all rows even if they are all NaN, see [here](#).
- Datetime accessor (dt) now supports `Series.dt.strftime` to generate formatted strings for datetime-likes, and `Series.dt.total_seconds` to generate each duration of the timedelta in seconds. See [here](#).
- Period and PeriodIndex can handle multiplied freq like 3D, which corresponding to 3 days span. See [here](#).
- Development installed versions of pandas will now have PEP440 compliant version strings (GH9518).
- Development support for benchmarking with the Air Speed Velocity library (GH8361).
- Support for reading SAS xport files, see [here](#).
- Documentation comparing SAS to pandas, see [here](#).
- Removal of the automatic TimeSeries broadcasting, deprecated since 0.8.0, see [here](#).
- Display format with plain text can optionally align with Unicode East Asian Width, see [here](#).
- Compatibility with Python 3.5 (GH11097).
- Compatibility with matplotlib 1.5.0 (GH11111).

Check the API Changes and deprecations before updating.

---

What’s new in v0.17.0

- New features
  - Datetime with TZ
  - Releasing the GIL
  - Plot submethods
  - Additional methods for dt accessor
    - `strftime`
* total_seconds
  - Period Frequency Enhancement
  - Support for SAS XPORT files
  - Support for Math Functions in .eval()
  - Changes to Excel with MultiIndex
  - Google BigQuery Enhancements
  - Display Alignment with Unicode East Asian Width
  - Other enhancements

• Backwards incompatible API changes
  - Changes to sorting API
  - Changes to to_datetime and to_timedelta
  * Error handling
  * Consistent Parsing
  - Changes to Index Comparisons
  - Changes to Boolean Comparisons vs. None
  - HDFStore dropna behavior
  - Changes to display.precision option
  - Changes to Categorical.unique
  - Changes to bool passed as header in Parsers
  - Other API Changes
  - Deprecations
  - Removal of prior version deprecations/changes

• Performance Improvements

• Bug Fixes

1.16.1 New features

1.16.1.1 Datetime with TZ

We are adding an implementation that natively supports datetime with timezones. A Series or a DataFrame column previously could be assigned a datetime with timezones, and would work as an object dtype. This had performance issues with a large number rows. See the docs for more details. (GH8260, GH10763, GH11034).

The new implementation allows for having a single-timezone across all rows, with operations in a performant manner.

In [1]: df = DataFrame({'A' : date_range('20130101', periods=3),
...:                   'B' : date_range('20130101', periods=3, tz='US/Eastern'),
...:                   'C' : date_range('20130101', periods=3, tz='CET'))
...:

In [2]: df

(continues on next page)
```python
Out[2]:
   A          B          C
0 2013-01-01 2013-01-01 00:00:00-05:00 2013-01-01 00:00:00+01:00
1 2013-01-02 2013-01-02 00:00:00-05:00 2013-01-02 00:00:00+01:00
2 2013-01-03 2013-01-03 00:00:00-05:00 2013-01-03 00:00:00+01:00

In [3]: df.dtypes
A  datetime64[ns]
B  datetime64[ns, US/Eastern]
C  datetime64[ns, CET]
dtype: object
```

This uses a new-dtype representation as well, that is very similar in look-and-feel to its numpy cousin `datetime64[ns]`

```python
In [4]: df.B
Out[4]:
0 2013-01-01 00:00:00-05:00
1 2013-01-02 00:00:00-05:00
2 2013-01-03 00:00:00-05:00
Name: B, dtype: datetime64[ns, US/Eastern]
```

```python
In [5]: df.B.dt.tz_localize(None)
Out[5]:
0 2013-01-01
1 2013-01-02
2 2013-01-03
Name: B, dtype: datetime64[ns]
```

```
Note: There is a slightly different string repr for the underlying DatetimeIndex as a result of the dtype changes, but functionally these are the same.

Previous Behavior:
```
In [1]: pd.date_range('20130101',periods=3,tz='US/Eastern')
Out[1]: DatetimeIndex([ '2013-01-01 00:00:00-05:00', '2013-01-02 00:00:00-05:00',
                        '2013-01-03 00:00:00-05:00'],
                       dtype='datetime64[ns]', freq='D', tz='US/Eastern')
```

```
In [2]: pd.date_range('20130101',periods=3,tz='US/Eastern').dtype
Out[2]: dtype('<M8[ns]')
```

New Behavior:
```
In [8]: pd.date_range('20130101',periods=3,tz='US/Eastern')
Out[8]:
```

1.16.1.2 Releasing the GIL

We are releasing the global-interpreter-lock (GIL) on some cython operations. This will allow other threads to run simultaneously during computation, potentially allowing performance improvements from multi-threading. Notably groupby, nsmallest, value_counts and some indexing operations benefit from this. (GH8882)

For example the groupby expression in the following code will have the GIL released during the factorization step, e.g. `df.groupby('key')` as well as the `.sum()` operation.

```python
N = 1000000
ngroups = 10
df = DataFrame({'key' : np.random.randint(0,ngroups,size=N),
                'data' : np.random.randn(N) })

df.groupby('key')['data'].sum()
```

Releasing of the GIL could benefit an application that uses threads for user interactions (e.g. QT), or performing multi-threaded computations. A nice example of a library that can handle these types of computation-in-parallel is the dask library.

1.16.1.3 Plot submethods

The Series and DataFrame `.plot()` method allows for customizing plot types by supplying the `kind` keyword arguments. Unfortunately, many of these kinds of plots use different required and optional keyword arguments, which makes it difficult to discover what any given plot kind uses out of the dozens of possible arguments.

To alleviate this issue, we have added a new, optional plotting interface, which exposes each kind of plot as a method of the `.plot` attribute. Instead of writing `series.plot(kind=<kind>, ...)`, you can now also use `series.plot.<kind>(...)`:

```python
In [10]: df = pd.DataFrame(np.random.rand(10, 2), columns=['a', 'b'])

In [11]: df.plot.bar()
```
As a result of this change, these methods are now all discoverable via tab-completion:

```
In [12]: df.plot.<TAB>
df.plot.area  df.plot.barh  df.plot.density  df.plot.hist  df.plot.line
  → df.plot.scatter
df.plot.bar  df.plot.box  df.plot.hexbin  df.plot.kde  df.plot.pie
```

Each method signature only includes relevant arguments. Currently, these are limited to required arguments, but in the future these will include optional arguments, as well. For an overview, see the new Plotting API documentation.

### 1.16.1.4 Additional methods for `dt` accessor

**strftime**

We are now supporting a `Series.dt.strftime` method for datetime-likes to generate a formatted string (GH10110). Examples:

```
# DatetimeIndex
In [13]: s = pd.Series(pd.date_range('20130101', periods=4))

In [14]: s
Out[14]:
0  2013-01-01
1  2013-01-02
2  2013-01-03
3  2013-01-04
dtype: datetime64[ns]

In [15]: s.dt.strftime('%Y/%m/%d')
Out[15]:
0  2013/01/01
```

(continues on next page)
1. PeriodIndex

```python
In [16]: s = pd.Series(pd.period_range('20130101', periods=4))
```

```python
In [17]: s
Out[17]:
0 2013-01-01
1 2013-01-02
2 2013-01-03
3 2013-01-04
dtype: object
```

```python
In [18]: s.dt.strftime('%Y/%m/%d')
```

```python
Out[18]:
0 2013/01/01
1 2013/01/02
2 2013/01/03
3 2013/01/04
dtype: object
```

The string format is as the python standard library and details can be found here

**total_seconds**

`pd.Series` of type `timedelta64` has new method `.dt.total_seconds()` returning the duration of the `timedelta` in seconds (GH10817)

```python
# TimedeltaIndex
In [19]: s = pd.Series(pd.timedelta_range('1 minutes', periods=4))
```

```python
In [20]: s
Out[20]:
0 0 days 00:01:00
1 1 days 00:01:00
2 2 days 00:01:00
3 3 days 00:01:00
dtype: timedelta64[ns]
```

```python
In [21]: s.dt.total_seconds()
```

```python
Out[21]:
0 60.0
1 86460.0
2 172860.0
3 259260.0
dtype: float64
```
1.16.1.5 Period Frequency Enhancement

Period, PeriodIndex and period_range can now accept multiplied freq. Also, Period.freq and PeriodIndex.freq are now stored as a DateOffset instance like DatetimeIndex, and not as str (GH7811)

A multiplied freq represents a span of corresponding length. The example below creates a period of 3 days. Addition and subtraction will shift the period by its span.

```
In [22]: p = pd.Period('2015-08-01', freq='3D')
In [23]: p
Out[23]: Period('2015-08-01', '3D')
In [24]: p + 1
Out[24]: Period('2015-08-04', '3D')
In [25]: p - 2
Out[25]: Period('2015-07-26', '3D')
In [26]: p.to_timestamp()
Out[26]: Timestamp('2015-08-01 00:00:00')
In [27]: p.to_timestamp(how='E')
Out[27]: Timestamp('2015-08-03 00:00:00')
```

You can use the multiplied freq in PeriodIndex and period_range.

```
In [28]: idx = pd.period_range('2015-08-01', periods=4, freq='2D')
In [29]: idx
Out[29]: PeriodIndex(['2015-08-01', '2015-08-03', '2015-08-05', '2015-08-07'], dtype='period[2D]', freq='2D')
In [30]: idx + 1
Out[30]: PeriodIndex(['2015-08-03', '2015-08-05', '2015-08-07', '2015-08-09'], dtype='period[2D]', freq='2D')
```

1.16.1.6 Support for SAS XPORT files

read_sas() provides support for reading SAS XPORT format files. (GH4052).

```
df = pd.read_sas('sas_xport.xpt')
```

It is also possible to obtain an iterator and read an XPORT file incrementally.

```
for df in pd.read_sas('sas_xport.xpt', chunksize=10000)
    do_something(df)
```

See the docs for more details.
1.16.1.7 Support for Math Functions in .eval()

`eval()` now supports calling math functions (GH4893)

```python
df = pd.DataFrame({'a': np.random.randn(10)})
df.eval("b = sin(a)")
```

The support math functions are sin, cos, exp, log, expm1, log1p, sqrt, sinh, cosh, tanh, arcsin, arccos, arctan, arccosh, arcsinh, arctanh, abs and arctan2.

These functions map to the intrinsics for the NumExpr engine. For the Python engine, they are mapped to NumPy calls.

1.16.1.8 Changes to Excel with MultiIndex

In version 0.16.2 a DataFrame with MultiIndex columns could not be written to Excel via `to_excel`. That functionality has been added (GH10564), along with updating `read_excel` so that the data can be read back with, no loss of information, by specifying which columns/rows make up the MultiIndex in the `header` and `index_col` parameters (GH4679)

See the documentation for more details.

```python
In [31]: df = pd.DataFrame([[1,2,3,4], [5,6,7,8]],
                          columns = pd.MultiIndex.from_product([[ 'foo','bar'], [ 'a','b']]),
                          names = ['col1', 'col2']
                   index = pd.MultiIndex.from_product([[ 'j'], [ 'l', 'k']]),
                          names = ['i1', 'i2']
                   )

In [32]: df
Out[32]:
       col1 foo bar
      col2 a b a b
   i1 i2
 j  1  2  3  4
 k  5  6  7  8

In [33]: df.to_excel('test.xlsx')

In [34]: df = pd.read_excel('test.xlsx', header=[0,1], index_col=[0,1])

In [35]: df
Out[35]:
       col1 foo bar
      col2 a b a b
   i1 i2
 j  1  2  3  4
 k  5  6  7  8
```

Previously, it was necessary to specify the `has_index_names` argument in `read_excel`, if the serialized data had index names. For version 0.17.0 the output format of `to_excel` has been changed to make this keyword unnecessary - the change is shown below.

Old
Warning: Excel files saved in version 0.16.2 or prior that had index names will still able to be read in, but the has_index_names argument must specified to True.

### 1.16.1.9 Google BigQuery Enhancements

- Added ability to automatically create a table/dataset using the `pandas.io.gbq.to_gbq()` function if the destination table/dataset does not exist. (GH8325, GH11121).
- Added ability to replace an existing table and schema when calling the `pandas.io.gbq.to_gbq()` function via the `if_exists` argument. See the docs for more details (GH8325).
- `InvalidColumnOrder` and `InvalidPageToken` in the gbq module will raise `ValueError` instead of `IOError`.
- The `generate_bq_schema()` function is now deprecated and will be removed in a future version (GH11121)
- The gbq module will now support Python 3 (GH11094).
1.16.1.10 Display Alignment with Unicode East Asian Width

**Warning:** Enabling this option will affect the performance for printing of DataFrame and Series (about 2 times slower). Use only when it is actually required.

Some East Asian countries use Unicode characters its width is corresponding to 2 alphabets. If a DataFrame or Series contains these characters, the default output cannot be aligned properly. The following options are added to enable precise handling for these characters.

- `display.unicode.east_asian_width`: Whether to use the Unicode East Asian Width to calculate the display text width. (GH2612)
- `display.unicode.ambiguous_as_wide`: Whether to handle Unicode characters belong to Ambiguous as Wide. (GH11102)

```python
In [36]: df = pd.DataFrame({u'' : ['UK', u''], u'' : ['Alice', u'']})
In [37]: df;
```

```plaintext
   名前 国籍
0  Alice  UK
1  しがく 日本
```

```python
In [38]: pd.set_option('display.unicode.east_asian_width', True)
In [39]: df;
```

```plaintext
   名前 国籍
0  Alice  UK
1  しがく 日本
```

For further details, see [here](#)

1.16.1.11 Other enhancements

- Support for openpyxl >= 2.2. The API for style support is now stable (GH10125)
- `merge` now accepts the argument `indicator` which adds a Categorical-type column (by default called `_merge`) to the output object that takes on the values (GH8790)

<table>
<thead>
<tr>
<th>Observation Origin</th>
<th>_merge value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merge key only in 'left' frame</td>
<td>left_only</td>
</tr>
<tr>
<td>Merge key only in 'right' frame</td>
<td>right_only</td>
</tr>
<tr>
<td>Merge key in both frames</td>
<td>both</td>
</tr>
</tbody>
</table>

```python
In [40]: df1 = pd.DataFrame({'coll':[0,1], 'col_left':['a','b']})
```

(continues on next page)
In [41]: df2 = pd.DataFrame({'col1':[1,2,2],'col_right':[2,2,2]})

In [42]: pd.merge(df1, df2, on='col1', how='outer', indicator=True)

Out[42]:
<table>
<thead>
<tr>
<th></th>
<th>col1</th>
<th>col_left</th>
<th>col_right</th>
<th>_merge</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>a</td>
<td>NaN</td>
<td>left_only</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>b</td>
<td>2.0</td>
<td>both</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>NaN</td>
<td>2.0</td>
<td>right_only</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>NaN</td>
<td>2.0</td>
<td>right_only</td>
</tr>
</tbody>
</table>

For more, see the updated docs

- pd.to_numeric is a new function to coerce strings to numbers (possibly with coercion) (GH11133)
- pd.merge will now allow duplicate column names if they are not merged upon (GH10639).
- pd.pivot will now allow passing index as None (GH3962).
- pd.concat will now use existing Series names if provided (GH10698).

In [43]: foo = pd.Series([1,2], name='foo')

In [44]: bar = pd.Series([1,2])

In [45]: baz = pd.Series([4,5])

Previous Behavior:

In [1]: pd.concat([foo, bar, baz], 1)
Out[1]:
<table>
<thead>
<tr>
<th></th>
<th>foo</th>
<th>bar</th>
<th>baz</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>NaN</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

New Behavior:

In [46]: pd.concat([foo, bar, baz], 1)
Out[46]:
<table>
<thead>
<tr>
<th></th>
<th>foo</th>
<th>bar</th>
<th>baz</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NaN</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

- DataFrame has gained the nlargest and nsmallest methods (GH10393)
- Add a limit_direction keyword argument that works with limit to enable interpolate to fill NaN values forward, backward, or both (GH9218, GH10420, GH11115)

In [47]: ser = pd.Series([np.nan, np.nan, 5, np.nan, np.nan, np.nan, 13])

In [48]: ser.interpolate(limit=1, limit_direction='both')
Out[48]:
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NaN</td>
</tr>
<tr>
<td>1</td>
<td>5.0</td>
</tr>
<tr>
<td>2</td>
<td>5.0</td>
</tr>
<tr>
<td>3</td>
<td>7.0</td>
</tr>
<tr>
<td>4</td>
<td>NaN</td>
</tr>
<tr>
<td>5</td>
<td>11.0</td>
</tr>
<tr>
<td>6</td>
<td>13.0</td>
</tr>
</tbody>
</table>

dtype: float64
• Added a `DataFrame.round` method to round the values to a variable number of decimal places (GH10568).

```python
In [49]: df = pd.DataFrame(np.random.random([3, 3]), columns=['A', 'B', 'C'], index=['first', 'second', 'third'])
....:
In [50]: df
Out[50]:
   A    B    C
first 0.34 0.30 0.42
second 0.68 0.88 0.51
third  0.67 0.59 0.62

In [51]: df.round(2)
   A    B    C
first 0.34 0.30 0.42
second 0.68 0.88 0.51
third  0.67 0.59 0.62

In [52]: df.round({'A': 0, 'C': 2})
   A    B    C
first 0.0 0.30 0.42
second 1.0 0.87 0.51
third  1.0 0.58 0.62
```

• `drop_duplicates` and `duplicated` now accept a `keep` keyword to target first, last, and all duplicates. The `take_last` keyword is deprecated, see here (GH6511, GH8505)

```python
In [53]: s = pd.Series(['A', 'B', 'C', 'A', 'B', 'D'])
In [54]: s.drop_duplicates()
Out[54]:
0  A
1  B
2  C
5  D
dtype: object

In [55]: s.drop_duplicates(keep='last')
Out[55]:
2  C
3  A
4  B
5  D
dtype: object

In [56]: s.drop_duplicates(keep=False)
   0  A
   1  B
   2  C
   5  D
dtype: object
```

• Reindex now has a `tolerance` argument that allows for finer control of *Limits on filling while reindexing* (GH10411):
In [57]: df = pd.DataFrame({'x': range(5),
   ..........:             't': pd.date_range('2000-01-01', periods=5)})
   ..........:
In [58]: df.reindex([0.1, 1.9, 3.5],
   ..........:       method='nearest',
   ..........:       tolerance=0.2)
   ..........:
Out[58]:
   x   t
0.1 0.0 2000-01-01
1.9 2.0 2000-01-03
3.5 NaN NaT

When used on a DatetimeIndex, TimedeltaIndex or PeriodIndex, tolerance will coerced into a Timedelta if possible. This allows you to specify tolerance with a string:

In [59]: df = df.set_index('t')

In [60]: df.reindex(pd.to_datetime(['1999-12-31']),
   ..........:       method='nearest',
   ..........:       tolerance='1 day')
   ..........:
Out[60]:
   x
1999-12-31 0

tolerance is also exposed by the lower level Index.get_indexer and Index.get_loc methods.

• Added functionality to use the base argument when resampling a TimeDeltaIndex (GH10530)
• DatetimeIndex can be instantiated using strings contains NaT (GH7599)
• to_datetime can now accept the yearfirst keyword (GH7599)
• pandas.tseries.offsets larger than the Day offset can now be used with a Series for addition/subtraction (GH10699). See the docs for more details.
• pd.Timedelta.total_seconds() now returns Timedelta duration to ns precision (previously microsecond precision) (GH10939)
• PeriodIndex now supports arithmetic with np.ndarray (GH10638)
• Support pickling of Period objects (GH10439)
• .as_blocks will now take a copy optional argument to return a copy of the data, default is to copy (no change in behavior from prior versions), (GH9607)
• regex argument to DataFrame.filter now handles numeric column names instead of raising ValueError (GH10384).
• Enable reading gzip compressed files via URL, either by explicitly setting the compression parameter or by inferring from the presence of the HTTP Content-Encoding header in the response (GH8685)
• Enable writing Excel files in memory using StringIO/BytesIO (GH7074)
• Enable serialization of lists and dicts to strings in ExcelWriter (GH8188)
• SQL io functions now accept a SQLAlchemy connectable. (GH7877)
• pd.read_sql and to_sql can accept database URI as con parameter (GH10214)
• read_sql_table will now allow reading from views (GH10750).
• Enable writing complex values to HDFStores when using the table format (GH10447)
• Enable pd.read_hdf to be used without specifying a key when the HDF file contains a single dataset (GH10443)
• pd.read_stata will now read Stata 118 type files. (GH9882)
• msgpack submodule has been updated to 0.4.6 with backward compatibility (GH10581)
• DataFrame.to_dict now accepts orient='index' keyword argument (GH10844).
• DataFrame.apply will return a Series of dicts if the passed function returns a dict and reduce=True (GH8735).
• Allow passing kwargs to the interpolation methods (GH10378).
• Improved error message when concatenating an empty iterable of DataFrame objects (GH9157)
• pd.read_csv can now read bz2-compressed files incrementally, and the C parser can read bz2-compressed files from AWS S3 (GH11070, GH11072).
• In pd.read_csv, recognize s3n:// and s3a:// URLs as designating S3 file storage (GH11070, GH11071).
• Read CSV files from AWS S3 incrementally, instead of first downloading the entire file. (Full file download still required for compressed files in Python 2.) (GH11070, GH11073)
• pd.read_csv is now able to infer compression type for files read from AWS S3 storage (GH11070, GH11074).

1.16.2 Backwards incompatible API changes

1.16.2.1 Changes to sorting API

The sorting API has had some longtime inconsistencies. (GH9816, GH8239).

Here is a summary of the API PRIOR to 0.17.0:
• Series.sort is INPLACE while DataFrame.sort returns a new object.
• Series.order returns a new object
• It was possible to use Series/DataFrame.sort_index to sort by values by passing the by keyword.
• Series/DataFrame.sortlevel worked only on a MultiIndex for sorting by index.

To address these issues, we have revamped the API:

• We have introduced a new method, DataFrame.sort_values(), which is the merger of DataFrame.sort(), Series.sort(), and Series.order(), to handle sorting of values.
• The existing methods Series.sort(), Series.order(), and DataFrame.sort() have been deprecated and will be removed in a future version.
• The by argument of DataFrame.sort_index() has been deprecated and will be removed in a future version.
• The existing method .sort_index() will gain the level keyword to enable level sorting.

We now have two distinct and non-overlapping methods of sorting. A * marks items that will show a FutureWarning.

To sort by the values:
To sort by the index:

<table>
<thead>
<tr>
<th>Previous</th>
<th>Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Series.sort()</td>
<td>Series.sort_values(inplace=True)</td>
</tr>
<tr>
<td>* DataFrame.sort(columns=...)</td>
<td>DataFrame.sort_values(by=...)</td>
</tr>
</tbody>
</table>

We have also deprecated and changed similar methods in two Series-like classes, `Index` and `Categorical`.

<table>
<thead>
<tr>
<th>Previous</th>
<th>Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Index.order()</td>
<td>Index.sort_values()</td>
</tr>
<tr>
<td>* Categorical.order()</td>
<td>Categorical.sort_values()</td>
</tr>
</tbody>
</table>

### 1.16.2.2 Changes to `to_datetime` and `to_timedelta`  

**Error handling**

The default for `pd.to_datetime` error handling has changed to `errors='raise'`. In prior versions it was `errors='ignore'`. Furthermore, the `coerce` argument has been deprecated in favor of `errors='coerce'`. This means that invalid parsing will raise rather than return the original input as in previous versions. (GH10636)

**Previous Behavior:**

```python
In [2]: pd.to_datetime(['2009-07-31', 'asd'])
Out[2]: array(['2009-07-31', 'asd'], dtype=object)
```

**New Behavior:**

```python
In [3]: pd.to_datetime(['2009-07-31', 'asd'])
ValueError: Unknown string format.
```

Of course you can coerce this as well.

```python
In [61]: to_datetime(['2009-07-31', 'asd'], errors='coerce')
Out[61]: DatetimeIndex(['2009-07-31', 'NaT'], dtype='datetime64[ns]', freq=None)
```

To keep the previous behavior, you can use `errors='ignore'`:

```python
In [62]: to_datetime(['2009-07-31', 'asd'], errors='ignore')
Out[62]: array(['2009-07-31', 'asd'], dtype=object)
```

Furthermore, `pd.to_timedelta` has gained a similar API, of `errors='raise'|'ignore'|'coerce'`, and the `coerce` keyword has been deprecated in favor of `errors='coerce'`.
Consistent Parsing

The string parsing of \texttt{to\_datetime}, \texttt{Timestamp} and \texttt{DatetimeIndex} has been made consistent. (GH7599)

Prior to v0.17.0, \texttt{Timestamp} and \texttt{to\_datetime} may parse year-only datetime-string incorrectly using today’s date, otherwise \texttt{DatetimeIndex} uses the beginning of the year. \texttt{Timestamp} and \texttt{to\_datetime} may raise \texttt{ValueError} in some types of datetime-string which \texttt{DatetimeIndex} can parse, such as a quarterly string.

Previous Behavior:

```python
In [1]: Timestamp('2012Q2')
Traceback
...  
ValueError: Unable to parse 2012Q2

# Results in today's date.
In [2]: Timestamp('2014')
Out [2]: 2014-08-12 00:00:00
```

v0.17.0 can parse them as below. It works on \texttt{DatetimeIndex} also.

New Behavior:

```python
In [63]: Timestamp('2012Q2')
Out[63]: Timestamp('2012-04-01 00:00:00')

In [64]: Timestamp('2014')
Out[64]: Timestamp('2014-01-01 00:00:00')

In [65]: DatetimeIndex(['2012Q2', '2014'])
Out [65]: DatetimeIndex(['2012-04-01', '2014-01-01'], dtype='datetime64[ns]', freq=None)
```

Note: If you want to perform calculations based on today’s date, use \texttt{Timestamp.now()} and \texttt{pandas.tseries.offsets}.

```python
In [66]: import pandas.tseries.offsets as offsets

In [67]: Timestamp.now()
Out [67]: Timestamp('2018-07-05 17:10:40.227744')

In [68]: Timestamp.now() + offsets.DateOffset(years=1)
Out [68]: Timestamp('2019-07-05 17:10:40.228803')
```

1.16.2.3 Changes to Index Comparisons

Operator equal on \texttt{Index} should behavior similarly to \texttt{Series} (GH9947, GH10637)

Starting in v0.17.0, comparing \texttt{Index} objects of different lengths will raise a \texttt{ValueError}. This is to be consistent with the behavior of \texttt{Series}.

Previous Behavior:
In [2]: pd.Index([1, 2, 3]) == pd.Index([1, 4, 5])
Out[2]: array([ True, False, False], dtype=bool)

In [3]: pd.Index([1, 2, 3]) == pd.Index([2])
Out[3]: array([False, True, False], dtype=bool)

In [4]: pd.Index([1, 2, 3]) == pd.Index([1, 2])
Out[4]: False

New Behavior:

In [8]: pd.Index([1, 2, 3]) == pd.Index([1, 4, 5])
Out[8]: array([ True, False, False], dtype=bool)

In [9]: pd.Index([1, 2, 3]) == pd.Index([2])
ValueError: Lengths must match to compare

In [10]: pd.Index([1, 2, 3]) == pd.Index([1, 2])
ValueError: Lengths must match to compare

Note that this is different from the numpy behavior where a comparison can be broadcast:

In [69]: np.array([1, 2, 3]) == np.array([1])
Out[69]: array([ True, False, False], dtype=bool)

or it can return False if broadcasting can not be done:

In [70]: np.array([1, 2, 3]) == np.array([1, 2])
Out[70]: False

1.16.2.4 Changes to Boolean Comparisons vs. None

Boolean comparisons of a Series vs None will now be equivalent to comparing with np.nan, rather than raise TypeError. (GH1079).

In [71]: s = Series(range(3))

In [72]: s.iloc[1] = None

In [73]: s
Out[73]:
0   0.0
1  NaN
2   2.0
dtype: float64

Previous Behavior:

In [5]: s==None
TypeError: Could not compare <type 'NoneType'> type with Series

New Behavior:

In [74]: s==None
Out[74]:
(continues on next page)
Usually you simply want to know which values are null.

```
In [75]: s.isnull()
Out[75]:
   0 False
   1  True
   2 False
dtype: bool
```

**Warning:** You generally will want to use `isnull/notnull` for these types of comparisons, as `isnull/notnull` tells you which elements are null. One has to be mindful that `nan`'s don't compare equal, but `None`'s do. Note that Pandas/numpy uses the fact that `np.nan != np.nan`, and treats `None` like `np.nan`.

```
In [76]: None == None
Out[76]: True

In [77]: np.nan == np.nan
Out[77]: False
```

### 1.16.2.5 HDFStore dropna behavior

The default behavior for HDFStore write functions with `format='table'` is now to keep rows that are all missing. Previously, the behavior was to drop rows that were all missing save the index. The previous behavior can be replicated using the `dropna=True` option. (GH9382)

**Previous Behavior:**

```
In [78]: df_with_missing = pd.DataFrame({'col1':[0, np.nan, 2],
                                           'col2':[1, np.nan, np.nan]})

In [79]: df_with_missing
Out[79]:
      col1  col2
   0    0.0   1.0
   1  NaN    NaN
   2    2.0  NaN

In [27]: df_with_missing.to_hdf('file.h5',
           'df_with_missing',
           format='table',
           mode='w')

In [28]: pd.read_hdf('file.h5', 'df_with_missing')
```

(continues on next page)
New Behavior:

```
In [80]: df_with_missing.to_hdf('file.h5',
    ....:   'df_with_missing',
    ....:   format='table',
    ....:   mode='w')

In [81]: pd.read_hdf('file.h5', 'df_with_missing')
```

```
Out[81]:
   col1  col2
0    0.0  1.0
1   NaN  NaN
2    2.0  NaN
```

See the docs for more details.

### 1.16.2.6 Changes to `display.precision` option

The `display.precision` option has been clarified to refer to decimal places (GH10451).

Earlier versions of pandas would format floating point numbers to have one less decimal place than the value in `display.precision`.

```
In [1]: pd.set_option('display.precision', 2)

In [2]: pd.DataFrame({'x': [123.456789]})
```

```
Out[2]:
   x
0 123.5
```

If interpreting precision as “significant figures” this did work for scientific notation but that same interpretation did not work for values with standard formatting. It was also out of step with how numpy handles formatting.

Going forward the value of `display.precision` will directly control the number of places after the decimal, for regular formatting as well as scientific notation, similar to how numpy’s `precision` print option works.

```
In [82]: pd.set_option('display.precision', 2)

In [83]: pd.DataFrame({'x': [123.456789]})
```

```
Out[83]:
   x
0 123.46
```

To preserve output behavior with prior versions the default value of `display.precision` has been reduced to 6 from 7.

### 1.16.2.7 Changes to `Categorical.unique`

`Categorical.unique` now returns new `Categoricals` with categories and codes that are unique, rather than returning `np.array` (GH10508)

- unordered category: values and categories are sorted by appearance order.
• ordered category: values are sorted by appearance order, categories keep existing order.

```
In [84]: cat = pd.Categorical(["C", "A", "B", "C"],
    ....:     categories=["A", "B", "C"],
    ....:     ordered=True)
    ....:

In [85]: cat
Out[85]:
[C, A, B, C]
Categories (3, object): [A < B < C]

In [86]: cat.unique()

Out[86]:
[C, A, B]
Categories (3, object): [A < B < C]

In [87]: cat = pd.Categorical(["C", "A", "B", "C"],
    ....:     categories=["A", "B", "C"])
    ....:

In [88]: cat
Out[88]:
[C, A, B, C]
Categories (3, object): [A, B, C]

In [89]: cat.unique()

Out[89]:
[C, A, B]
Categories (3, object): [C, A, B]
```

1.16.2.8 Changes to bool passed as header in Parsers

In earlier versions of pandas, if a bool was passed the header argument of read_csv, read_excel, or read_html it was implicitly converted to an integer, resulting in header=0 for False and header=1 for True (GH6113)

A bool input to header will now raise a TypeError

```
In [29]: df = pd.read_csv('data.csv', header=False)
TypeError: Passing a bool to header is invalid. Use header=None for no header or header=int or list-like of ints to specify the row(s) making up the column names
```

1.16.2.9 Other API Changes

• Line and kde plot with subplots=True now uses default colors, not all black. Specify color='k' to draw all lines in black (GH9894)

• Calling the .value_counts() method on a Series with a categorical dtype now returns a Series with a CategoricalIndex (GH10704)

• The metadata properties of subclasses of pandas objects will now be serialized (GH10553).

• groupby using Categorical follows the same rule as Categorical.unique described above (GH10508)
• When constructing DataFrame with an array of complex64 dtype previously meant the corresponding column was automatically promoted to the complex128 dtype. Pandas will now preserve the itemsize of the input for complex data (GH10952)

• some numeric reduction operators would return ValueError, rather than TypeError on object types that includes strings and numbers (GH11131)

• Passing currently unsupported chunksize argument to read_excel or ExcelFile.parse will now raise Not ImplementedError (GH8011)

• Allow an ExcelFile object to be passed into read_excel (GH11198)

• DatetimeIndex.union does not infer freq if self and the input have None as freq (GH11086)

• NaT's methods now either raise ValueError, or return np.nan or NaT (GH9513)

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>return np.nan</td>
<td>weekday, isoweekday</td>
</tr>
<tr>
<td>return NaT</td>
<td>date, now, replace, to_datetime, today</td>
</tr>
<tr>
<td>return np.datetime64('NaT')</td>
<td>to_datetime64 (unchanged)</td>
</tr>
<tr>
<td>raise ValueError</td>
<td>All other public methods (names not beginning with underscores)</td>
</tr>
</tbody>
</table>

### 1.16.2.10 Deprecations

• For Series the following indexing functions are deprecated (GH10177).

<table>
<thead>
<tr>
<th>Deprecated Function</th>
<th>Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>.irow(i)</td>
<td>.iloc[i] or .iat[i]</td>
</tr>
<tr>
<td>.iget(i)</td>
<td>.iloc[i] or .iat[i]</td>
</tr>
<tr>
<td>.iget_value(i)</td>
<td>.iloc[i] or .iat[i]</td>
</tr>
</tbody>
</table>

• For DataFrame the following indexing functions are deprecated (GH10177).

<table>
<thead>
<tr>
<th>Deprecated Function</th>
<th>Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>.irow(i)</td>
<td>.iloc[i]</td>
</tr>
<tr>
<td>.iget_value(i, j)</td>
<td>.iloc[i] or .iat[i]</td>
</tr>
<tr>
<td>.icol(j)</td>
<td>.iloc[:, j]</td>
</tr>
</tbody>
</table>

**Note:** These indexing function have been deprecated in the documentation since 0.11.0.

• Categorical.name was deprecated to make Categorical more numpy.ndarray like. Use Series(cat, name="whatever") instead (GH10482).

• Setting missing values (NaN) in a Categorical's categories will issue a warning (GH10748). You can still have missing values in the values.

• drop_duplicates and duplicated's take_last keyword was deprecated in favor of keep. (GH6511, GH8505)

• Series.nsmallest and nlargest's take_last keyword was deprecated in favor of keep. (GH10792)

• DataFrame.combineAdd and DataFrame.combineMult are deprecated. They can easily be replaced by using the add and mul methods: DataFrame.add(other, fill_value=0) and DataFrame.mul(other, fill_value=1.) (GH10735).
• TimeSeries deprecated in favor of Series (note that this has been an alias since 0.13.0), (GH10890)
• SparsePanel deprecated and will be removed in a future version (GH11157).
• Series.is_time_series deprecated in favor of Series.index.is_all_dates (GH11135)
• Legacy offsets (like 'A@JAN') are deprecated (note that this has been alias since 0.8.0) (GH10878)
• WidePanel deprecated in favor of Panel, LongPanel in favor of DataFrame (note these have been aliases since < 0.11.0), (GH10892)
• DataFrame.convert_objects has been deprecated in favor of type-specific functions pd.to_datetime, pd.to_timestamp and pd.to_numeric (new in 0.17.0) (GH11133).

1.16.2.11 Removal of prior version deprecations/changes

• Removal of na_last parameters from Series.order() and Series.sort(), in favor of na_position. (GH5231)
• Remove of percentile_width from .describe(), in favor of percentiles. (GH7088)
• Removal of colSpace parameter from DataFrame.to_string(), in favor of col_space, circa 0.8.0 version.
• Removal of automatic time-series broadcasting (GH2304)

Previously

```
In [90]: np.random.seed(1234)
In [91]: df = DataFrame(np.random.randn(5,2),columns=list('AB'),index=date_range('20130101',periods=5))
In [92]: df
Out[92]:
     A       B
2013-01-01  0.471435 -1.190976
2013-01-02  1.432707 -0.312652
2013-01-03 -0.720589  0.887163
2013-01-04  0.859588 -0.636524
2013-01-05  0.015696 -2.242685
```

FutureWarning: TimeSeries broadcasting along DataFrame index by default is deprecated.
Please use DataFrame.<op> to explicitly broadcast arithmetic operations along the index

```
In [3]: df + df.A
```

Current

```
A     B
2013-01-01 0.471435 -1.190976
2013-01-02 1.432707 -0.312652
2013-01-03 -0.720589  0.887163
2013-01-04  0.859588 -0.636524
2013-01-05  0.015696 -2.242685
```
In [93]: df.add(df.A, axis='index')
Out[93]:
     A       B
2013-01-01  0.942870 -0.719541
2013-01-02  2.865414  1.120055
2013-01-03 -1.441177  0.166574
2013-01-04  1.719177  0.223065
2013-01-05  0.031393 -2.226989

• Remove table keyword in HDFStore.put/append, in favor of using format= (GH4645)
• Remove kind in read_excel/ExcelFile as its unused (GH4712)
• Remove infer_type keyword from pd.read_html as its unused (GH4770, GH7032)
• Remove offset and timeRule keywords from Series.tshift/shift, in favor of freq (GH4853, GH4864)
• Remove pd.load/pd.save aliases in favor of pd.to_pickle/pd.read_pickle (GH3787)

1.16.3 Performance Improvements

• Development support for benchmarking with the Air Speed Velocity library (GH8361)
• Added vbench benchmarks for alternative ExcelWriter engines and reading Excel files (GH7171)
• Performance improvements in Categorical.value_counts (GH10804)
• Performance improvements in SeriesGroupBy.nunique and SeriesGroupBy.value_counts and SeriesGroupby.transform (GH10820, GH11077)
• Performance improvements in DataFrame.drop_duplicates with integer dtypes (GH10917)
• Performance improvements in DataFrame.duplicated with wide frames. (GH10161, GH11180)
• 4x improvement in timedelta string parsing (GH6755, GH10426)
• 8x improvement in timedelta64 and datetime64 ops (GH6755)
• Significantly improved performance of indexing MultiIndex with slicers (GH10287)
• 8x improvement in iloc using list-like input (GH10791)
• Improved performance of Series.isin for datetimelike/integer Series (GH10287)
• 20x improvement in concat of Categoricals when categories are identical (GH10587)
• Improved performance of to_datetime when specified format string is ISO8601 (GH10178)
• 2x improvement of Series.value_counts for float dtype (GH10821)
• Enable infer_datetime_format in to_datetime when date components do not have 0 padding (GH11142)
• Regression from 0.16.1 in constructing DataFrame from nested dictionary (GH11084)
• Performance improvements in addition/subtraction operations for DateOffset with Series or DatetimeIndex (GH10744, GH11205)
1.16.4 Bug Fixes

- Bug in incorect computation of .mean() on timedelta64[ns] because of overflow (GH9442)
- Bug in .isin on older numpies (GH11232)
- Bug in DataFrame.to_html(index=False) renders unnecessary name row (GH10344)
- Bug in DataFrame.to_latex() the column_format argument could not be passed (GH9402)
- Bug in DatetimeIndex when localizing with NaT (GH10477)
- Bug in Series.dt ops in preserving meta-data (GH10477)
- Bug in preserving NaT when passed in an otherwise invalid to_datetime construction (GH10477)
- Bug in DataFrame.apply when function returns categorical series. (GH9573)
- Bug in to_datetime with invalid dates and formats supplied (GH10154)
- Bug in Index.drop_duplicates dropping name(s) (GH10115)
- Bug in Series.quantile dropping name (GH10881)
- Bug in pd.Series when setting a value on an empty Series whose index has a frequency. (GH10193)
- Bug in pd.Series.interpolate with invalid order keyword values. (GH10633)
- Bug in DataFrame.plot raises ValueError when color name is specified by multiple characters (GH10387)
- Bug in Index construction with a mixed list of tuples (GH10697)
- Bug in DataFrame.reset_index when index contains NaT. (GH10388)
- Bug in ExcelReader when worksheet is empty (GH6403)
- Bug in BinGrouper.group_info where returned values are not compatible with base class (GH10914)
- Bug in clearing the cache on DataFrame.pop and a subsequent inplace op (GH10912)
- Bug in indexing with a mixed-integer Index causing an ImportError (GH10610)
- Bug in Series.count when index has nulls (GH10946)
- Bug in pickling of a non-regular freq DatetimeIndex (GH11002)
- Bug causing DataFrame.where to not respect the axis parameter when the frame has a symmetric shape. (GH9736)
- Bug in Table.select_column where name is not preserved (GH10392)
- Bug in offsets.generate_range where start and end have finer precision than offset (GH9907)
- Bug in pd.rolling_* where Series.name would be lost in the output (GH10565)
- Bug in stack when index or columns are not unique. (GH10417)
- Bug in setting a Panel when an axis has a multi-index (GH10360)
- Bug in USFederalHolidayCalendar where USMemorialDay and USMartinLutherKingJr were incorrect (GH10278 and GH9760)
- Bug in .sample() where returned object, if set, gives unnecessary SettingWithCopyWarning (GH10738)
- Bug in .sample() where weights passed as Series were not aligned along axis before being treated positionally, potentially causing problems if weight indices were not aligned with sampled object. (GH10738)
- Regression fixed in (GH9311, GH6620, GH9345), where groupby with a datetime-like converting to float with certain aggregators (GH10979)
- Bug in DataFrame.interpolate with axis=1 and inplace=True (GH10395)
- Bug in io.sql.get_schema when specifying multiple columns as primary key (GH10385).
- Bug in groupby(sort=False) with datetime-like Categorical raises ValueError (GH10505)
- Bug in groupby(axis=1) with filter() throws IndexError (GH11041)
- Bug in test_categorical on big-endian builds (GH10425)
- Bug in Series.shift and DataFrame.shift not supporting categorical data (GH9416)
- Bug in Series.map using categorical Series raises AttributeError (GH10324)
- Bug in MultiIndex.get_level_values including Categorical raises AttributeError (GH10460)
- Bug in pd.get_dummies with sparse=True not returning SparseDataFrame (GH10531)
- Bug in Index subtypes (such as PeriodIndex) not returning their own type for .drop and .insert methods (GH10620)
- Bug in algos.outer_join_indexer when right array is empty (GH10618)
- Bug in filter (regression from 0.16.0) and transform when grouping on multiple keys, one of which is datetime-like (GH10114)
- Bug in to_datetime and to_timedelta causing Index name to be lost (GH10875)
- Bug in len(DataFrame.groupby) causing IndexError when there’s a column containing only NaNs (GH11016)
- Bug that caused segfault when resampling an empty Series (GH10228)
- Bug inDatetimeIndex and PeriodIndex.value_counts resets name from its result, but retains in result’s Index. (GH10150)
- Bug in pd.eval using numexpr engine coerces 1 element numpy array to scalar (GH10546)
- Bug in pd.concat with axis=0 when column is of dtype category (GH10177)
- Bug in read_msgpack where input type is not always checked (GH10369, GH10630)
- Bug in pd.read_csv with kwargs index_col=False, index_col=[a', 'b'] or dtype (GH10413, GH10467, GH10577)
- Bug in Series.from_csv with header kwarg not setting the Series.name or the Series.index name (GH10483)
- Bug in groupby.var which caused variance to be inaccurate for small float values (GH10448)
- Bug in Series.plot(kind='hist') Y Label not informative (GH10485)
- Bug in read_csv when using a converter which generates a uint8 type (GH9266)
- Bug causes memory leak in time-series line and area plot (GH9003)
- Bug when setting a Panel sliced along the major or minor axes when the right-hand side is a DataFrame (GH11014)
- Bug that returns None and does not raise NotImplementedError when operator functions (e.g. .add) of Panel are not implemented (GH7692)
- Bug in line and kde plot cannot accept multiple colors when subplots=True (GH9804)
• Bug in DataFrame.plot raises ValueError when color name is specified by multiple characters (GH10387)
• Bug in left and right align of Series with MultiIndex may be inverted (GH10665)
• Bug in left and right join of with MultiIndex may be inverted (GH10741)
• Bug in read_stata when reading a file with a different order set in columns (GH10757)
• Bug in Categorical may not representing properly when category contains tz or Period (GH10713)
• Bug in Categorical.__iter__ may not returning correct datetime and Period (GH10713)
• Bug in indexing with a PeriodIndex on an object with a PeriodIndex (GH4125)
• Bug in read_csv with engine='c': EOF preceded by a comment, blank line, etc. was not handled correctly (GH10728, GH10548)
• Reading “famafrench” data via DataReader results in HTTP 404 error because of the website url is changed (GH10591).
• Bug in read_msgpack where DataFrame to decode has duplicate column names (GH9618)
• Bug in io.common.get_filepath_or_buffer which caused reading of valid S3 files to fail if the bucket also contained keys for which the user does not have read permission (GH10604)
• Bug in vectorised setting of timestamp columns with python datetime.date and numpy datetime64 (GH10408, GH10412)
• Bug in Index.take may add unnecessary freq attribute (GH10791)
• Bug in merge with empty DataFrame may raise IndexError (GH10824)
• Bug in to_latex where unexpected keyword argument for some documented arguments (GH10888)
• Bug in indexing of large DataFrame where IndexError is uncaught (GH10645 and GH10692)
• Bug in read_csv when using the nrows or chunksize parameters if file contains only a header line (GH9535)
• Bug in serialization of category types in HDF5 in presence of alternate encodings. (GH10366)
• Bug in pd.DataFrame when constructing an empty DataFrame with a string dttype (GH9428)
• Bug in pd.DataFrame.diff when DataFrame is not consolidated (GH10907)
• Bug in pd.unique for arrays with the datetime64 or timedelta64 dttype that meant an array with object dttype was returned instead the original dttype (GH9431)
• Bug in Timedelta raising error when slicing from 0s (GH10583)
• Bug in DatetimeIndex.take and TimedeltaIndex.take may not raise IndexError against invalid index (GH10295)
• Bug in Series({np.nan}).astype('M8[ms]'), which now returns Series({pd.NaT}) (GH10747)
• Bug in PeriodIndex.order reset freq (GH10295)
• Bug in date_range when freq divides end as nanos (GH10885)
• Bug in iloc allowing memory outside bounds of a Series to be accessed with negative integers (GH10779)
• Bug in read_msgpack where encoding is not respected (GH10581)
• Bug preventing access to the first index when using iloc with a list containing the appropriate negative integer (GH10547, GH10779)
• Bug in TimedeltaIndex formatter causing error while trying to save DataFrame with TimedeltaIndex using to_csv (GH10833)
• Bug in DataFrame.where when handling Series slicing (GH10218, GH9558)
• Bug where pd.read_gbq throws ValueError when Bigquery returns zero rows (GH10273)
• Bug in to_json which was causing segmentation fault when serializing 0-rank ndarray (GH9576)
• Bug in plotting functions may raise IndexError when plotted on GridSpec (GH10819)
• Bug in plot result may show unnecessary minor ticklabels (GH10657)
• Bug in groupby incorrect computation for aggregation on DataFrame with NaT (E.g first, last, min). (GH10590, GH11010)
• Bug when constructing DataFrame where passing a dictionary with only scalar values and specifying columns did not raise an error (GH10856)
• Bug in .var() causing roundoff errors for highly similar values (GH10242)
• Bug in DataFrame.plot (subplots=True) with duplicated columns outputs incorrect result (GH10962)
• Bug in Index arithmetic may result in incorrect class (GH10638)
• Bug in date_range results in empty if freq is negative annually, quarterly and monthly (GH11018)
• Bug in DatetimeIndex cannot infer negative freq (GH11018)
• Remove use of some deprecated numpy comparison operations, mainly in tests. (GH10569)
• Bug in Index dtype may not applied properly (GH11017)
• Bug in io.gbq when testing for minimum google api client version (GH10652)
• Bug in DataFrame construction from nested dict with timedelta keys (GH11129)
• Bug in .fillna against may raise TypeError when data contains datetime dtype (GH7095, GH11153)
• Bug in .groupby when number of keys to group by is same as length of index (GH11185)
• Bug in convert_objects where converted values might not be returned if all null and coerce (GH9589)
• Bug in convert_objects where copy keyword was not respected (GH9589)

1.17 v0.16.2 (June 12, 2015)

This is a minor bug-fix release from 0.16.1 and includes a a large number of bug fixes along some new features (pipe() method), enhancements, and performance improvements.

We recommend that all users upgrade to this version.

Highlights include:

• A new pipe method, see here
• Documentation on how to use numba with pandas, see here

What’s new in v0.16.2

• New features
  – Pipe
### 1.17.1 New features

#### 1.17.1.1 Pipe

We've introduced a new method `DataFrame.pipe()`. As suggested by the name, `pipe` should be used to pipe data through a chain of function calls. The goal is to avoid confusing nested function calls like

```python
# df is a DataFrame
# f, g, and h are functions that take and return DataFrames
f(g(h(df), arg1=1), arg2=2, arg3=3)
```

The logic flows from inside out, and function names are separated from their keyword arguments. This can be rewritten as

```python
(df.pipe(h)
 .pipe(g, arg1=1)
 .pipe(f, arg2=2, arg3=3)
)
```

Now both the code and the logic flow from top to bottom. Keyword arguments are next to their functions. Overall the code is much more readable.

In the example above, the functions `f`, `g`, and `h` each expected the DataFrame as the first positional argument. When the function you wish to apply takes its data anywhere other than the first argument, pass a tuple of `(function, keyword)` indicating where the DataFrame should flow. For example:

```python
# statsmodels.formula.api as sm
import statsmodels.formula.api as sm

bb = pd.read_csv('data/baseball.csv', index_col='id')
# sm.ols takes (formula, data)
(fg(h(df), arg1=1), arg2=2, arg3=3)
```

```python
In [1]: import statsmodels.formula.api as sm
In [2]: bb = pd.read_csv('data/baseball.csv', index_col='id')
In [3]: (bb.query('h > 0')
 .assign(ln_h = lambda df: np.log(df.h))
 .pipe((sm.ols, 'data'), 'hr ~ ln_h + year + g + C(lg)')
 .fit()
 .summary()
)
```

```
Out[3]:
```
The pipe method is inspired by unix pipes, which stream text through processes. More recently dplyr and magrittr have introduced the popular `%>%` pipe operator for R.

See the documentation for more. (GH10129)

1.17.1.2 Other Enhancements

- Added `rsplit` to Index/Series StringMethods (GH10303)
- Removed the hard-coded size limits on the DataFrame HTML representation in the IPython notebook, and leave this to IPython itself (only for IPython v3.0 or greater). This eliminates the duplicate scroll bars that appeared in the notebook with large frames (GH10231).

Note that the notebook has a toggle output scrolling feature to limit the display of very large frames (by clicking left of the output). You can also configure the way DataFrames are displayed using the pandas options, see here.

- `axis` parameter of DataFrame.quantile now accepts also index and column. (GH9543)

1.17.2 API Changes

- Holiday now raises NotImplementedError if both offset and observance are used in the constructor instead of returning an incorrect result (GH10217).

1.17.3 Performance Improvements

- Improved Series.resample performance with `dtype=datetime64[ns]` (GH7754)
- Increase performance of str.split when `expand=True` (GH10081)
1.17.4 Bug Fixes

- Bug in `Series.hist` raises an error when a one row Series was given (GH10214)
- Bug where `HDFStore.select` modifies the passed columns list (GH7212)
- Bug in `Categorical` repr with `display.width` of `None` in Python 3 (GH10087)
- Bug in `to_json` with certain orients and a `CategoricalIndex` would segfault (GH10317)
- Bug where some of the nan funcs do not have consistent return dtypes (GH10251)
- Bug in `DataFrame.quantile` on checking that a valid axis was passed (GH9543)
- Bug in `groupby.apply` aggregation for Categorical not preserving categories (GH10138)
- Bug in `to_csv` where `date_format` is ignored if the datetime is fractional (GH10209)
- Bug in `DataFrame.to_json` with mixed data types (GH10289)
- Bug in cache updating when consolidating (GH10264)
- Bug in `mean()` where integer dtypes can overflow (GH10172)
- Bug where `Panel.from_dict` does not set dtype when specified (GH10058)
- Bug in `Index.union` raises `AttributeError` when passing array-likes. (GH10149)
- Bug in `Timestamp`'s`' `microsecond`, `quarter`, `dayofyear`, `week` and `daysinmonth` properties return `np.int32` type, not built-in `int`. (GH10050)
- Bug in `NaT` raises `AttributeError` when accessing to `daysinmonth`, `dayofweek` properties. (GH10096)
- Bug in `Index repr` when using the `max_seq_items=None` setting (GH10182).
- Bug in getting timezone data with `dateutil` on various platforms (GH9059, GH8639, GH9663, GH10121)
- Bug in displaying datetimes with mixed frequencies; display ‘ms’ datetimes to the proper precision. (GH10170)
- Bug in `setitem` where type promotion is applied to the entire block (GH10280)
- Bug in `Series` arithmetic methods may incorrectly hold names (GH10068)
- Bug in `GroupBy.get_group` when grouping on multiple keys, one of which is categorical. (GH10132)
- Bug in `DatetimeIndex` and `TimedeltaIndex` names are lost after timedelta arithmetics (GH9926)
- Bug in `DataFrame` construction from nested `dict` with `datetime64` (GH10160)
- Bug in `Series` construction from `dict` with `datetime64` keys (GH9456)
- Bug in `Series.plot(label="LABEL")` not correctly setting the label (GH10119)
- Bug in `plot` not defaulting to `matplotlib` `axes.grid` setting (GH9792)
- Bug causing strings containing an exponent, but no decimal to be parsed as `int` instead of `float` in `engine='python'` for the `read_csv` parser (GH9565)
- Bug in `Series.align` resets name when `fill_value` is specified (GH10067)
- Bug in `read_csv` causing index name not to be set on an empty `DataFrame` (GH10184)
- Bug in `SparseSeries.abs` resets name (GH10241)
- Bug in `TimedeltaIndex` slicing may reset freq (GH10292)
- Bug in `GroupBy.get_group` raises `ValueError` when group key contains `NaT` (GH6992)
- Bug in `SparseSeries` constructor ignores input data name (GH10258)
• Bug in `Categorical.remove_categories` causing a `ValueError` when removing the NaN category if underlying dtype is floating-point (GH10156)
• Bug where `infer_freq` infers timerule (WOM-5XXX) unsupported by `to_offset` (GH9425)
• Bug in `DataFrame.to_hdf()` where table format would raise a seemingly unrelated error for invalid (non-string) column names. This is now explicitly forbidden. (GH9057)
• Bug to handle masking empty `DataFrame` (GH10126).
• Bug where MySQL interface could not handle numeric table/column names (GH10255)
• Bug in `read_csv` with a `date_parser` that returned a `datetime64` array of other time resolution than [ns] (GH10245)
• Bug in `Panel.apply` when the result has ndim=0 (GH10332)
• Bug in `read_hdf` where `auto_close` could not be passed (GH9327).
• Bug in `read_hdf` where open stores could not be used (GH10330).
• Bug in adding empty `DataFrames`, now results in a `DataFrame` that `.equals` an empty `DataFrame` (GH10181).
• Bug in `to_hdf` and `HDFStore` which did not check that complib choices were valid (GH4582, GH8874).

1.18 v0.16.1 (May 11, 2015)

This is a minor bug-fix release from 0.16.0 and includes a a large number of bug fixes along several new features, enhancements, and performance improvements. We recommend that all users upgrade to this version.

Highlights include:

• Support for a `CategoricalIndex`, a category based index, see here
• New section on how-to-contribute to `pandas`, see here
• Revised “Merge, join, and concatenate” documentation, including graphical examples to make it easier to understand each operations, see here
• New method `sample` for drawing random samples from `Series`, `DataFrames` and `Panels`. See here
• The default `Index` printing has changed to a more uniform format, see here
• `BusinessHour` datetime-offset is now supported, see here
• Further enhancement to the `.str` accessor to make string operations easier, see here

What’s new in v0.16.1

• **Enhancements**
  – `CategoricalIndex`
  – `Sample`
  – **String Methods Enhancements**
  – **Other Enhancements**
• **API changes**
  – **Deprecations**
1.18.1 Enhancements

1.18.1.1 CategoricalIndex

We introduce a CategoricalIndex, a new type of index object that is useful for supporting indexing with duplicates. This is a container around a Categorical (introduced in v0.15.0) and allows efficient indexing and storage of an index with a large number of duplicated elements. Prior to 0.16.1, setting the index of a DataFrame/Series with a category dtype would convert this to regular object-based Index.

```python
In [1]: df = DataFrame({'A' : np.arange(6),
                   'B' : Series(list('aabbca')).astype('category',
                   categories=list('cab'))
                   }

In [2]: df
Out[2]:
   A  B
0  0  a
1  1  a
2  2  b
3  3  b
4  4  c
5  5  a

In [3]: df.dtypes
Out[3]:
   A  int64
   B  category
dtype: object

In [4]: df.B.cat.categories
Out[4]: Index(['c', 'a', 'b'], dtype='object')
```

setting the index, will create a CategoricalIndex

```python
In [5]: df2 = df.set_index('B')

In [6]: df2.index
Out[6]: CategoricalIndex(['a', 'a', 'b', 'b', 'c', 'a'], categories=['c', 'a', 'b'],
                        ordered=False, name='B', dtype='category')
```

indexing with `__getitem__`, `.iloc`, `.loc`, `.ix` works similarly to an Index with duplicates. The indexers MUST be in the category or the operation will raise.

Warning: In pandas 0.17.0, the sub-package pandas.io.data will be removed in favor of a separately installable package (GH8961).
In [7]: df2.loc['a']
Out[7]:
   A  B
  a  0  1
  a  5

and preserves the CategoricalIndex

In [8]: df2.loc['a'].index
Out[8]: CategoricalIndex(['a', 'a', 'a'], categories=['c', 'a', 'b'], ordered=False,
  name='B', dtype='category')

sorting will order by the order of the categories

In [9]: df2.sort_index()
Out[9]:
   A  B
  c  4
  a  0
  a  1
  a  5
  b  2
  b  3

groupby operations on the index will preserve the index nature as well

In [10]: df2.groupby(level=0).sum()
Out[10]:
   A  B
  c  4
  a  6
  b  5

In [11]: df2.groupby(level=0).sum().index
Out[11]: CategoricalIndex(['c', 'a', 'b'], categories=['c', 'a', 'b'], ordered=False,
  name='B', dtype='category')

reindexing operations, will return a resulting index based on the type of the passed indexer, meaning that passing a list will return a plain-old-Index; indexing with a Categorical will return a CategoricalIndex, indexed according to the categories of the PASSED Categorical dtype. This allows one to arbitrarily index these even with values NOT in the categories, similarly to how you can reindex ANY pandas index.

In [12]: df2.reindex(['a','e'])
Out[12]:
   A  B
  a  0.0
  a  1.0
  a  5.0
  e  NaN

In [13]: df2.reindex(['a','e']).index
Out[13]: Index(['a', 'a', 'e'], dtype='object', name='B')
In [14]: df2.reindex(pd.Categorical(['a', 'e'], categories=list('abcde')))  
Out[14]:  
    A  
   a 0.0  
   a 1.0  
   a 5.0  
  e NaN  
In [15]: df2.reindex(pd.Categorical(['a', 'e'], categories=list('abcde'))).index  
Out[15]: CategoricalIndex(['a', 'a', 'a', 'e'], categories=['a', 'b', 'c', 'd', 'e'],  
                      ordered=False, name='B', dtype='category')  

See the documentation for more. (GH7629, GH10038, GH10039)

1.18.1.2 Sample

Series, DataFrames, and Panels now have a new method: sample(). The method accepts a specific number of rows or columns to return, or a fraction of the total number or rows or columns. It also has options for sampling with or without replacement, for passing in a column for weights for non-uniform sampling, and for setting seed values to facilitate replication. (GH2419)

In [1]: example_series = Series([0, 1, 2, 3, 4, 5])  
# When no arguments are passed, returns 1  
In [2]: example_series.sample()  
Out[2]:  
3 3  
dtype: int64  
# One may specify either a number of rows:  
In [3]: example_series.sample(n=3)  
Out[3]:  
5 5  
1 1  
4 4  
dtype: int64  
# Or a fraction of the rows:  
In [4]: example_series.sample(frac=0.5)  
Out[4]:  
4 4  
1 1  
0 0  
dtype: int64  
# weights are accepted.  
In [5]: example_weights = [0, 0, 0.2, 0.2, 0.2, 0.4]  
In [6]: example_series.sample(n=3, weights=example_weights)  
Out[6]:  
2 2  
3 3  
5 5  
(continues on next page)
dtype: int64

# weights will also be normalized if they do not sum to one,
# and missing values will be treated as zeros.
In [8]: example_weights2 = [0.5, 0, 0, None, np.nan]

In [9]: example_series.sample(n=1, weights=example_weights2)
Out[9]:
0 0
dtype: int64

When applied to a DataFrame, one may pass the name of a column to specify sampling weights when sampling from rows.

In [9]: df = DataFrame({'col1':[9,8,7,6], 'weight_column':[0.5, 0.4, 0.1, 0]})

In [10]: df.sample(n=3, weights='weight_column')
Out[10]:
col1 weight_column
0 9 0.5
1 8 0.4
2 7 0.1

1.18.1.3 String Methods Enhancements

Continuing from v0.16.0, the following enhancements make string operations easier and more consistent with standard python string operations.

- Added StringMethods (.str accessor) to Index (GH9068)

  The .str accessor is now available for both Series and Index.

In [11]: idx = Index([' jack', 'jill ', ' jesse ', 'frank'])

In [12]: idx.str.strip()
Out[12]: Index(['jack', 'jill', 'jesse', 'frank'], dtype='object')

One special case for the .str accessor on Index is that if a string method returns bool, the .str accessor will return a np.array instead of a boolean Index (GH8875). This enables the following expression to work naturally:

In [13]: idx = Index(['a1', 'a2', 'b1', 'b2'])

In [14]: s = Series(range(4), index=idx)

In [15]: s
Out[15]:
a1 0
a2 1
b1 2
b2 3
dtype: int64

In [16]: idx.str.startswith('a')

Out[16]: array([ True, False, False, False], dtype=bool)

(continues on next page)
In [17]: s[s.index.str.startswith('a')]
   →
a1  0
a2  1
dtype: int64

- The following new methods are accessible via `.str` accessor to apply the function to each value. (GH9766, GH9773, GH10031, GH10045, GH10052)

<table>
<thead>
<tr>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>capitalize()</td>
</tr>
<tr>
<td>swapcase()</td>
</tr>
<tr>
<td>normalize()</td>
</tr>
<tr>
<td>partition()</td>
</tr>
<tr>
<td>rpartition()</td>
</tr>
<tr>
<td>index()</td>
</tr>
<tr>
<td>rindex()</td>
</tr>
<tr>
<td>translate()</td>
</tr>
</tbody>
</table>

- `split` now takes `expand` keyword to specify whether to expand dimensionality. `return_type` is deprecated. (GH9847)

In [18]: s = Series(['a,b', 'a,c', 'b,c'])

# return Series
In [19]: s.str.split(',')
Out[19]:
0  [a, b]
1  [a, c]
2  [b, c]
dtype: object

# return DataFrame
In [20]: s.str.split(',', expand=True)

In [21]: idx = Index(['a,b', 'a,c', 'b,c'])

# return Index
In [22]: idx.str.split(',', expand=True)

# return MultiIndex
In [23]: idx.str.split(',', expand=True)

- Improved `extract` and `get_dummies` methods for `Index.str` (GH9980)

1.18.1.4 Other Enhancements

- `BusinessHour` offset is now supported, which represents business hours starting from 09:00 - 17:00 on `BusinessDay` by default. See `Here` for details. (GH7905)
In [24]: from pandas.tseries.offsets import BusinessHour
In [25]: Timestamp('2014-08-01 09:00') + BusinessHour()
Out[25]: Timestamp('2014-08-01 10:00:00')

In [26]: Timestamp('2014-08-01 07:00') + BusinessHour()
Out[26]: Timestamp('2014-08-01 10:00:00')

In [27]: Timestamp('2014-08-01 16:30') + BusinessHour()
Out[27]: Timestamp('2014-08-04 09:30:00')

- DataFrame.diff now takes an axis parameter that determines the direction of differencing (GH9727)
- Allow clip, clip_lower, and clip_upper to accept array-like arguments as thresholds (This is a regression from 0.11.0). These methods now have an axis parameter which determines how the Series or DataFrame will be aligned with the threshold(s). (GH6966)
- DataFrame.mask() and Series.mask() now support same keywords as where (GH8801)
- drop function can now accept errors keyword to suppress ValueError raised when any of label does not exist in the target data. (GH6736)

In [28]: df = DataFrame(np.random.randn(3, 3), columns=['A', 'B', 'C'])
In [29]: df.drop(['A', 'X'], axis=1, errors='ignore')
Out[29]:
   B     C
0  1.058969 -0.397840
1  1.047579  1.045938
2 -0.122092  0.124713

- Add support for separating years and quarters using dashes, for example 2014-Q1. (GH9688)
- Allow conversion of values with dtype datetime64 or timedelta64 to strings using astype(str) (GH9757)
- get_dummies function now accepts sparse keyword. If set to True, the return DataFrame is sparse, e.g. SparseDataFrame. (GH8823)
- Period now accepts datetime64 as value input. (GH9054)
- Allow timedelta string conversion when leading zero is missing from time definition, ie 0:00:00 vs 00:00:00. (GH9570)
- Allow Panel.shift with axis='items' (GH9890)
- Trying to write an excel file now raises NotImplementedError if the DataFrame has a MultiIndex instead of writing a broken Excel file. (GH9794)
- Allow Categorical.add_categories to accept Series or np.array. (GH9927)
- Add/delete str/dt/cat accessors dynamically from __dir__. (GH9910)
- Add normalize as a dt accessor method. (GH10047)
- DataFrame and Series now have _constructor_expanddim property as overridable constructor for one higher dimensionality data. This should be used only when it is really needed, see here
- pd.lib.infer_dtypes now returns 'bytes' in Python 3 where appropriate. (GH10032)
1.18.2 API changes

- When passing in an ax to df.plot(..., ax=ax), the sharex kwarg will now default to False. The result is that the visibility of xlabels and xticklabels will not anymore be changed. You have to do that by yourself for the right axes in your figure or set sharex=True explicitly (but this changes the visible for all axes in the figure, not only the one which is passed in!). If pandas creates the subplots itself (e.g. no passed in ax kwarg), then the default is still sharex=True and the visibility changes are applied.

- assign() now inserts new columns in alphabetical order. Previously the order was arbitrary. (GH9777)

- By default, read_csv and read_table will now try to infer the compression type based on the file extension. Set compression=None to restore the previous behavior (no decompression). (GH9770)

1.18.2.1 Deprecations

- Series.str.split's return_type keyword was removed in favor of expand (GH9847)

1.18.3 Index Representation

The string representation of Index and its sub-classes have now been unified. These will show a single-line display if there are few values; a wrapped multi-line display for a lot of values (but less than display.max_seq_items; if lots of items (> display.max_seq_items) will show a truncated display (the head and tail of the data). The formatting for MultiIndex is unchanges (a multi-line wrapped display). The display width responds to the option display.max_seq_items, which is defaulted to 100. (GH6482)

Previous Behavior

```python
In [2]: pd.Index(range(4),name='foo')
Out[2]: Int64Index([0, 1, 2, 3], dtype='int64')

In [3]: pd.Index(range(104),name='foo')
Out[3]: Int64Index([0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, ...
| 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, ...
| 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, ...
| 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, ...
| 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, ...], dtype=
| int64')

In [4]: pd.date_range('20130101',periods=4,name='foo',tz='US/Eastern')
Out[4]: <class 'pandas.tseries.index.DatetimeIndex'>
[2013-01-01 00:00:00-05:00, ..., 2013-01-04 00:00:00-05:00]
Length: 4, Freq: D, Timezone: US/Eastern

In [5]: pd.date_range('20130101',periods=104,name='foo',tz='US/Eastern')
Out[5]: <class 'pandas.tseries.index.DatetimeIndex'>
[2013-01-01 00:00:00-05:00, ..., 2013-04-14 00:00:00-04:00]
Length: 104, Freq: D, Timezone: US/Eastern
```

New Behavior

```python
In [30]: pd.set_option('display.width', 80)

In [31]: pd.Index(range(4), name='foo')
Out[31]: RangeIndex(start=0, stop=4, step=1, name='foo')
```
In [32]: pd.Index(range(30), name='foo')
Out[32]: RangeIndex(start=0, stop=30, step=1, name='foo')

In [33]: pd.Index(range(104), name='foo')
Out[33]: RangeIndex(start=0, stop=104, step=1, name='foo')

In [34]: pd.CategoricalIndex(['a','bb','ccc','dddd'], ordered=True, name='foobar')
Out[34]: CategoricalIndex(['a', 'bb', 'ccc', 'dddd'], categories=['a', 'bb', 'ccc', 'dddd'], ordered=True, name='foobar', dtype='category')

In [35]: pd.CategoricalIndex(['a','bb','ccc','dddd']*10, ordered=True, name='foobar')
Out[35]: CategoricalIndex(['a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd'], categories=['a', 'bb', 'ccc', 'dddd'], ordered=True, name='foobar', dtype='category')

In [36]: pd.CategoricalIndex(['a','bb','ccc','dddd']*100, ordered=True, name='foobar')
Out[36]: CategoricalIndex(['a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd', 'a', 'bb', 'ccc', 'dddd'], length=400)

In [37]: pd.date_range('20130101',periods=4, name='foo', tz='US/Eastern')
Out[37]: DatetimeIndex(['2013-01-01 00:00:00-05:00', '2013-01-02 00:00:00-05:00',
                   '2013-01-03 00:00:00-05:00', '2013-01-04 00:00:00-05:00'],
                   dtype='datetime64[ns, US/Eastern]', name='foo', freq='D')

In [38]: pd.date_range('20130101',periods=25, freq='D')
Out[38]: DatetimeIndex(['2013-01-01', '2013-01-02', '2013-01-03', '2013-01-04',
                   '2013-01-25'],
                   dtype='datetime64[ns]', freq='D')

In [39]: pd.date_range('20130101',periods=104, name='foo', tz='US/Eastern')
1.18.4 Performance Improvements

- Improved csv write performance with mixed dtypes, including datetimes by up to 5x (GH9940)
- Improved csv write performance generally by 2x (GH9940)
- Improved the performance of pd.lib.max_len_string_array by 5-7x (GH10024)

1.18.5 Bug Fixes

- Bug where labels did not appear properly in the legend of DataFrame.plot(), passing label= arguments works, and Series indices are no longer mutated. (GH9542)
- Bug in json serialization causing a segfault when a frame had zero length. (GH9805)
- Bug in read_csv where missing trailing delimiters would cause segfault. (GH5664)
- Bug in retaining index name on appending (GH9862)
- Bug in scatter_matrix draws unexpected axis ticklabels (GH5662)
- Fixed bug in StataWriter resulting in changes to input DataFrame upon save (GH9795).
- Bug in transform causing length mismatch when null entries were present and a fast aggregator was being used (GH9697)
- Bug in equals causing false negatives when block order differed (GH9330)
- Bug in grouping with multiple pd.Grouper where one is non-time based (GH10063)
- Bug in read_sql_table error when reading postgres table with timezone (GH7139)
- Bug in DataFrame slicing may not retain metadata (GH9776)
- Bug where TimedeltaIndex were not properly serialized in fixed HDFStore (GH9635)
- Bug with TimedeltaIndex constructor ignoring name when given another TimedeltaIndex as data (GH10025).
- Bug in DataFrameFormatter._get_formatted_index with not applying max_colwidth to the DataFrame index (GH7856)
- Bug in .loc with a read-only ndarray data source (GH10043)
- Bug in groupby.apply() that would raise if a passed user defined function either returned only None (for all input). (GH9685)
• Always use temporary files in pytables tests (GH9992)
• Bug in plotting continuously using secondary_y may not show legend properly. (GH9610, GH9779)
• Bug in DataFrame.plot(kind="hist") results in TypeError when DataFrame contains non-numeric columns (GH9853)
• Bug where repeated plotting of DataFrame with a DatetimeIndex may raise TypeError (GH9852)
• Bug in setup.py that would allow an incompat cython version to build (GH9827)
• Bug in plotting secondary_y incorrectly attaches right_ax property to secondary axes specifying itself recursively. (GH9861)
• Bug in Series.quantile on empty Series of type Datetime or Timedelta (GH9675)
• Bug in where causing incorrect results when upcasting was required (GH9731)
• Bug in FloatArrayFormatter where decision boundary for displaying “small” floats in decimal format is off by one order of magnitude for a given display.precision (GH9764)
• Fixed bug where DataFrame.plot() raised an error when both color and style keywords were passed and there was no color symbol in the style strings (GH9671)
• Not showing a DeprecationWarning on combining list-likes with an Index (GH10083)
• Bug in read_csv and read_table when using skip_rows parameter if blank lines are present. (GH9832)
• Bug in read_csv() interprets index_col=True as 1 (GH9798)
• Bug in index equality comparisons using == failing on Index/MultiIndex type incompatibility (GH9785)
• Bug in which SparseDataFrame could not take nan as a column name (GH8822)
• Bug in to_msgpack and read_msgpack zlib and blosc compression support (GH9783)
• Bug GroupBy.size doesn’t attach index name properly if grouped by TimeGrouper (GH9925)
• Bug causing an exception in slice assignments because length_of_indexer returns wrong results (GH9995)
• Bug in csv parser causing lines with initial whitespace plus one non-space character to be skipped. (GH9710)
• Bug in C csv parser causing spurious NaNs when data started with newline followed by whitespace. (GH10022)
• Bug causing elements with a null group to spill into the final group when grouping by a Categorical (GH9603)
• Bug where .iloc and .loc behavior is not consistent on empty dataframes (GH9964)
• Bug in invalid attribute access on a TimedeltaIndex incorrectly raised ValueError instead of AttributeError (GH9680)
• Bug in unequal comparisons between categorical data and a scalar, which was not in the categories (e.g. Series(Categorical(list("abc"), ordered=True)) > "d". This returned False for all elements, but now raises a TypeError. Equality comparisons also now return False for == and True for !.=. (GH9848)
• Bug in DataFrame __setitem__ when right hand side is a dictionary (GH9874)
• Bug in where when dtype is datetime64/timedelta64, but dtype of other is not (GH9804)
• Bug in MultiIndex.sortlevel() results in unicode level name breaks (GH9856)
• Bug in which groupby.transform incorrectly enforced output dtypes to match input dtypes. (GH9807)
• Bug in DataFrame constructor when columns parameter is set, and data is an empty list (GH9939)
• Bug in bar plot with \texttt{log=True} raises \texttt{TypeError} if all values are less than 1 (GH9905)
• Bug in horizontal bar plot ignores \texttt{log=True} (GH9905)
• Bug in PyTables queries that did not return proper results using the index (GH8265, GH9676)
• Bug where dividing a dataframe containing values of type \texttt{Decimal} by another \texttt{Decimal} would raise. (GH9787)
• Bug where using DataFrames \texttt{asfreq} would remove the name of the index. (GH9885)
• Bug causing extra index point when resample BM/BQ (GH9756)
• Changed caching in \texttt{AbstractHolidayCalendar} to be at the instance level rather than at the class level as the latter can result in unexpected behaviour. (GH9552)
• Fixed latex output for multi-indexed dataframes (GH9778)
• Bug causing an exception when setting an empty range using \texttt{DataFrame.loc} (GH9596)
• Bug in hiding ticklabels with subplots and shared axes when adding a new plot to an existing grid of axes (GH9158)
• Bug in \texttt{transform} and \texttt{filter} when grouping on a categorical variable (GH9921)
• Bug in \texttt{transform} when groups are equal in number and dtype to the input index (GH9700)
• Google BigQuery connector now imports dependencies on a per-method basis. (GH9713)
• Updated BigQuery connector to no longer use deprecated \texttt{oauth2client.tools.run()} (GH8327)
• Bug in subclassed \texttt{DataFrame}. It may not return the correct class, when slicing or subsetting it. (GH9632)
• Bug in \texttt{.median()} where non-float null values are not handled correctly (GH10040)
• Bug in \texttt{Series.fillna()} where it raises if a numerically convertible string is given (GH10092)

1.19 v0.16.0 (March 22, 2015)

This is a major release from 0.15.2 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

• \texttt{DataFrame.assign} method, see \texttt{here}
• \texttt{Series.to_coo/from_coo} methods to interact with \texttt{scipy.sparse}, see \texttt{here}
• Backwards incompatible change to \texttt{Timedelta} to conform the \texttt{.seconds} attribute with \texttt{datetime.timedelta}, see \texttt{here}
• Changes to the \texttt{.loc} slicing API to conform with the behavior of \texttt{.ix} see \texttt{here}
• Changes to the default for ordering in the \texttt{Categorical} constructor, see \texttt{here}
• Enhancement to the \texttt{.str} accessor to make string operations easier, see \texttt{here}
• The \texttt{pandas.tools.rplot}, \texttt{pandas.sandbox.qtpandas} and \texttt{pandas.rpy} modules are deprecated. We refer users to external packages like \texttt{seaborn}, \texttt{pandas-qt} and \texttt{rpy2} for similar or equivalent functionality, see \texttt{here}

Check the \texttt{API Changes} and \texttt{deprecations} before updating.
What’s new in v0.16.0

- **New features**
  - DataFrame Assign
  - Interaction with scipy.sparse
  - String Methods Enhancements
  - Other enhancements
- **Backwards incompatible API changes**
  - Changes in Timedelta
  - Indexing Changes
  - Categorical Changes
  - Other API Changes
  - Deprecations
  - Removal of prior version deprecations/changes
- **Performance Improvements**
- **Bug Fixes**

1.19.1 New features

1.19.1.1 DataFrame Assign

Inspired by dplyr’s `mutate` verb, DataFrame has a new `assign()` method. The function signature for `assign` is simply `**kwargs`. The keys are the column names for the new fields, and the values are either a value to be inserted (for example, a `Series` or NumPy array), or a function of one argument to be called on the DataFrame. The new values are inserted, and the entire DataFrame (with all original and new columns) is returned.

```
In [1]: iris = read_csv('data/iris.data')

In [2]: iris.head()
Out[2]:
   SepalLength  SepalWidth  PetalLength  PetalWidth     Name
0       5.1        3.5         1.4        0.2   Iris-setosa
1       4.9        3.0         1.4        0.2   Iris-setosa
2       4.7        3.2         1.3        0.2   Iris-setosa
3       4.6        3.1         1.5        0.2   Iris-setosa
4       5.0         3.6         1.4        0.2   Iris-setosa

In [3]: iris.assign(sepal_ratio=iris['SepalWidth'] / iris['SepalLength']).head()
```

```
  SepalLength  SepalWidth  PetalLength  PetalWidth     Name  sepal_ratio
0       5.1        3.5         1.4        0.2   Iris-setosa  0.686275
1       4.9        3.0         1.4        0.2   Iris-setosa  0.612245
2       4.7        3.2         1.3        0.2   Iris-setosa  0.680851
3       4.6        3.1         1.5        0.2   Iris-setosa  0.673913
4       5.0         3.6         1.4        0.2   Iris-setosa  0.720000
```
Above was an example of inserting a precomputed value. We can also pass in a function to be evaluated.

```
In [4]: iris.assign(sepal_ratio = lambda x: (x['SepalWidth'] / x['SepalLength'])).head()
```

```
Out[4]:
<table>
<thead>
<tr>
<th>SepalLength</th>
<th>SepalWidth</th>
<th>PetalLength</th>
<th>PetalWidth</th>
<th>Name</th>
<th>sepal_ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>3.5</td>
<td>1.4</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.686275</td>
</tr>
<tr>
<td>4.9</td>
<td>3.0</td>
<td>1.4</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.612245</td>
</tr>
<tr>
<td>4.7</td>
<td>3.2</td>
<td>1.3</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.680851</td>
</tr>
<tr>
<td>4.6</td>
<td>3.1</td>
<td>1.5</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.673913</td>
</tr>
<tr>
<td>5.0</td>
<td>3.6</td>
<td>1.4</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.720000</td>
</tr>
</tbody>
</table>
```

The power of `assign` comes when used in chains of operations. For example, we can limit the DataFrame to just those with a Sepal Length greater than 5, calculate the ratio, and plot

```
In [5]: (iris.query('SepalLength > 5')
    ...: .assign(SepalRatio = lambda x: x.SepalWidth / x.SepalLength,
    ...:           PetalRatio = lambda x: x.PetalWidth / x.PetalLength)
    ...: .plot(kind='scatter', x='SepalRatio', y='PetalRatio'))
```

```
Out[5]: <matplotlib.axes._subplots.AxesSubplot at 0x1c41df41d0>
```

See the documentation for more. (GH9229)

1.19.1.2 Interaction with scipy.sparse

Added `SparseSeries.to_coo()` and `SparseSeries.from_coo()` methods (GH8048) for converting to and from `scipy.sparse.coo_matrix` instances (see here). For example, given a SparseSeries with MultiIndex we can convert to a `scipy.sparse.coo_matrix` by specifying the row and column labels as index levels:

```
In [6]: from numpy import nan

In [7]: s = Series([3.0, nan, 1.0, 3.0, nan, nan])

In [8]: s.index = MultiIndex.from_tuples([(1, 2, 'a', 0),
    ...:             (1, 2, 'a', 1),
    ...:             (1, 1, 'b', 0),
    ...:             (1, 1, 'b', 1),
    ...:             (2, 1, 'b', 0),
    ...: ])
```

(continues on next page)
...:                (2, 1, 'b', 1)),
...:            names=['A', 'B', 'C', 'D'])

In [9]: s
Out[9]:
A B C D
1 2 a 0 3.0
1 NaN
1 b 0 1.0
1 3.0
2 1 b 0 NaN
1 NaN
dtype: float64

# SparseSeries
In [10]: ss = s.to_sparse()

In [11]: ss
Out[11]:
A B C D
1 2 a 0 3.0
1 NaN
1 b 0 1.0
1 3.0
2 1 b 0 NaN
1 NaN
dtype: float64

BlockIndex
Block locations: array([0, 2], dtype=int32)
Block lengths: array([1, 2], dtype=int32)

In [12]: A, rows, columns = ss.to_coo(row_levels=['A', 'B'],
.....:                column_levels=['C', 'D'],
.....:                sort_labels=False)

In [13]: A
Out[13]:
<3x4 sparse matrix of type '<class 'numpy.float64'>'
    with 3 stored elements in COOrdinate format>

In [14]: A.todense()

\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n...
The `from_coo` method is a convenience method for creating a SparseSeries from a `scipy.sparse.coo_matrix`:

```python
In [17]: from scipy import sparse

In [18]: A = sparse.coo_matrix(([3.0, 1.0, 2.0], ([1, 0, 0], [0, 2, 3])),
                           shape=(3, 4))

In [19]: A
Out[19]:
<3x4 sparse matrix of type '<class 'numpy.float64'>'
   with 3 stored elements in COOrdinate format>

In [20]: A.todense()
→
matrix([[ 0., 0., 1., 2.],
         [ 3., 0., 0., 0.],
         [ 0., 0., 0., 0.]])

In [21]: ss = SparseSeries.from_coo(A)

In [22]: ss
Out[22]:
0 2 1.0
3 2.0
1 0 3.0
dtype: float64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([3], dtype=int32)
```

### 1.19.1.3 String Methods Enhancements

- Following new methods are accesible via `.str` accessor to apply the function to each values. This is intended to make it more consistent with standard methods on strings. (GH9282, GH9352, GH9386, GH9387, GH9439)

<table>
<thead>
<tr>
<th>Methods</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>isalnum()</td>
<td>isalpha()</td>
<td>isdigit()</td>
<td>isdigit()</td>
<td>isspace()</td>
<td></td>
</tr>
<tr>
<td>islower()</td>
<td>isupper()</td>
<td>istitle()</td>
<td>isnumeric()</td>
<td>isdecimal()</td>
<td></td>
</tr>
<tr>
<td>find()</td>
<td>rfind()</td>
<td>ljust()</td>
<td>rjust()</td>
<td>zfill()</td>
<td></td>
</tr>
</tbody>
</table>

```python
In [23]: s = Series(['abcd', '3456', 'EFGH'])

In [24]: s.str.isalpha()
Out[24]:
0   True
1  False
2   True
dtype: bool

In [25]: s.str.find('ab')
→
0
```

(continues on next page)
• Series.str.pad() and Series.str.center() now accept fillchar option to specify filling character (GH9352)

```
In [26]: s = Series(["12", '300', '25'])

In [27]: s.str.pad(5, fillchar=' _')
Out [27]:
0 ___12
1 __300
2 ___25
dtype: object
```

• Added Series.str.slice_replace(), which previously raised NotImplementedError (GH8888)

```
In [28]: s = Series(['ABCD', 'EFGH', 'IJK'])

In [29]: s.str.slice_replace(1, 3, 'X')
Out [29]:
0 AXD
1 EXH
2 IX

dtype: object
```

```
# replaced with empty char
In [30]: s.str.slice_replace(0, 1)
Out [30]:
0 BCD
1 FGH
2 JK

dtype: object
```

1.19.1.4 Other enhancements

• Reindex now supports method='nearest' for frames or series with a monotonic increasing or decreasing index (GH9258):

```
In [31]: df = pd.DataFrame({'x': range(5)})

In [32]: df.reindex([0.2, 1.8, 3.5], method='nearest')
Out [32]:
         x
0.2  0
1.8  2
3.5  4
```

This method is also exposed by the lower level Index.get_indexer and Index.get_loc methods.

• The read_excel() function’s sheetname argument now accepts a list and None, to get multiple or all sheets respectively. If more than one sheet is specified, a dictionary is returned. (GH9450)

```
# Returns the 1st and 4th sheet, as a dictionary of DataFrames.
pd.read_excel('path_to_file.xls',sheetname=['Sheet1',3])
```
- Allow Stata files to be read incrementally with an iterator; support for long strings in Stata files. See the docs here (GH9493).
- Paths beginning with ~ will now be expanded to begin with the user’s home directory (GH9066)
- Added time interval selection in get_data_yahoo (GH9071)
- Added Timestamp.to_datetime64() to complement Timedelta.to_timedelta64() (GH9255)
- tseries.frequencies.to_offset() now accepts Timedelta as input (GH9064)
- Lag parameter was added to the autocorrelation method of Series, defaults to lag-1 autocorrelation (GH9192)
- Timedelta will now accept nanoseconds keyword in constructor (GH9273)
- SQL code now safely escapes table and column names (GH8986)
- Added auto-complete for Series.str.<tab>, Series.dt.<tab> and Series.cat.<tab> (GH9322)
- Index.get_indexer now supports method='pad' and method='backfill' even for any target array, not just monotonic targets. These methods also work for monotonic decreasing as well as monotonic increasing indexes (GH9258).
- Index.asof now works on all index types (GH9258).
- A verbose argument has been augmented in io.read_excel(), defaults to False. Set to True to print sheet names as they are parsed. (GH9450)
- Added days_in_month (compatibility alias daysinmonth) property to Timestamp, DatetimeIndex, Period, PeriodIndex, and Series.dt (GH9572)
- Added decimal option in to_csv to provide formatting for non-’.’ decimal separators (GH781)
- Added normalize option for Timestamp to normalized to midnight (GH8794)
- Added example for DataFrame import to R using HDF5 file and rhdf5 library. See the documentation for more (GH9636).

1.19.2 Backwards incompatible API changes

1.19.2.1 Changes in Timedelta

In v0.15.0 a new scalar type Timedelta was introduced, that is a sub-class of datetime.timedelta. Mentioned here was a notice of an API change w.r.t. the .seconds accessor. The intent was to provide a user-friendly set of accessors that give the ‘natural’ value for that unit, e.g. if you had a Timedelta('1 day, 10:11:12'), then .seconds would return 12. However, this is at odds with the definition of datetime.timedelta, which defines .seconds as 10 * 3600 + 11 * 60 + 12 == 36672.

So in v0.16.0, we are restoring the API to match that of datetime.timedelta. Further, the component values are still available through the .components accessor. This affects the .seconds and .microseconds accessors, and removes the .hours, .minutes, .milliseconds accessors. These changes affect TimedeltaIndex and the Series .dt accessor as well. (GH9185, GH9139)

Previous Behavior

```python
In [2]: t = pd.Timedelta('1 day, 10:11:12.100123')
In [3]: t.days
Out[3]: 1
```

(continues on next page)
In [4]: t.seconds
Out[4]: 12

In [5]: t.microseconds
Out[5]: 123

New Behavior

In [33]: t = pd.Timedelta('1 day, 10:11:12.100123')
In [34]: t.days
Out[34]: 1
In [35]: t.seconds
Out[35]: 36672
In [36]: t.microseconds
Out[36]: 100123

Using .components allows the full component access

In [37]: t.components
Out[37]: Components(days=1, hours=10, minutes=11, seconds=12, milliseconds=100, microseconds=123, nanoseconds=0)
In [38]: t.components.seconds
Out[38]: 12

1.19.2.2 Indexing Changes

The behavior of a small sub-set of edge cases for using .loc have changed (GH8613). Furthermore we have improved the content of the error messages that are raised:

• Slicing with .loc where the start and/or stop bound is not found in the index is now allowed; this previously would raise a KeyError. This makes the behavior the same as .ix in this case. This change is only for slicing, not when indexing with a single label.

In [39]: df = DataFrame(np.random.randn(5,4),
....:    columns=list('ABCD'),
....:    index=date_range('20130101',periods=5))
In [40]: df
Out[40]:
   A          B         C        D
2013-01-01 -0.322795  0.841675  2.390961  0.076200
2013-01-02 -0.566446  0.036142 -2.074978  0.247792
2013-01-03 -0.897157 -0.136795  0.018289  0.755414
2013-01-04  0.215269  0.841009 -1.445810 -1.401973
2013-01-05 -0.100918 -0.548242 -0.144620  0.354020

In [41]: s = Series(range(5),[-2,-1,1,2,3])
In [42]: s

(continues on next page)
Previous Behavior

In [4]: df.loc['2013-01-02':'2013-01-10']
KeyError: 'stop bound [2013-01-10] is not in the [index]'

In [6]: s.loc[-10:3]
KeyError: 'start bound [-10] is not the [index]'

New Behavior

In [43]: df.loc['2013-01-02':'2013-01-10']
Out[43]:
   A      B      C      D
2013-01-02 -0.566446 0.036142 -2.074978 0.247792
2013-01-03 -0.897157 -0.136795 0.018289 0.755414
2013-01-04  0.215269  0.841009 -1.445810 -1.401973
2013-01-05 -0.100918 -0.548242 -0.144620  0.354020

In [44]: s.loc[-10:3]
   →
   -2  0
   -1  1
   1  2
   2  3
   3  4
Out[44]:
   0  1  2  3
-2  0  1  2
-1  1  2  3
  1  2  3  4
dtype: int64

• Allow slicing with float-like values on an integer index for .ix. Previously this was only enabled for .loc:

Previous Behavior

In [8]: s.ix[-1.0:2]
TypeError: the slice start value [-1.0] is not a proper indexer for this index

New Behavior

In [2]: s.ix[-1.0:2]
Out[2]:
   0  1  2  3
-2  0  1  2
-1  1  2  3
   1  2  3  4
dtype: int64

• Provide a useful exception for indexing with an invalid type for that index when using .loc. For example trying to use .loc on an index of type DatetimeIndex or PeriodIndex or TimedeltaIndex, with an integer (or a float).
pandas: powerful Python data analysis toolkit, Release 0.23.2

In [4]: df.loc[2:3]
KeyError: 'start bound [2] is not the [index]'

New Behavior

In [4]: df.loc[2:3]
TypeError: Cannot do slice indexing on <class 'pandas.tseries.index.DatetimeIndex'> with <type 'int'> keys

1.19.2.3 Categorical Changes

In prior versions, Categoricals that had an unspecified ordering (meaning no ordered keyword was passed) were defaulted as ordered Categoricals. Going forward, the ordered keyword in the Categorical constructor will default to False. Ordering must now be explicit.

Furthermore, previously you could change the ordered attribute of a Categorical by just setting the attribute, e.g. cat.ordered=True; This is now deprecated and you should use cat.as_ordered() or cat.as_unordered(). These will by default return a new object and not modify the existing object. (GH9347, GH9190)

Previous Behavior

In [3]: s = Series([0,1,2], dtype='category')
In [4]: s
Out[4]:
0 0
1 1
2 2
dtype: category
Categories (3, int64): [0 < 1 < 2]
In [5]: s.cat.ordered
Out[5]: True
In [6]: s.cat.ordered = False
In [7]: s
Out[7]:
0 0
1 1
2 2
dtype: category
Categories (3, int64): [0, 1, 2]

New Behavior

In [45]: s = Series([0,1,2], dtype='category')
In [46]: s
Out[46]:
0 0
1 1
2 2
dtype: category
Categories (3, int64): [0, 1, 2]
In [47]: s.cat.ordered
Out[47]: False

In [48]: s = s.cat.as_ordered()

In [49]: s
Out[49]:
0 0
1 1
2 2
dtype: category
Categories (3, int64): [0 < 1 < 2]

In [50]: s.cat.ordered
Out[50]: True

# you can set in the constructor of the Categorical
In [51]: s = Series(Categorical([0,1,2], ordered=True))

In [52]: s
Out[52]:
0 0
1 1
2 2
dtype: category
Categories (3, int64): [0 < 1 < 2]

In [53]: s.cat.ordered
Out[53]: True

For ease of creation of series of categorical data, we have added the ability to pass keywords when calling .astype(). These are passed directly to the constructor.

In [54]: s = Series(['a','b','c','a']).astype('category', ordered=True)

In [55]: s
Out[55]:
0  a
1  b
2  c
3  a
dtype: category
Categories (3, object): [a < b < c]

In [56]: s = Series(['a','b','c','a']).astype('category', categories=list('abcdef'), ordered=False)

In [57]: s
Out[57]:
0  a
1  b
2  c
1.19.4 Other API Changes

- Index.duplicated now returns np.array(dtype=bool) rather than Index(dtype=object) containing bool values. (GH8875)

- DataFrame.to_json now returns accurate type serialisation for each column for frames of mixed dtype (GH9037)

  Previously data was coerced to a common dtype before serialisation, which for example resulted in integers being serialised to floats:

  ```
  In [2]: pd.DataFrame({"i": [1,2], "f": [3.0, 4.2]}).to_json()
  Out[2]: \'{"f":{"0":3.0,"1":4.2},"i":{"0":1.0,"1":2.0}}\'
  ```

  Now each column is serialised using its correct dtype:

  ```
  In [2]: pd.DataFrame({"i": [1,2], "f": [3.0, 4.2]}).to_json()
  Out[2]: \'{"f":{"0":3.0,"1":4.2},"i":{"0":1,"1":2}}\'
  ```

- DatetimeIndex, PeriodIndex and TimedeltaIndex.summary now output the same format. (GH9116)

- TimedeltaIndex.freqstr now output the same string format as DatetimeIndex. (GH9116)

- Bar and horizontal bar plots no longer add a dashed line along the info axis. The prior style can be achieved with matplotlib’s axhline or axvline methods (GH9088).

- Series accessors .dt, .cat and .str now raise AttributeError instead of TypeError if the series does not contain the appropriate type of data (GH9617). This follows Python’s built-in exception hierarchy more closely and ensures that tests like hasattr(s, 'cat') are consistent on both Python 2 and 3.

- Series now supports bitwise operation for integral types (GH9016). Previously even if the input dtypes were integral, the output dtype was coerced to bool.

  Previous Behavior

  ```
  In [2]: pd.Series([0,1,2,3], list('abcd')) | pd.Series([4,4,4,4], list('abcd'))
  Out[2]:
  a  True
  b  True
  c  True
  d  True
dtype: bool
  ```

  New Behavior. If the input dtypes are integral, the output dtype is also integral and the output values are the result of the bitwise operation.

  ```
  In [2]: pd.Series([0,1,2,3], list('abcd')) | pd.Series([4,4,4,4], list('abcd'))
  Out[2]:
  a  4
  b  5
c  6
  ```
• During division involving a Series or DataFrame, 0/0 and 0//0 now give np.nan instead of np.inf. (GH9144, GH8445)

Previous Behavior

```python
In [2]: p = pd.Series([0, 1])
In [3]: p / 0
Out[3]:
   0   inf
   1   inf
 dtype: float64

In [4]: p // 0
Out[4]:
   0   inf
   1   inf
 dtype: float64
```

New Behavior

```python
In [54]: p = pd.Series([0, 1])
In [55]: p / 0
Out[55]:
   0  NaN
   1   inf
 dtype: float64

In [56]: p // 0
Out[56]:
   0  NaN
   1   inf
 dtype: float64
```

• Series.values_counts and Series.describe for categorical data will now put NaN entries at the end. (GH9443)

• Series.describe for categorical data will now give counts and frequencies of 0, not NaN, for unused categories (GH9443)

• Due to a bug fix, looking up a partial string label with DatetimeIndex.asof now includes values that match the string, even if they are after the start of the partial string label (GH9258).

Old behavior:

```python
In [4]: pd.to_datetime(['2000-01-31', '2000-02-28']).asof('2000-02')
Out[4]: Timestamp('2000-01-31 00:00:00')
```

Fixed behavior:

```python
In [57]: pd.to_datetime(['2000-01-31', '2000-02-28']).asof('2000-02')
Out[57]: Timestamp('2000-02-28 00:00:00')
```
1.19.2.5 Deprecations

- The `rplot` trellis plotting interface is deprecated and will be removed in a future version. We refer to external packages like `seaborn` for similar but more refined functionality (GH3445). The documentation includes some examples how to convert your existing code using `rplot` to `seaborn`: `rplot docs`.

- The `pandas.sandbox.qtpandas` interface is deprecated and will be removed in a future version. We refer users to the external package `pandas-qt` (GH9615).

- The `pandas.rpy` interface is deprecated and will be removed in a future version. Similar functionality can be accessed thru the `rpy2` project (GH9602).

- Adding `DatetimeIndex/PeriodIndex` to another `DatetimeIndex/PeriodIndex` is being deprecated as a set-operation. This will be changed to a `TypeError` in a future version. `.union()` should be used for the union set operation. (GH9094)

- Subtracting `DatetimeIndex/PeriodIndex` from another `DatetimeIndex/PeriodIndex` is being deprecated as a set-operation. This will be changed to an actual numeric subtraction yielding a `TimeDeltaIndex` in a future version. `.difference()` should be used for the differencing set operation. (GH9094)

1.19.2.6 Removal of prior version deprecations/changes

- `DataFrame.pivot_table` and `crosstab`'s rows and cols keyword arguments were removed in favor of index and columns (GH6581).

- `DataFrame.to_excel` and `DataFrame.to_csv` cols keyword argument was removed in favor of columns (GH6581).

- Removed `convert_dummies` in favor of `get_dummies` (GH6581).

- Removed `value_range` in favor of `describe` (GH6581).

1.19.3 Performance Improvements

- Fixed a performance regression for `.loc` indexing with an array or list-like (GH9126).

- `DataFrame.to_json` 30x performance improvement for mixed dtype frames. (GH9037)

- Performance improvements in `MultiIndex.duplicated` by working with labels instead of values (GH9125)

- Improved the speed of `nunique` by calling `unique` instead of `value_counts` (GH9129, GH7771)

- Performance improvement of up to 10x in `DataFrame.count` and `DataFrame.dropna` by taking advantage of homogeneous/heterogeneous dtypes appropriately (GH9136)

- Performance improvement of up to 20x in `DataFrame.count` when using a `MultiIndex` and the `level` keyword argument (GH9163)

- Performance and memory usage improvements in `merge` when key space exceeds `int64` bounds (GH9151)

- Performance improvements in multi-key groupby (GH9429)

- Performance improvements in `MultiIndex.sortlevel` (GH9445)

- Performance and memory usage improvements in `DataFrame.duplicated` (GH9398)
• Cythonized Period (GH9440)
• Decreased memory usage on to_hdf (GH9648)

1.19.4 Bug Fixes

• Changed .to_html to remove leading/trailing spaces in table body (GH4987)
• Fixed issue using read_csv on s3 with Python 3 (GH9452)
• Fixed compatibility issue in DatetimeIndex affecting architectures where numpy.int_ defaults to numpy.int32 (GH9493)
• Bug in Panel indexing with an object-like (GH9140)
• Bug in the returned Series.dt.components index was reset to the default index (GH9247)
• Bug in Categorical.__getitem__/__setitem__ with listlike input getting incorrect results from indexer coercion (GH9469)
• Bug in partial setting with a DatetimeIndex (GH9478)
• Bug in groupby for integer and datetime64 columns when applying an aggregator that caused the value to be changed when the number was sufficiently large (GH9311, GH6620)
• Fixed bug in to_sql when mapping a Timestamp object column (datetime column with timezone info) to the appropriate sqlalchemy type (GH9085).
• Fixed bug in to_sql dtype argument not accepting an instantiated SQLAlchemy type (GH9083).
• Bug in .loc partial setting with a np.datetime64 (GH9516)
• Incorrect dtypes inferred on datetimelike looking Series & on .xs slices (GH9477)
• Items in Categorical.unique() (and s.unique() if s is of dtype category) now appear in the order in which they are originally found, not in sorted order (GH9331). This is now consistent with the behavior for other dtypes in pandas.
• Fixed bug on big endian platforms which produced incorrect results in StataReader (GH8688).
• Bug in MultiIndex.has_duplicates when having many levels causes an indexer overflow (GH9075, GH5873)
• Bug in pivot and unstack where nan values would break index alignment (GH4862, GH7401, GH7403, GH7405, GH7466, GH9497)
• Bug in left join on multi-index with sort=True or null values (GH9210).
• Bug in MultiIndex where inserting new keys would fail (GH9250).
• Bug in groupby when key space exceeds int64 bounds (GH9096).
• Bug in unstack with TimedeltaIndex or DatetimeIndex and nulls (GH9491).
• Bug in rank where comparing floats with tolerance will cause inconsistent behaviour (GH8365).
• Fixed character encoding bug in read stata and StataReader when loading data from a URL (GH9231).
• Bug in adding offsets.Nano to other offsets raises TypeError (GH9284)
• Bug in DatetimeIndex iteration, related to (GH8890), fixed in (GH9100)
• Bugs in resample around DST transitions. This required fixing offset classes so they behave correctly on DST transitions. (GH5172, GH8744, GH8653, GH9173, GH9468).
• Bug in binary operator method (eg .mul()) alignment with integer levels (GH9463).
• Bug in boxplot, scatter and hexbin plot may show an unnecessary warning (GH8877)
• Bug in subplot with `layout` kw may show unnecessary warning (GH9464)
• Bug in using grouper functions that need passed thru arguments (e.g. axis), when using wrapped function (e.g. `fillna`), (GH9221)
• `DataFrame` now properly supports simultaneous `copy` and `dtype` arguments in constructor (GH9099)
• Bug in `read_csv` when using `skiprows` on a file with CR line endings with the `c` engine. (GH9079)
• `isnull` now detects `NaT` in `PeriodIndex` (GH9129)
• Bug in `groupby .nth()` with a multiple column groupby (GH8979)
• Bug in `DataFrame.where` and `Series.where` coerce numerics to string incorrectly (GH9280)
• Accessing `Series.str` methods on with non-string values now raises `TypeError` instead of producing incorrect results (GH9184)
• Bug in `DatetimeIndex.__contains__` when index has duplicates and is not monotonic increasing (GH9512)
• Fixed division by zero error for `Series.kurt()` when all values are equal (GH9197)
• Fixed issue in the `xlsxwriter` engine where it added a default ‘General’ format to cells if no other format was applied. This prevented other row or column formatting being applied. (GH9167)
• Fixes issue with `index_col=False` when `usecols` is also specified in `read_csv`. (GH9082)
• Bug where `wide_to_long` would modify the input stubnames list (GH9204)
• Bug in `to_sql` not storing float64 values using double precision. (GH9009)
• `SparseSeries` and `SparsePanel` now accept zero argument constructors (same as their non-sparse counterparts) (GH9272).
• Regression in merging Categorical and object dtypes (GH9426)
• Bug in `read_csv` with buffer overflows with certain malformed input files (GH9205)
• Bug in `groupby` MultiIndex with missing pair (GH9049, GH9344)
• Fixed bug in `Series.groupby` where grouping on MultiIndex levels would ignore the sort argument (GH9444)
• Fix bug in `DataFrame.Groupby` where `sort=False` is ignored in the case of Categorical columns. (GH8868)
• Fixed bug with reading CSV files from Amazon S3 on python 3 raising a TypeError (GH9452)
• Bug in the Google BigQuery reader where the ‘jobComplete’ key may be present but False in the query results (GH8728)
• Bug in `Series.values_counts` with excluding `NaN` for categorical type `Series` with `dropna=True` (GH9443)
• Fixed missing numeric_only option for `DataFrame.std/var/sem` (GH9201)
• Support constructing `Panel` or `Panel4D` with scalar data (GH8285)
• `Series` text representation disconnected from `max_rows/max_columns` (GH7508).
• Series number formatting inconsistent when truncated (GH8532).

Previous Behavior

In [2]: pd.options.display.max_rows = 10
In [3]: s = pd.Series([1,1,1,1,1,1,1,1,1,1,0.9999,1,1]*10)
In [4]: s
Out[4]:
0     1
1     1
2     1
...  
127  0.9999
128  1.0000
129  1.0000
Length: 130, dtype: float64

New Behavior

0   1.0000
1   1.0000
2   1.0000
3   1.0000
4   1.0000
...  
125  1.0000
126  1.0000
127  0.9999
128  1.0000
129  1.0000
dtype: float64

• A Spurious SettingWithCopy Warning was generated when setting a new item in a frame in some cases (GH8730)

The following would previously report a SettingWithCopy Warning.

In [1]: df1 = DataFrame({'x': Series(['a','b','c']), 'y': Series(['d','e','f'])})
In [2]: df2 = df1[['x']]
In [3]: df2['y'] = ['g', 'h', 'i']

1.20 v0.15.2 (December 12, 2014)

This is a minor release from 0.15.1 and includes a large number of bug fixes along with several new features, enhancements, and performance improvements. A small number of API changes were necessary to fix existing bugs. We recommend that all users upgrade to this version.

• Enhancements
• API Changes
• Performance Improvements
• Bug Fixes
1.20.1 API changes

- Indexing in MultiIndex beyond lex-sort depth is now supported, though a lexically sorted index will have a better performance. (GH2646)

```python
In [1]: df = pd.DataFrame({'jim':[0, 0, 1, 1],
                      'joe':['x', 'x', 'z', 'y'],
                      'jolie':np.random.rand(4)}).set_index(['jim', 'joe'])

In [2]: df
Out[2]:
      jolie
    jim joe
0  x  0.123943
   x  0.119381
1  z  0.738523
   y  0.587304

In [3]: df.index.lexsort_depth
    →1
# in prior versions this would raise a KeyError
# will now show a PerformanceWarning
In [4]: df.loc[(1, 'z')]
    →
      jolie
    jim joe
1  z  0.738523
# lexically sorting

In [5]: df2 = df.sort_index()

In [6]: df2
Out[6]:
      jolie
    jim joe
0  x  0.123943
   x  0.119381
1  y  0.587304
   z  0.738523

In [7]: df2.index.lexsort_depth
    →2

In [8]: df2.loc[(1, 'z')]
    →
      jolie
    jim joe
1  z  0.738523
```

- Bug in unique of Series with category dtype, which returned all categories regardless whether they were “used” or not (see GH8559 for the discussion). Previous behaviour was to return all categories:
In [3]: cat = pd.Categorical(['a', 'b', 'a'], categories=['a', 'b', 'c'])

In [4]: cat
Out[4]:
[a, b, a]
Categories (3, object): [a < b < c]

In [5]: cat.unique()
Out[5]: array(['a', 'b', 'c'], dtype=object)

Now, only the categories that do effectively occur in the array are returned:

In [9]: cat = pd.Categorical(['a', 'b', 'a'], categories=['a', 'b', 'c'])

In [10]: cat.unique()
Out[10]: [a, b]
Categories (2, object): [a, b]

• Series.all and Series.any now support the level and skipna parameters. Series.all, Series.any, Index.all, and Index.any no longer support the out and keepdims parameters, which existed for compatibility with ndarray. Various index types no longer support the all and any aggregation functions and will now raise TypeError. (GH8302).

• Allow equality comparisons of Series with a categorical dtype and object dtype; previously these would raise TypeError (GH8938)

• Bug in NDFrame: conflicting attribute/column names now behave consistently between getting and setting. Previously, when both a column and attribute named y existed, data.y would return the attribute, while data.y = z would update the column (GH8994)

In [11]: data = pd.DataFrame({'x': [1, 2, 3]})

In [12]: data.y = 2

In [13]: data['y'] = [2, 4, 6]

In [14]: data
Out[14]:
   x  y
0  1  2
1  2  4
2  3  6

# this assignment was inconsistent
In [15]: data.y = 5

Old behavior:

In [6]: data.y
Out[6]: 2

In [7]: data['y'].values
Out[7]: array([5, 5, 5])

New behavior:
In [16]: data.y
Out[16]: 5

In [17]: data['y'].values
Out[17]: array([2, 4, 6])

• Timestamp('now') is now equivalent to Timestamp.now() in that it returns the local time rather than UTC. Also, Timestamp('today') is now equivalent to Timestamp.today() and both have tz as a possible argument. (GH9000)

• Fix negative step support for label-based slices (GH8753)

Old behavior:

In [1]: s = pd.Series(np.arange(3), ['a', 'b', 'c'])
Out[1]:
a 0
b 1
c 2
dtype: int64

In [2]: s.loc['c':'a':-1]
Out[2]:
c 2
dtype: int64

New behavior:

In [18]: s = pd.Series(np.arange(3), ['a', 'b', 'c'])

In [19]: s.loc['c':'a':-1]
Out[19]:
c 2
b 1
a 0
dtype: int64

1.20.2 Enhancements

Categorical enhancements:

• Added ability to export Categorical data to Stata (GH8633). See here for limitations of categorical variables exported to Stata data files.

• Added flag order_categoricals to StataReader and read_stata to select whether to order imported categorical data (GH8836). See here for more information on importing categorical variables from Stata data files.

• Added ability to export Categorical data to/to from HDF5 (GH7621). Queries work the same as if it was an object array. However, the category dtype data is stored in a more efficient manner. See here for an example and caveats w.r.t. prior versions of pandas.

• Added support for searchsorted() on Categorical class (GH8420).

Other enhancements:

• Added the ability to specify the SQL type of columns when writing a DataFrame to a database (GH8778). For example, specifying to use the sqlalchemy String type instead of the default Text type for string columns:
from sqlalchemy.types import String

data.to_sql('data_dtype', engine, dtype={'Col_1': String})

• Series.all and Series.any now support the level and skipna parameters (GH8302):

In [20]: s = pd.Series([False, True, False], index=[0, 0, 1])

In [21]: s.any(level=0)
Out[21]:
0  True
1  False
dtype: bool

• Panel now supports the all and any aggregation functions. (GH8302):

In [22]: p = pd.Panel(np.random.rand(2, 5, 4) > 0.1)

In [23]: p.all()
Out[23]:
     0  1  2  3
0   True  True  True  True
1   True  True  False  True
2   True  True  True  True
3   True  True  False  True
4   True  True  True  True

• Added support for utcfromtimestamp(), fromtimestamp(), and combine() on Timestamp class (GH5351).

• Added Google Analytics (pandas.io.ga) basic documentation (GH8835). See here.

• Timedelta arithmetic returns NotImplemented in unknown cases, allowing extensions by custom classes (GH8813).

• Timedelta now supports arithmetic with numpy.ndarray objects of the appropriate dtype (numpy 1.8 or newer only) (GH8884).

• Added Timedelta.to_timedelta64() method to the public API (GH8884).

• Added gbq.generate_bq_schema() function to the gbq module (GH8325).

• Series now works with map objects the same way as generators (GH8909).

• Added context manager to HDFStore for automatic closing (GH8791).

• to_datetime gains an exact keyword to allow for a format to not require an exact match for a provided format string (if its False). exact defaults to True (meaning that exact matching is still the default) (GH8904)

• Added axvlines boolean option to parallel_coordinates plot function, determines whether vertical lines will be printed, default is True

• Added ability to read table footers to read_html (GH8552)

• to_sql now infers datatypes of non-NA values for columns that contain NA values and have dtype object (GH8778).

1.20.3 Performance

• Reduce memory usage when skiprows is an integer in read_csv (GH8681)
- **Performance** boost for `to_datetime` conversions with a passed `format=`, and the `exact=False` (GH8904)

### 1.20.4 Bug Fixes

- **Bug in** `concat` of `Series` with `category` `dtype` which were coercing to `object`. (GH8641)
- **Bug in** `Timestamp-Timestamp` not returning a `Timedelta` type and date-like-date-like ops with timezones (GH8865)
- Made consistent a timezone mismatch exception (either tz operated with `None` or incompatible timezone), will now return `TypeError` rather than `ValueError` (a couple of edge cases only), (GH8865)
- **Bug in** using a `pd.Grouper(key=...)` with no level/axis or level only (GH8795, GH8866)
- **Bug** in using a `pd.Grouper(key=...)` with no level/axis or level only (GH8795, GH8866)
- **Bug in** `Timestamp-Timestamp` not returning a `Timedelta` type and date-like-date-like ops with timezones (GH8865)
- **Report a** `TypeError` when invalid/no parameters are passed in a `groupby` (GH8015)
- **Bug in** packaging pandas with `py2app/cx_Freeze` (GH8602, GH8831)
- **Bug in** `df.groupby` signatures that didn’t include `*args` or `**kwargs` (GH8733).
- `io.data.Options` now raises `RemoteDataError` when no expiry dates are available from Yahoo and when it receives no data from Yahoo (GH8761), (GH8783).
- Unclear error message in csv parsing when passing dtype and names and the parsed data is a different data type (GH8833)
- **Bug in** slicing a multi-index with an empty list and at least one boolean indexer (GH8781)
- `io.data.Options` now raises `RemoteDataError` when no expiry dates are available from Yahoo (GH8761).
- `Timedelta` `kwargs` may now be numpy ints and floats (GH8757).
- Fixed several outstanding bugs for `Timedelta` arithmetic and comparisons (GH8813, GH5963, GH5436).
- `sql_schema` now generates dialect appropriate `CREATE TABLE` statements (GH8697)
- `slice` string method now takes step into account (GH8754)
- **Bug in** `BlockManager` where setting values with different type would break block integrity (GH8850)
- **Bug in** `DatetimeIndex` when using `time` `object` as key (GH8667)
- **Bug in** `merge` where how='left' and sort=False would not preserve left frame order (GH7331)
- **Bug in** `MultiIndex.reindex` where reindexing at level would not reorder labels (GH4088)
- **Bug in** certain operations with dateutil timezones, manifesting with dateutil 2.3 (GH8639)
- Regression in `DatetimeIndex` iteration with a Fixed/Local offset timezone (GH8890)
- **Bug in** `to_datetime` when parsing a nanoseconds using the `%f` format (GH8989)
- `io.data.Options` now raises `RemoteDataError` when no expiry dates are available from Yahoo and when it receives no data from Yahoo (GH8761), (GH8783).
- **Fix:** The font size was only set on x axis if vertical or the y axis if horizontal. (GH8765)
- **Fixed division by 0** when reading big csv files in python 3 (GH8621)
- **Bug in** outputting a `Multindex` with `to_html`, `index=False` which would add an extra column (GH8452)
- **Imported categorical variables** from Stata files retain the ordinal information in the underlying data (GH8836).
- Defined `.size` attribute across `NDFrame` objects to provide compat with numpy >= 1.9.1; buggy with `np.array_split` (GH8846)
• Skip testing of histogram plots for matplotlib <= 1.2 (GH8648).
• Bug where `get_data_google` returned object dtypes (GH3995)
• Bug in `DataFrame.stack(..., dropna=False)` when the DataFrame’s columns is a MultiIndex whose labels do not reference all its levels. (GH8844)
• Bug in that Option context applied on `__enter__` (GH8514)
• Bug in resample that causes a ValueError when resampling across multiple days and the last offset is not calculated from the start of the range (GH8683)
• Bug where `DataFrame.plot(kind='scatter')` fails when checking if an np.array is in the DataFrame (GH8852)
• Bug in `pd.infer_freq/DataFrame.inferred_freq` that prevented proper sub-daily frequency inference when the index contained DST days (GH8772).
• Bug where index name was still used when plotting a series with `use_index=False` (GH8558).
• Bugs when trying to stack multiple columns, when some (or all) of the level names are numbers (GH8584).
• Bug in `MultiIndex` where `__contains__` returns wrong result if index is not lexically sorted or unique (GH7724)
• BUG CSV: fix problem with trailing whitespace in skipped rows, (GH8679), (GH8661), (GH8983)
• Regression in `Timestamp` does not parse ‘Z’ zone designator for UTC (GH8771)
• Bug in `StataWriter` the produces writes strings with 244 characters irrespective of actual size (GH8969)
• Fixed ValueError raised by `cummin/cummax` when datetime64 Series contains NaT. (GH8965)
• Bug in `DataReader` returns object dtype if there are missing values (GH8980)
• Bug in plotting if `sharex` was enabled and index was a timeseries, would show labels on multiple axes (GH3964).
• Bug where passing a unit to the `TimedeltaIndex` constructor applied the to nano-second conversion twice. (GH9011).
• Bug in plotting of a period-like array (GH9012)

1.21 v0.15.1 (November 9, 2014)

This is a minor bug-fix release from 0.15.0 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

• Enhancements
• API Changes
• Bug Fixes

1.21.1 API changes

• `s.dt.hour` and other `.dt` accessors will now return `np.nan` for missing values (rather than previously -1). (GH8689)
In [1]: s = Series(date_range('20130101', periods=5, freq='D'))

In [2]: s.iloc[2] = np.nan

In [3]: s
Out[3]:
0 2013-01-01
1 2013-01-02
2 NaT
3 2013-01-04
4 2013-01-05
dtype: datetime64[ns]

previous behavior:

In [6]: s.dt.hour
Out[6]:
0 0
1 0
2 -1
3 0
4 0
dtype: int64

current behavior:

In [4]: s.dt.hour
Out[4]:
0 0.0
1 0.0
2 NaN
3 0.0
4 0.0
dtype: float64

• groupby with as_index=False will not add erroneous extra columns to result (GH8582):

In [5]: np.random.seed(2718281)

In [6]: df = pd.DataFrame(np.random.randint(0, 100, (10, 2)),
...: columns=['jim', 'joe'])

In [7]: df.head()
Out[7]:
   jim  joe
0   61   81
1   96   49
2   55   65
3   72   51
4   77   12

In [8]: ts = pd.Series(5 * np.random.randint(0, 3, 10))
In [4]: df.groupby(ts, as_index=False).max()
Out[4]:
         NaN  jim  joe
0      0.0  72.0  83.0
1      5.0  77.0  84.0
2     10.0  96.0  65.0

current behavior:

In [9]: df.groupby(ts, as_index=False).max()
Out[9]:
         jim  joe
0      72.0  83.0
1      77.0  84.0
2     96.0  65.0

• groupby will not erroneously exclude columns if the column name conflicts with the grouper name (GH8112):

In [10]: df = pd.DataFrame({'jim': range(5), 'joe': range(5, 10)})

In [11]: df
Out[11]:
         jim  joe
0       0.0   5.0
1       1.0   6.0
2       2.0   7.0
3       3.0   8.0
4       4.0   9.0

In [12]: gr = df.groupby(df['jim'] < 2)

previous behavior (excludes 1st column from output):

In [4]: gr.apply(sum)
Out[4]:

       joe
jim
False  24.0
True   11.0

current behavior:

In [13]: gr.apply(sum)
Out[13]:

       jim  joe
       jim
jim
False  9.0  24.0
True   1.0   11.0

• Support for slicing with monotonic decreasing indexes, even if start or stop is not found in the index (GH7860):

In [14]: s = pd.Series(['a', 'b', 'c', 'd'], [4, 3, 2, 1])

In [15]: s
Out[15]:
4    a

(continues on next page)
previous behavior:

```
In [8]: s.loc[3.5:1.5]
KeyError: 3.5
```

current behavior:

```
In [16]: s.loc[3.5:1.5]
Out[16]:
3  b
2  c
dtype: object
```

• `io.data.Options` has been fixed for a change in the format of theYahoo Options page (GH8612), (GH8741)

**Note:** As a result of a change in Yahoo’s option page layout, when an expiry date is given, `Options` methods now return data for a single expiry date. Previously, methods returned all data for the selected month.

The `month` and `year` parameters have been undeprecated and can be used to get all options data for a given month.

If an expiry date that is not valid is given, data for the next expiry after the given date is returned.

Option data frames are now saved on the instance as `callsYYMMDD` or `putsYYMMDD`. Previously they were saved as `callsMMYY` and `putsMMYY`. The next expiry is saved as `calls` and `puts`.

New features:

– The expiry parameter can now be a single date or a list-like object containing dates.

– A new property `expiry_dates` was added, which returns all available expiry dates.

Current behavior:

```
In [17]: from pandas.io.data import Options
In [18]: aapl = Options('aapl','yahoo')
In [19]: aapl.get_call_data().iloc[0:5,0:1]
Out[19]:
   Strike  Expiry          Type Symbol         Last
     80  2014-11-14    call AAPL141114C00080000  29.05
     84  2014-11-14    call AAPL141114C00084000  24.80
     85  2014-11-14    call AAPL141114C00085000  24.05
     86  2014-11-14    call AAPL141114C00086000  22.76
     87  2014-11-14    call AAPL141114C00087000  21.74
In [20]: aapl.expiry_dates
Out[20]:
[datetime.date(2014, 11, 14),
  datetime.date(2014, 11, 15),
]```
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
datetime.date(2014, 11, 22),
datetime.date(2014, 11, 28),
datetime.date(2014, 12, 5),
datetime.date(2014, 12, 12),
datetime.date(2014, 12, 20),
datetime.date(2015, 1, 17),
datetime.date(2015, 2, 20),
datetime.date(2015, 4, 17),
datetime.date(2015, 7, 17),
datetime.date(2016, 1, 15),
datetime.date(2017, 1, 20)]
```

```python
In [21]: aapl.get_near_stock_price(expiry=aapl.expiry_dates[0:3]).iloc[0:5,0:1]
Out[21]:
```

<table>
<thead>
<tr>
<th>Strike</th>
<th>Expiry</th>
<th>Type</th>
<th>Symbol</th>
<th>Last</th>
</tr>
</thead>
<tbody>
<tr>
<td>109</td>
<td>2014-11-22</td>
<td>call</td>
<td>AAPL141122C00109000</td>
<td>1.48</td>
</tr>
<tr>
<td></td>
<td>2014-11-28</td>
<td>call</td>
<td>AAPL141128C00109000</td>
<td>1.79</td>
</tr>
<tr>
<td>110</td>
<td>2014-11-14</td>
<td>call</td>
<td>AAPL141114C00110000</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>2014-11-22</td>
<td>call</td>
<td>AAPL141122C00110000</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>2014-11-28</td>
<td>call</td>
<td>AAPL141128C00110000</td>
<td>1.32</td>
</tr>
</tbody>
</table>

- pandas now also registers the `datetime64` dtype in matplotlib’s units registry to plot such values as datetimes. This is activated once pandas is imported. In previous versions, plotting an array of `datetime64` values will have resulted in plotted integer values. To keep the previous behaviour, you can do `del matplotlib.units.registry[np.datetime64]` (GH8614).

### 1.21.2 Enhancements

- `concat` permits a wider variety of iterables of pandas objects to be passed as the first parameter (GH8645):

```python
In [17]: from collections import deque
In [18]: df1 = pd.DataFrame([1, 2, 3])
In [19]: df2 = pd.DataFrame([4, 5, 6])
```

previous behavior:

```python
In [7]: pd.concat(deque((df1, df2)))
 TypeError: first argument must be a list-like of pandas objects, you passed an object of type "deque"
```

current behavior:

```python
In [20]: pd.concat(deque((df1, df2)))
Out[20]:
```

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```
• Represent MultiIndex labels with a dtype that utilizes memory based on the level size. In prior versions, the memory usage was a constant 8 bytes per element in each level. In addition, in prior versions, the reported memory usage was incorrect as it didn’t show the usage for the memory occupied by the underlying data array. (GH8456)

```python
In [21]: dfi = DataFrame(1,index=pd.MultiIndex.from_product([['a'],range(1000)]),
       →columns=['A'])
```

previous behavior:

```python
# this was underreported in prior versions
In [1]: dfi.memory_usage(index=True)
Out[1]:
Index 8000 # took about 24008 bytes in < 0.15.1
A 8000
dtype: int64
```

current behavior:

```python
In [22]: dfi.memory_usage(index=True)
Out [22]:
Index 52080
A 8000
dtype: int64
```

• Added Index properties `is_monotonic_increasing` and `is_monotonic_decreasing` (GH8680).
• Added option to select columns when importing Stata files (GH7935)
• Qualify memory usage in DataFrame.info() by adding + if it is a lower bound (GH8578)
• Raise errors in certain aggregation cases where an argument such as numeric_only is not handled (GH8592).
• Added support for 3-character ISO and non-standard country codes in io.wb.download() (GH8482)
• World Bank data requests now will warn/raise based on an errors argument, as well as a list of hard-coded country codes and the World Bank’s JSON response. In prior versions, the error messages didn’t look at the World Bank’s JSON response. Problem-inducing input were simply dropped prior to the request. The issue was that many good countries were cropped in the hard-coded approach. All countries will work now, but some bad countries will raise exceptions because some edge cases break the entire response. (GH8482)
• Added option to Series.str.split() to return a DataFrame rather than a Series (GH8428)
• Added option to df.info(null_counts=None|True|False) to override the default display options and force showing of the null-counts (GH8701)

1.21.3 Bug Fixes

• Bug in unpickling of a CustomBusinessDay object (GH8591)
• Bug in coercing Categorical to a records array, e.g. df.to_records() (GH8626)
• Bug in Categorical not created properly with Series.to_frame() (GH8626)
• Bug in coercing in astype of a Categorical of a passed pd.Categorical (this now raises TypeError correctly), (GH8626)
• Bug in cut/qcut when using Series and retbins=True (GH8589)
• Bug in writing Categorical columns to an SQL database with to_sql (GH8624).
• Bug in comparing Categorical of datetime raising when being compared to a scalar datetime (GH8687)
• Bug in selecting from a Categorical with .iloc (GH8623)
• Bug in groupby-transform with a Categorical (GH8623)
• Bug in duplicated/drop_duplicates with a Categorical (GH8623)
• Bug in Categorical reflected comparison operator raising if the first argument was a numpy array scalar (e.g. np.int64) (GH8658)
• Bug in Panel indexing with a list-like (GH8710)
• Compat issue is DataFrame.dtypes when options.mode.use_inf_as_null is True (GH8722)
• Bug in read_csv, dialect parameter would not take a string (GH8703)
• Bug in slicing a multi-index level with an empty-list (GH8737)
• Bug in numeric index operations of add/sub with Float/Index Index with numpy arrays (GH8608)
• Bug in setitem with empty indexer and unwanted coercion of dtypes (GH8669)
• Bug in ix/loc block splitting on setitem (manifests with integer-like dtypes, e.g. datetime64) (GH8607)
• Bug when doing label based indexing with integers not found in the index for non-unique but monotonic indexes (GH8680).
• Bug when indexing a Float64Index with np.nan on numpy 1.7 (GH8980).
• Fix shape attribute for MultiIndex (GH8609)
• Bug in GroupBy where a name conflict between the grouper and columns would break groupby operations (GH7115, GH8112)
• Fixed a bug where plotting a column y and specifying a label would mutate the index name of the original DataFrame (GH8494)
• Fix regression in plotting of a DatetimeIndex directly with matplotlib (GH8614).
• Bug in date_range where partially-specified dates would incorporate current date (GH6961)
• Bug in Setting by indexer to a scalar value with a mixed-dtype Panel4d was failing (GH8702)
• Bug where DataReader's would fail if one of the symbols passed was invalid. Now returns data for valid symbols and np.nan for invalid (GH8494)
• Bug in get_quote_yahoo that wouldn’t allow non-float return values (GH5229).

1.22 v0.15.0 (October 18, 2014)

This is a major release from 0.14.1 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Warning: pandas >= 0.15.0 will no longer support compatibility with NumPy versions < 1.7.0. If you want to use the latest versions of pandas, please upgrade to NumPy >= 1.7.0 (GH7711)

• Highlights include:
  – The Categorical type was integrated as a first-class pandas type, see here
  – New scalar type Timedelta, and a new index type TimedeltaIndex, see here
– New datetimelike properties accessor .dt for Series, see Datetimelike Properties
– New DataFrame default display for df.info() to include memory usage, see Memory Usage
– read_csv will now by default ignore blank lines when parsing, see here
– API change in using Indexes in set operations, see here
– Enhancements in the handling of timezones, see here
– A lot of improvements to the rolling and expanding moment functions, see here
– Internal refactoring of the Index class to no longer sub-class ndarray, see Internal Refactoring
– dropping support for PyTables less than version 3.0.0, and numexpr less than version 2.1 (GH7990)
– Split indexing documentation into Indexing and Selecting Data and MultiIndex / Advanced Indexing
– Split out string methods documentation into Working with Text Data

• Check the API Changes and deprecations before updating
• Other Enhancements
• Performance Improvements
• Bug Fixes

Warning: In 0.15.0 Index has internally been refactored to no longer sub-class ndarray but instead subclass PandasObject, similarly to the rest of the pandas objects. This change allows very easy sub-classing and creation of new index types. This should be a transparent change with only very limited API implications (See the Internal Refactoring)

Warning: The refactorings in Categorical changed the two argument constructor from “codes/labels and levels” to “values and levels (now called ‘categories’)”. This can lead to subtle bugs. If you use Categorical directly, please audit your code before updating to this pandas version and change it to use the from_codes() constructor. See more on Categorical here

1.22.1 New features

1.22.1.1 Categoricals in Series/DataFrame

Categorical can now be included in Series and DataFrames and gained new methods to manipulate. Thanks to Jan Schulz for much of this API/implementation. (GH3943, GH5313, GH5314, GH7444, GH7839, GH7848, GH7864, GH7914, GH7768, GH8006, GH3678, GH8075, GH8076, GH8143, GH8453, GH8518).

For full docs, see the categorical introduction and the API documentation.

In [1]: df = DataFrame({"id": [1, 2, 3, 4, 5, 6], "raw_grade": ['a', 'b', 'b', 'a', 'a', 'e ∧']})

In [2]: df["grade"] = df["raw_grade"].astype("category")

In [3]: df["grade"]
Out[3]:
   0  a
   1  b

(continues on next page)
Name: grade, dtype: category
Categories (3, object): [a, b, e]

# Rename the categories
In [4]: df["grade"].cat.categories = ["very good", "good", "very bad"]

# Reorder the categories and simultaneously add the missing categories
In [5]: df["grade"] = df["grade"].cat.set_categories(["very bad", "bad", "medium", "good", "very good"])

In [6]: df["grade"]
Out[6]:
0 very good
1 good
2 good
3 very good
4 very good
5 very bad
Name: grade, dtype: category
Categories (5, object): [very bad, bad, medium, good, very good]

In [7]: df.sort_values("grade")

In [8]: df.groupby("grade").size()
1.22.1.2 TimedeltaIndex/Scalar

We introduce a new scalar type Timedelta, which is a subclass of \texttt{datetime.timedelta}, and behaves in a similar manner, but allows compatibility with \texttt{np.timedelta64} types as well as a host of custom representation, parsing, and attributes. This type is very similar to how \texttt{Timestamp} works for datetimes. It is a nice-API box for the type. See the \texttt{docs}. (GH3009, GH4533, GH8209, GH8187, GH8190, GH7869, GH7661, GH8345, GH8471)

\begin{table}[h]
\centering
\begin{tabular}{|l|}
\hline
\textbf{Warning:} Timedelta scalars (and TimedeltaIndex) component fields are \textit{not the same} as the component fields on a \texttt{datetime.timedelta} object. For example, \texttt{.seconds} on a \texttt{datetime.timedelta} object returns the total number of seconds combined between hours, minutes and seconds. In contrast, the pandas \texttt{Timedelta} breaks out hours, minutes, microseconds and nanoseconds separately. \\
\hline
\end{tabular}
\end{table}

\begin{verbatim}
# Timedelta accessor
In [9]: tds = Timedelta('31 days 5 min 3 sec')

In [10]: tds.minutes
Out[10]: 5L

In [11]: tds.seconds
Out[11]: 3L

# datetime.timedelta accessor
# this is 5 minutes * 60 + 3 seconds
In [12]: tds.to_pytimedelta().seconds
Out[12]: 303
\end{verbatim}

\textbf{Note:} this is no longer true starting from v0.16.0, where full compatibility with \texttt{datetime.timedelta} is introduced. See the \texttt{0.16.0 whatstnew entry}

\begin{table}[h]
\centering
\begin{tabular}{|l|}
\hline
\textbf{Warning:} Prior to 0.15.0 \texttt{pd.to_timedelta} would return a Series for list-like/Series input, and a \texttt{np.timedelta64} for scalar input. It will now return a TimedeltaIndex for list-like input, Series for Series input, and Timedelta for scalar input.

The arguments to \texttt{pd.to_timedelta} are now (\texttt{arg,unit='ns',box=True,coerce=False}), previously were (\texttt{arg,box=True,unit='ns'}) as these are more logical.

\end{tabular}
\end{table}

Construct a scalar

\begin{verbatim}
In [9]: Timedelta('1 days 06:05:01.00003')
Out[9]: Timedelta('1 days 06:05:01.000030')

In [10]: Timedelta('15.5us')
Out[10]: Timedelta('0 days 00:00:00.000015')

In [11]: Timedelta('1 hour 15.5us')
Out[11]: Timedelta('0 days 01:00:00.000015')

# negative Timedeltas have this string repr
# to be more consistent with datetime.timedelta conventions
In [12]: Timedelta('-1us')
Out[12]: Timedelta('-1 days +23:59:59.999999')
\end{verbatim}

(continues on next page)
# a NaT

```
In [13]: Timedelta('nan')
NaT
```

Access fields for a `Timedelta`

```
In [14]: td = Timedelta('1 hour 3m 15.5us')
In [15]: td.seconds
Out[15]: 3780
In [16]: td.microseconds
Out[16]: 16
In [17]: td.nanoseconds
Out[17]: 500
```

Construct a `TimedeltaIndex`

```
In [18]: TimedeltaIndex(['1 days','1 days, 00:00:05',
                      ....:  np.timedelta64(2,'D'),timedelta(days=2,seconds=2))])
```

Constructing a `TimedeltaIndex` with a regular range

```
In [19]: timedelta_range('1 days',periods=5,freq='D')
Out[19]: TimedeltaIndex(['1 days', '2 days', '3 days', '4 days', '5 days'],
                      dtype='timedelta64[ns]', freq='D')
In [20]: timedelta_range(start='1 days',end='2 days',freq='30T')
Out[20]: TimedeltaIndex(['1 days 00:00:00', '1 days 00:30:00', '1 days 01:00:00',
                        '1 days 01:30:00', '1 days 02:00:00', '1 days 02:30:00',
                        '1 days 03:00:00', '1 days 03:30:00', '1 days 04:00:00',
                        '1 days 04:30:00', '1 days 05:00:00', '1 days 05:30:00',
                        '1 days 06:00:00', '1 days 06:30:00', '1 days 07:00:00',
                        '1 days 07:30:00', '1 days 08:00:00', '1 days 08:30:00',
                        '1 days 09:00:00', '1 days 09:30:00', '1 days 10:00:00',
                        '1 days 10:30:00', '1 days 11:00:00', '1 days 11:30:00',
                        '1 days 12:00:00', '1 days 12:30:00', '1 days 13:00:00',
                        '1 days 13:30:00', '1 days 14:00:00', '1 days 14:30:00',
                        '1 days 15:00:00', '1 days 15:30:00', '1 days 16:00:00',
                        '1 days 16:30:00', '1 days 17:00:00', '1 days 17:30:00',
                        '1 days 18:00:00', '1 days 18:30:00', '1 days 19:00:00',
                        '1 days 19:30:00', '1 days 20:00:00', '1 days 20:30:00',
                        '1 days 21:00:00', '1 days 21:30:00', '1 days 22:00:00',
                        '1 days 22:30:00', '1 days 23:00:00', '1 days 23:30:00',
                        '2 days 00:00:00'],
                       dtype='timedelta64[ns]', freq='30T')
```
You can now use a TimedeltaIndex as the index of a pandas object

```python
In [21]: s = Series(np.arange(5),
                   index=timedelta_range('1 days', periods=5, freq='s'))

In [22]: s
Out[22]:
    1 days 00:00:00    0
    1 days 00:00:01    1
    1 days 00:00:02    2
    1 days 00:00:03    3
    1 days 00:00:04    4
Freq: S, dtype: int64
```

You can select with partial string selections

```python
In [23]: s['1 day 00:00:02']
Out[23]: 2

In [24]: s['1 day':'1 day 00:00:02']
Out[24]:
    1 days 00:00:00    0
    1 days 00:00:01    1
    1 days 00:00:02    2
Freq: S, dtype: int64
```

Finally, the combination of TimedeltaIndex with DatetimeIndex allow certain combination operations that are NaT preserving:

```python
In [25]: tdi = TimedeltaIndex(['1 days', pd.NaT, '2 days'])

In [26]: tdi.tolist()
Out[26]: [Timedelta('1 days 00:00:00'), NaT, Timedelta('2 days 00:00:00')]

In [27]: dti = date_range('20130101', periods=3)

In [28]: dti.tolist()
Out[28]: [Timestamp('2013-01-01 00:00:00', freq='D'),
          Timestamp('2013-01-02 00:00:00', freq='D'),
          Timestamp('2013-01-03 00:00:00', freq='D')]

In [29]: (dti + tdi).tolist()
Out[29]: [Timestamp('2013-01-02 00:00:00'), NaT, Timestamp('2013-01-05 00:00:00')]

In [30]: (dti - tdi).tolist()
Out[30]: [Timestamp('2012-12-31 00:00:00'), NaT, Timestamp('2013-01-01 00:00:00')]
```

- iteration of a Series e.g. list(Series(...)) of timedelta64[ns] would prior to v0.15.0 return np.timedelta64 for each element. These will now be wrapped in Timedelta.

### 1.2.2.1.3 Memory Usage

Implemented methods to find memory usage of a DataFrame. See the FAQ for more. (GH6852).
A new display option `display.memory_usage` (see Options and Settings) sets the default behavior of the `memory_usage` argument in the `df.info()` method. By default `display.memory_usage` is `True`.

```python
In [31]: dtypes = ['int64', 'float64', 'datetime64[ns]', 'timedelta64[ns]',
          'complex128', 'object', 'bool']

In [32]: n = 5000

In [33]: data = dict{ (t, np.random.randint(100, size=n).astype(t))
          for t in dtypes}

In [34]: df = DataFrame(data)

In [35]: df['categorical'] = df['object'].astype('category')

In [36]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5000 entries, 0 to 4999
Data columns (total 8 columns):
    int64 5000 non-null int64
    float64 5000 non-null float64
    datetime64[ns] 5000 non-null datetime64[ns]
    timedelta64[ns] 5000 non-null timedelta64[ns]
    complex128 5000 non-null complex128
    object 5000 non-null object
    bool 5000 non-null bool
categorical 5000 non-null category
dtypes: bool(1), category(1), complex128(1), datetime64[ns](1), float64(1), int64(1),
˓→object(1), timedelta64[ns](1)
memory usage: 289.1+ KB
```

Additionally `memory_usage()` is an available method for a dataframe object which returns the memory usage of each column.

```python
In [37]: df.memory_usage(index=True)
Out[37]:
Index     80
int64  40000
float64 40000
datetime64[ns] 40000
timedelta64[ns] 40000
complex128 80000
object  40000
bool  5000
 categorical 10920
dtype: int64
```

### 1.22.1.4 .dt accessor

Series has gained an accessor to succinctly return datetime like properties for the values of the Series, if its a datetime/period like Series. (GH7207) This will return a Series, indexed like the existing Series. See the docs

```python
# datetime
In [38]: s = Series(date_range('20130101 09:10:12', periods=4))
```
In [39]: s
Out[39]:
0 2013-01-01 09:10:12
1 2013-01-02 09:10:12
2 2013-01-03 09:10:12
3 2013-01-04 09:10:12
dtype: datetime64[ns]

In [40]: s.dt.hour
Out[40]:
0 9
1 9
2 9
3 9
dtype: int64

In [41]: s.dt.second
Out[41]:
0 12
1 12
2 12
3 12
dtype: int64

In [42]: s.dt.day
Out[42]:
0 1
1 2
2 3
3 4
dtype: int64

In [43]: s.dt.freq
Out[43]: 'D'

This enables nice expressions like this:

In [44]: s[s.dt.day==2]
Out[44]:
1 2013-01-02 09:10:12
dtype: datetime64[ns]

You can easily produce tz aware transformations:

In [45]: stz = s.dt.tz_localize('US/Eastern')

In [46]: stz
Out[46]:
0 2013-01-01 09:10:12-05:00
1 2013-01-02 09:10:12-05:00
2 2013-01-03 09:10:12-05:00
3 2013-01-04 09:10:12-05:00
You can also chain these types of operations:

```
In [48]: stz.dt.tz_localize('UTC').dt.tz_convert('US/Eastern')
Out[48]:
0  2013-01-01 04:10:12-05:00
1  2013-01-02 04:10:12-05:00
2  2013-01-03 04:10:12-05:00
3  2013-01-04 04:10:12-05:00
dtype: datetime64[ns, US/Eastern]
```

The `.dt` accessor works for period and timedelta dtypes.

```
In [49]: s = Series(period_range('20130101', periods=4, freq='D'))
In [50]: s
Out[50]:
0  2013-01-01
1  2013-01-02
2  2013-01-03
3  2013-01-04
dtype: object
In [51]: s.dt.year
Out[51]:
0  2013
1  2013
2  2013
3  2013
dtype: int64
In [52]: s.dt.day
Out[52]:
0  1
1  2
2  3
3  4
dtype: int64
```

```
In [53]: s = Series(timedelta_range('1 day 00:00:05', periods=4, freq='s'))
In [54]: s
Out[54]:
0  1 days 00:00:05
1  1 days 00:00:06
2  1 days 00:00:07
3  1 days 00:00:08
```
dtype: timedelta64[ns]

In [55]: s.dt.days

→ 0 1
   1 1
   2 1
   3 1
dtype: int64

In [56]: s.dt.seconds

→ 0 5
   1 6
   2 7
   3 8
dtype: int64

In [57]: s.dt.components

→  days  hours  minutes  seconds  milliseconds  microseconds  nanoseconds
   0  1  0  0  5  0  0  0
   1  1  0  0  6  0  0  0
   2  1  0  0  7  0  0  0
   3  1  0  0  8  0  0  0

1.22.1.5 Timezone handling improvements

- `tz_localize(None)` for tz-aware Timestamp and DatetimeIndex now removes timezone holding local time, previously this resulted in Exception or TypeError (GH7812)

In [58]: ts = Timestamp('2014-08-01 09:00', tz='US/Eastern')

In [59]: ts
Out[59]: Timestamp('2014-08-01 09:00:00-04:00', tz='US/Eastern')

In [60]: ts.tz_localize(None)

→ Timestamp('2014-08-01 09:00:00')

In [61]: didx = DatetimeIndex(start='2014-08-01 09:00', freq='H', periods=10, tz=→'US/Eastern')

In [62]: didx
Out[62]: DatetimeIndex(['2014-08-01 09:00:00-04:00', '2014-08-01 10:00:00-04:00',
   '2014-08-01 11:00:00-04:00', '2014-08-01 12:00:00-04:00',
   '2014-08-01 13:00:00-04:00', '2014-08-01 14:00:00-04:00',
   '2014-08-01 15:00:00-04:00', '2014-08-01 16:00:00-04:00',
   '2014-08-01 17:00:00-04:00', '2014-08-01 18:00:00-04:00'],
dtype='datetime64[ns, US/Eastern]', freq='H')
In [63]: didx.tz_localize(None)

Datet imeIndex(['2014-08-01 09:00:00', '2014-08-01 10:00:00', '2014-08-01 11:00:00', '2014-08-01 12:00:00', '2014-08-01 13:00:00', '2014-08-01 14:00:00', '2014-08-01 15:00:00', '2014-08-01 16:00:00', '2014-08-01 17:00:00', '2014-08-01 18:00:00'],
dtype='datetime64[ns]', freq='H')

• tz_localize now accepts the ambiguous keyword which allows for passing an array of bools indicating whether the date belongs in DST or not, 'NaT' for setting transition times to NaT, 'infer' for inferring DST/non-DST, and 'raise' (default) for an AmbiguousTimeError to be raised. See the docs for more details (GH7943)

• DataFrame.tz_localize and DataFrame.tz_convert now accepts an optional level argument for localizing a specific level of a MultiIndex (GH7846)

• Timestamp.tz_localize and Timestamp.tz_convert now raise TypeError in error cases, rather than Exception (GH8025)

• a timeseries/index localized to UTC when inserted into a Series/DataFrame will preserve the UTC timezone (rather than being a naive datetime64[ns]) as object dtype (GH8411)

• Timestamp.__repr__ displays dateutil.tz.tzoffset info (GH7907)

1.22.1.6 Rolling/Expanding Moments improvements

• rolling_min(), rolling_max(), rolling_cov(), and rolling_corr() now return objects with all NaN when len(arg) < min_periods <= window rather than raising. (This makes all rolling functions consistent in this behavior). (GH7766)

Prior to 0.15.0

In [64]: s = Series([10, 11, 12, 13])

In [15]: rolling_min(s, window=10, min_periods=5)
ValueError: min_periods (5) must be <= window (4)

New behavior

In [4]: pd.rolling_min(s, window=10, min_periods=5)
Out[4]:
0   NaN
1   NaN
2   NaN
3   NaN
dtype: float64

• rolling_max(), rolling_min(), rolling_sum(), rolling_mean(), rolling_median(), rolling_std(), rolling_var(), rolling_skew(), rolling_kurt(), rolling_quantile(), rolling_cov(), rolling_corr(), rolling_corr_pairwise(), rolling_window(), and rolling_apply() with center=True previously would return a result of the same structure as the input arg with NaN in the final (window-1)/2 entries.

Now the final (window-1)/2 entries of the result are calculated as if the input arg were followed by (window-1)/2 NaN values (or with shrinking windows, in the case of rolling_apply()). (GH7925, GH8269)
Prior behavior (note final value is NaN):

```python
In [7]: rolling_sum(Series(range(4)), window=3, min_periods=0, center=True)
Out[7]:
0   1
1   3
2   6
3  NaN
dtype: float64
```

New behavior (note final value is $5 = \sum([2, 3, \text{NaN}])$):

```python
In [7]: rolling_sum(Series(range(4)), window=3, min_periods=0, center=True)
Out[7]:
0   1
1   3
2   6
3   5
dtype: float64
```

- `rolling_window()` now normalizes the weights properly in rolling mean mode ($\text{mean=True}$) so that the calculated weighted means (e.g. ‘triang’, ‘gaussian’) are distributed about the same means as those calculated without weighting (i.e. ‘boxcar’). See the note on normalization for further details. (GH7618)

Behavior prior to 0.15.0:

```python
In [39]: rolling_window(s, window=3, win_type='triang', center=True)
Out[39]:
0   NaN
1  6.583333
2  6.883333
3  6.683333
4   NaN
dtype: float64
```

New behavior

```python
In [10]: pd.rolling_window(s, window=3, win_type='triang', center=True)
Out[10]:
0   NaN
1   9.875
2  10.325
3  10.025
4   NaN
dtype: float64
```

- Removed `center` argument from all `expanding_` functions (see list), as the results produced when `center=True` did not make much sense. (GH7925)
- Added optional `ddof` argument to `expanding_cov()` and `rolling_cov()`. The default value of 1 is backwards-compatible. (GH8279)
- Documented the `ddof` argument to `expanding_var()`, `expanding_std()`, `rolling_var()`, and `rolling_std()`. These functions’ support of a `ddof` argument (with a default value of 1) was previously undocumented. (GH8064)
• `ewma()`, `ewmstd()`, `ewmvol()`, `ewmvar()`, `ewmcov()`, and `ewmcorr()` now interpret `min_periods` in the same manner that the `rolling_*()` and `expanding_*()` functions do: a given result entry will be NaN if the (expanding, in this case) window does not contain at least `min_periods` values. The previous behavior was to set to NaN the `min_periods` entries starting with the first non-NaN value. (GH7977)

Prior behavior (note values start at index 2, which is `min_periods` after index 0 (the index of the first non-empty value)):

```
In [66]: s = Series([1, None, None, None, 2, 3])
In [51]: ewma(s, com=3., min_periods=2)
Out[51]:
0    NaN
1    NaN
2    1.000000
3    1.000000
4    1.571429
5    2.189189
dtype: float64
```

New behavior (note values start at index 4, the location of the 2nd (since `min_periods=2`) non-empty value):

```
In [2]: pd.ewma(s, com=3., min_periods=2)
Out[2]:
0    NaN
1    NaN
2    NaN
3    NaN
4    1.759644
5    2.383784
dtype: float64
```

• `ewmstd()`, `ewmvol()`, `ewmvar()`, `ewmcov()`, and `ewmcorr()` now have an optional `adjust` argument, just like `ewma()` does, affecting how the weights are calculated. The default value of `adjust` is `True`, which is backwards-compatible. See Exponentially weighted moment functions for details. (GH7911)

• `ewma()`, `ewmstd()`, `ewmvol()`, `ewmvar()`, `ewmcov()`, and `ewmcorr()` now have an optional `ignore_na` argument. When `ignore_na=False` (the default), missing values are taken into account in the weights calculation. When `ignore_na=True` (which reproduces the pre-0.15.0 behavior), missing values are ignored in the weights calculation. (GH7543)

```
In [7]: pd.ewma(Series([None, 1., 8.]), com=2.)
Out[7]:
0  1.0
1  5.2
dtype: float64
```

```
In [8]: pd.ewma(Series([1., None, 8.]), com=2., ignore_na=True)  # pre-0.15.0 behavior
Out[8]:
0  1.0
1  1.0
2  5.2
dtype: float64
```

```
In [9]: pd.ewma(Series([1., None, 8.]), com=2., ignore_na=False)  # new default
(continues on next page)
```
Out[9]:
0  1.000000
1  1.000000
2  5.846154
dtype: float64

**Warning:** By default (ignore_na=False) the ewm*() functions’ weights calculation in the presence of missing values is different than in pre-0.15.0 versions. To reproduce the pre-0.15.0 calculation of weights in the presence of missing values one must specify explicitly ignore_na=True.

- Bug in expanding_cov(), expanding_corr(), rolling_cov(), rolling_cor(), ewmcov(), and ewmcorr() returning results with columns sorted by name and producing an error for non-unique columns: now handles non-unique columns and returns columns in original order (except for the case of two DataFrames with pairwise=False, where behavior is unchanged) (GH7542)
- Bug in rolling_count() and expanding_*() functions unnecessarily producing error message for zero-length data (GH8056)
- Bug in rolling_apply() and expanding_apply() interpreting min_periods=0 as min_periods=1 (GH8080)
- Bug in expanding_std() and expanding_var() for a single value producing a confusing error message (GH7900)
- Bug in rolling_std() and rolling_var() for a single value producing 0 rather than NaN (GH7900)
- Bug in ewmstd(), ewmvol(), ewmvar(), and ewmcorr() calculation of de-biasing factors when bias=False (the default). Previously an incorrect constant factor was used, based on adjust=True, ignore_na=True, and an infinite number of observations. Now a different factor is used for each entry, based on the actual weights (analogous to the usual \(N/(N-1)\) factor). In particular, for a single point a value of NaN is returned when bias=False, whereas previously a value of (approximately) 0 was returned.

For example, consider the following pre-0.15.0 results for ewmvar(..., bias=False), and the corresponding debiasing factors:

```
In [67]: s = Series([1., 2., 0., 4.])
In [89]: ewmvar(s, com=2., bias=False)
Out[89]:
0   -2.775558e-16
1     3.000000e-01
2     9.556787e-01
3    3.585799e+00
dtype: float64
In [90]: ewmvar(s, com=2., bias=False) / ewmvar(s, com=2., bias=True)
Out[90]:
0     1.25
1     1.25
2     1.25
3     1.25
dtype: float64
```

Note that entry 0 is approximately 0, and the debiasing factors are a constant 1.25. By comparison, the following 0.15.0 results have a NaN for entry 0, and the debiasing factors are decreasing (towards 1.25):
```python
In [14]: pd.ewmvar(s, com=2., bias=False)
Out[14]:
0    NaN
1   0.500000
2   1.210526
3   4.089069
dtype: float64

In [15]: pd.ewmvar(s, com=2., bias=False) / pd.ewmvar(s, com=2., bias=True)
Out[15]:
0   NaN
1  2.083333
2  1.583333
3  1.425439
dtype: float64
```

See *Exponentially weighted moment functions* for details. (GH7912)

### 1.22.1.7 Improvements in the sql io module

- Added support for a `chunksize` parameter to `to_sql` function. This allows DataFrame to be written in chunks and avoid packet-size overflow errors (GH8062).
- Added support for a `chunksize` parameter to `read_sql` function. Specifying this argument will return an iterator through chunks of the query result (GH2908).
- Added support for writing `datetime.date` and `datetime.time` object columns with `to_sql` (GH6932).
- Added support for specifying a `schema` to read from/write to with `read_sql_table` and `to_sql` (GH7441, GH7952). For example:

  ```python
df.to_sql('table', engine, schema='other_schema')
pd.read_sql_table('table', engine, schema='other_schema')
  ```

- Added support for writing NaN values with `to_sql` (GH2754).
- Added support for writing datetime64 columns with `to_sql` for all database flavors (GH7103).

### 1.22.2 Backwards incompatible API changes

#### 1.22.2.1 Breaking changes

API changes related to `Categorical` (see *here* for more details):

- The `Categorical` constructor with two arguments changed from “codes/labels and levels” to “values and levels (now called ‘categories’)”. This can lead to subtle bugs. If you use `Categorical` directly, please audit your code by changing it to use the `from_codes()` constructor.

  An old function call like (prior to 0.15.0):

  ```python
  pd.Categorical([0,1,0,2,1], levels=['a', 'b', 'c'])
  ```

  will have to adapted to the following to keep the same behaviour:
In [2]: pd.Categorical.from_codes([0,1,0,2,1], categories=['a', 'b', 'c'])
Out[2]:
[a, b, a, c, b]
Categories (3, object): [a, b, c]

API changes related to the introduction of the Timedelta scalar (see above for more details):

- Prior to 0.15.0 to_timedelta() would return a Series for list-like/Series input, and a np.
timedelta64 for scalar input. It will now return a TimedeltaIndex for list-like input, Series for
Series input, and Timedelta for scalar input.

For API changes related to the rolling and expanding functions, see detailed overview above.

Other notable API changes:

- Consistency when indexing with .loc and a list-like indexer when no values are found.

In [68]: df = DataFrame([['a'], ['b']],index=[1,2])
In [69]: df
Out[69]:
   0
  0 a
  1 b

In prior versions there was a difference in these two constructs:

- df.loc[[3]] would return a frame reindexed by 3 (with all np.nan values)
- df.loc[[3],:] would raise KeyError.

Both will now raise a KeyError. The rule is that at least 1 indexer must be found when using a list-like and .loc (GH7999)

Furthermore in prior versions these were also different:

- df.loc[[1,3]] would return a frame reindexed by [1,3]
- df.loc[[1,3],:] would raise KeyError.

Both will now return a frame reindex by [1,3]. E.g.

In [3]: df.loc[[1,3]]
Out[3]:
   0
  0 a
  1 a
  3 NaN

In [4]: df.loc[[1,3],:]
Out[4]:
   0
  0 a
  1 a
  3 NaN

This can also be seen in multi-axis indexing with a Panel.

In [70]: p = Panel(np.arange(2*3*4).reshape(2,3,4),
   ....:     items=['ItemA','ItemB'],
   ....:     major_axis=[1,2,3],
   ....:     minor_axis=['A','B','C','D'])
   ....:
(continues on next page)
In [71]: p
Out[71]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 3 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemB
Major_axis axis: 1 to 3
Minor_axis axis: A to D

The following would raise **KeyError** prior to 0.15.0:

In [5]:
Out[5]:
    ItemA  ItemD
   1     3  NaN
   2     7  NaN
   3    11  NaN

Furthermore, `.loc` will raise **KeyError** if no values are found in a multi-index with a list-like indexer:

In [72]: s = Series(np.arange(3, dtype='int64'),
               index=MultiIndex.from_product([['A'], ['foo', 'bar', 'baz']],
                                           names=['one', 'two'])).sort_index()

In [73]: s
Out[73]:
   one   two
   A   bar  1
   baz  2
   foo  0
dtype: int64

In [74]: try:
    ....:    s.loc[['D']]  
    ....: except KeyError as e:
    ....:        print("KeyError: " + str(e))
    ....:        print("\['D' not in index"

• Assigning values to `None` now considers the dtype when choosing an ‘empty’ value (GH7941).

Previously, assigning to `None` in numeric containers changed the dtype to object (or errored, depending on the call). It now uses NaN:

In [75]: s = Series([1, 2, 3])

In [76]: s.loc[0] = None

In [77]: s
Out[77]:
   0  NaN
   1  2.0
   2  3.0
dtype: float64
NaT is now used similarly for datetime containers.

For object containers, we now preserve None values (previously these were converted to NaN values).

```
In [78]: s = Series(['a', 'b', 'c'])
In [79]: s.loc[0] = None
In [80]: s
Out[80]:
0    None
1      b
2      c
dtype: object
```

To insert a NaN, you must explicitly use np.nan. See the docs.

- In prior versions, updating a pandas object inplace would not reflect in other python references to this object. (GH8511, GH5104)

```
In [81]: s = Series([1, 2, 3])
In [82]: s2 = s
In [83]: s += 1.5

Behavior prior to v0.15.0

# the original object
In [5]: s
Out[5]:
0    2.5
1    3.5
2    4.5
dtype: float64

# a reference to the original object
In [7]: s2
Out[7]:
0    1
1    2
2    3
dtype: int64

This is now the correct behavior

# the original object
In [84]: s
Out[84]:
0    2.5
1    3.5
2    4.5
dtype: float64

# a reference to the original object
In [85]: s2
```

(continues on next page)
pandas: powerful Python data analysis toolkit, Release 0.23.2

1 3.5
2 4.5
dtype: float64

• Made both the C-based and Python engines for read_csv and read_table ignore empty lines in input as well as whitespace-filled lines, as long as sep is not whitespace. This is an API change that can be controlled by the keyword parameter skip_blank_lines. See the docs (GH4466)

• A timeseries/index localized to UTC when inserted into a Series/DataFrame will preserve the UTC timezone and inserted as object dtype rather than being converted to a naive datetime64[ns] (GH8411).

• Bug in passing a DatetimeIndex with a timezone that was not being retained in DataFrame construction from a dict (GH7822)

  In prior versions this would drop the timezone, now it retains the timezone, but gives a column of object dtype:

  In [86]: i = date_range('1/1/2011', periods=3, freq='10s', tz = 'US/Eastern')
  In [87]: i
  Out[87]:
  DatetimeIndex(['2011-01-01 00:00:00-05:00', '2011-01-01 00:00:10-05:00',
  '2011-01-01 00:00:20-05:00'],
  dtype='datetime64[ns, US/Eastern]', freq='10S')
  In [88]: df = DataFrame( {'a' : i } )
  In [89]: df
  Out[89]:
  a
  0 2011-01-01 00:00:00-05:00
  1 2011-01-01 00:00:10-05:00
  2 2011-01-01 00:00:20-05:00

  Previously this would have yielded a column of datetime64 dtype, but without timezone info.

  The behaviour of assigning a column to an existing dataframe as df['a'] = i remains unchanged (this already returned an object column with a timezone).

• When passing multiple levels to stack(), it will now raise a ValueError when the levels aren’t all level names or all level numbers (GH7660). See Reshaping by stacking and unstacking.

• Raise a ValueError in df.to_hdf with ‘fixed’ format, if df has non-unique columns as the resulting file will be broken (GH7761)

• SettingWithCopy raise/warnings (according to the option mode.chained_assignment) will now be issued when setting a value on a sliced mixed-dtype DataFrame using chained-assignment. (GH7845, GH7950)
• merge, DataFrame.merge, and ordered_merge now return the same type as the left argument (GH7737).

• Previously an enlargement with a mixed-dtype frame would act unlike .append which will preserve dtypes (related GH2578, GH8176):

```python
In [91]: df = DataFrame([[True, 1],[False, 2]],
                        columns=["female","fitness"])
            ....:
            ....:

In [92]: df
Out[92]:
female fitness
0   True   1
1  False   2

In [93]: df.dtypes                                                                 
Out[93]:
female    bool
fitness   int64
dtype: object

# dtypes are now preserved

In [95]: df
Out[95]:
female fitness
0   True   1
1  False   2
2  False   2

In [96]: df.dtypes                                                                 
Out[96]:
female    bool
fitness   int64
dtype: object
```

• Series.to_csv() now returns a string when path=None, matching the behaviour of DataFrame.to_csv() (GH8215).

• read_hdf now raises IOError when a file that doesn’t exist is passed in. Previously, a new, empty file was created, and a KeyError raised (GH7715).

• DataFrame.info() now ends its output with a newline character (GH8114)

• Concatenating no objects will now raise a ValueError rather than a bare Exception.

• Merge errors will now be sub-classes of ValueError rather than raw Exception (GH8501)
• **DataFrame.plot** and **Series.plot** keywords are now have consistent orders (GH8037)

### 1.22.2.2 Internal Refactoring

In 0.15.0 Index has internally been refactored to no longer sub-class **ndarray** but instead subclass **PandasObject**, similarly to the rest of the pandas objects. This change allows very easy sub-classing and creation of new index types. This should be a transparent change with only very limited API implications (GH5080, GH7439, GH7796, GH8024, GH8367, GH7997, GH8522):

- you may need to unpickle pandas version < 0.15.0 pickles using `pd.read_pickle` rather than `pickle.load`. See `pickle docs`
- when plotting with a PeriodIndex, the matplotlib internal axes will now be arrays of Period rather than a PeriodIndex (this is similar to how a DatetimeIndex passes arrays of datetimes now)
- MultiIndexes will now raise similarly to other pandas objects w.r.t. truth testing, see here (GH7897).
- When plotting a DatetimeIndex directly with matplotlib’s plot function, the axis labels will no longer be formatted as dates but as integers (the internal representation of a datetime64). **UPDATE** This is fixed in 0.15.1, see here.

### 1.22.2.3 Deprecations

- The attributes **Categorical labels** and **levels** attributes are deprecated and renamed to **codes** and **categories**.
- The **outtype** argument to `pd.DataFrame.to_dict` has been deprecated in favor of **orient**. (GH7840)
- The **convert_dummies** method has been deprecated in favor of **get_dummies** (GH8140)
- The **infer_dst** argument in `tz_localize` will be deprecated in favor of **ambiguous** to allow for more flexibility in dealing with DST transitions. Replace **infer_dst=True** with **ambiguous='infer'** for the same behavior (GH7943). See the docs for more details.
- The top-level **pd.value_range** has been deprecated and can be replaced by `.describe()` (GH8481)
- The **Index** set operations `+` and `-` were deprecated in order to provide these for numeric type operations on certain index types. `+` can be replaced by `.union()` or `|`, and `-` by `.difference()`. Further the method name `Index.diff()` is deprecated and can be replaced by `Index.difference()` (GH8226)

```
# +
Index(['a', 'b', 'c']) + Index(['b', 'c', 'd'])
# should be replaced by
Index(['a', 'b', 'c']).union(Index(['b', 'c', 'd']))

# -
Index(['a', 'b', 'c']) - Index(['b', 'c', 'd'])
# should be replaced by
Index(['a', 'b', 'c']).difference(Index(['b', 'c', 'd']))
```

- The **infer_types** argument to `read_html()` now has no effect and is deprecated (GH7762, GH7032).

### 1.22.2.4 Removal of prior version deprecations/changes

- Remove **DataFrame.delevel** method in favor of **DataFrame.reset_index**
### 1.22.3 Enhancements

Enhancements in the importing/exporting of Stata files:

- Added support for bool, uint8, uint16 and uint32 datatypes in `to_stata` (GH7097, GH7365)
- Added conversion option when importing Stata files (GH8527)
- `DataFrame.to_stata` and `StataWriter` check string length for compatibility with limitations imposed in dta files where fixed-width strings must contain 244 or fewer characters. Attempting to write Stata dta files with strings longer than 244 characters raises a `ValueError`. (GH7858)
- `read_stata` and `StataReader` can import missing data information into a `DataFrame` by setting the argument `convert_missing` to True. When using this options, missing values are returned as `StataMissingValue` objects and columns containing missing values have `object` data type. (GH8045)

Enhancements in the plotting functions:

- Added `layout` keyword to `DataFrame.plot`. You can pass a tuple of `(rows, columns)`, one of which can be `-1` to automatically infer (GH6667, GH8071).
- Allow to pass multiple axes to `DataFrame.plot`, `hist` and `boxplot` (GH5353, GH6970, GH7069)
- Added support for `c`, `colormap` and `colorbar` arguments for `DataFrame.plot` with `kind='scatter'` (GH7780)
- Histogram from `DataFrame.plot` with `kind='hist'` (GH7809), See the docs.
- Boxplot from `DataFrame.plot` with `kind='box'` (GH7998), See the docs.

Other:

- `read_csv` now has a keyword parameter `float_precision` which specifies which floating-point converter the C engine should use during parsing, see here (GH8002, GH8044)
- Added `searchsorted` method to `Series` objects (GH7447)
- `describe()` on mixed-types DataFrames is more flexible. Type-based column filtering is now possible via the `include/exclude` arguments. See the docs (GH8164).

```
In [97]: df = DataFrame(['catA': ['foo', 'foo', 'bar'] * 8,
    ....:             'catB': ['a', 'b', 'c', 'd'] * 6,
    ....:             'numC': np.arange(24),
    ....:             'numD': np.arange(24.) + .5})

In [98]: df.describe(include=['object'])
Out[98]:
     catA  catB
   count   24   24
   unique  2   4
   top    foo  a
   freq   16   6

In [99]: df.describe(include=['number', 'object'], exclude=['float'])
```

(continues on next page)
Requesting all columns is possible with the shorthand ‘all’

```
In [100]: df.describe(include='all')
Out[100]:
         catA      catB  numC  numD
       count       24    24.000000  24.000000
       unique     2       4    NaN    NaN
        top       foo     a    NaN    NaN
        freq      16       6    NaN    NaN
       mean       NaN    NaN   11.500000  12.000000
       std        NaN    NaN    7.071068  7.071068
       min        NaN    NaN    0.000000  0.500000
       25%        NaN    NaN    5.750000  6.250000
       50%        NaN    NaN   11.500000  12.000000
       75%        NaN    NaN   17.250000  17.750000
       max        NaN    NaN   23.000000  23.500000
```

Without those arguments, `describe` will behave as before, including only numerical columns or, if none are, only categorical columns. See also the `docs`

- Added `split` as an option to the `orient` argument in `pd.DataFrame.to_dict`. (GH7840)
- The `get_dummies` method can now be used on DataFrames. By default only categorical columns are encoded as 0’s and 1’s, while other columns are left untouched.

```
In [101]: df = DataFrame({'A': ['a', 'b', 'a'], 'B': ['c', 'c', 'b'],
                          'C': [1, 2, 3]})
```

```
In [102]: pd.get_dummies(df)
Out[102]:
     C   A_a   A_b   B_b   B_c
0  1  1.00  0.00  0.00  1.00
1  2  0.00  1.00  0.00  1.00
2  3  0.00  0.00  1.00  0.00
```

- `PeriodIndex` supports `resolution` as the same as `DatetimeIndex` (GH7708)
- `pandas.tseries.holiday` has added support for additional holidays and ways to observe holidays (GH7070)
- `pandas.tseries.holiday.Holiday` now supports a list of offsets in Python3 (GH7070)
- `pandas.tseries.holiday.Holiday` now supports a `days_of_week` parameter (GH7070)
- `GroupBy.nth()` now supports selecting multiple `nth` values (GH7910)
# get the first, 4th, and last date index for each month
In [105]: df.groupby((df.index.year, df.index.month)).nth([0, 3, -1])
Out[105]:
   a  b
2014 4 1 1
    4 1 1
    4 1 1
    5 1 1
    5 1 1
    5 1 1
    6 1 1
    6 1 1
    6 1 1

- Period and PeriodIndex supports addition/subtraction with timedelta-likes (GH7966)

  If Period freq is D, H, T, S, L, U, N, Timedelta-like can be added if the result can have same freq. Otherwise, only the same offsets can be added.

  In [106]: idx = pd.period_range('2014-07-01 09:00', periods=5, freq='H')
     
  In [107]: idx
Out[107]:
PeriodIndex(['2014-07-01 09:00', '2014-07-01 10:00', '2014-07-01 11:00',
            '2014-07-01 12:00', '2014-07-01 13:00'],
            dtype='period[H]', freq='H')

  In [108]: idx + pd.offsets.Hour(2)
      
  In [109]: idx + pd.offsets.Hour(2)

  In [110]: idx = pd.period_range('2014-07', periods=5, freq='M')
     
  In [111]: idx
Out[111]:
            dtype='period[M]', freq='M')

  In [112]: idx + pd.offsets.MonthEnd(3)

- Added experimental compatibility with openpyxl for versions >= 2.0. The DataFrame.to_excel method engine keyword now recognizes openpyxl1 and openpyxl2 which will explicitly require openpyxl v1 and v2 respectively, failing if the requested version is not available. The openpyxl engine is a now a meta-engine that automatically uses whichever version of openpyxl is installed. (GH7177)
• DataFrame.fillna can now accept a DataFrame as a fill value (GH8377)

• Passing multiple levels to stack() will now work when multiple level numbers are passed (GH7660). See Reshaping by stacking and unstacking.

• set_names(), set_labels(), and set_levels() methods now take an optional level keyword argument to all modification of specific level(s) of a MultiIndex. Additionally set_names() now accepts a scalar string value when operating on an Index or on a specific level of a MultiIndex (GH7792)

```
In [113]: idx = MultiIndex.from_product([['a'], range(3), list('pqr')], names=['foo', 'bar', 'baz'])

In [114]: idx.set_names('qux', level=0)
Out[114]: MultiIndex(levels=[['a'], [0, 1, 2], ['p', 'q', 'r']], labels=[[0, 0, 0, 0, 0, 0, 0, 0, 0], [0, 0, 0, 1, 1, 1, 2, 2, 2], [0, 1, 2, 0, 1, 2, 0, 1, 2]], names=['qux', 'bar', 'baz'])

In [115]: idx.set_names(['qux','corge'], level=[0,1])

In [116]: idx.set_levels(['a','b','c'], level='bar')

In [117]: idx.set_levels([['a','b','c'],[1,2,3]], level=[1,2])
```

• Index.isin now supports a level argument to specify which index level to use for membership tests (GH7892, GH7890)

```
In [1]: idx = MultiIndex.from_product([[0, 1], ['a', 'b', 'c']])

In [2]: idx.values
Out[2]: array([0, 'a'), (0, 'b'), (0, 'c'), (1, 'a'), (1, 'b'), (1, 'c')], dtype=object)

In [3]: idx.isin(['a', 'c', 'e'], level=1)
Out[3]: array([ True, False, True, True, False, True], dtype=bool)

• Index now supports duplicated and drop_duplicates. (GH4060)

```
In [118]: idx = Index([1, 2, 3, 4, 1, 2])
```
In [119]: idx
Out[119]: Int64Index([1, 2, 3, 4, 1, 2], dtype='int64')

In [120]: idx.duplicated()
Out[120]: array([False, False, False, True, True], dtype=bool)

In [121]: idx.drop_duplicates()
Out[121]: Int64Index([1, 2, 3, 4], dtype='int64')

• add copy=True argument to pd.concat to enable pass thru of complete blocks (GH8252)
• Added support for numpy 1.8+ data types (bool_, int_, float_, string_) for conversion to R dataframe (GH8400)

1.22.4 Performance

• Performance improvements in DatetimeIndex.__iter__ to allow faster iteration (GH7683)
• Performance improvements in Period creation (and PeriodIndex setitem) (GH5155)
• Improvements in Series.transform for significant performance gains (revised) (GH6496)
• Performance improvements in StataReader when reading large files (GH8040, GH8073)
• Performance improvements in StataWriter when writing large files (GH8079)
• Performance and memory usage improvements in multi-key groupby (GH8128)
• Performance improvements in groupby .agg and .apply where builtins max/min were not mapped to numpy/cythonized versions (GH7722)
• Performance improvement in writing to sql (to_sql) of up to 50% (GH8208).
• Performance benchmarking of groupby for large value of ngroups (GH6787)
• Performance improvement in CustomBusinessDay,CustomBusinessMonth (GH8236)
• Performance improvement for MultiIndex.values for multi-level indexes containing datetimes (GH8543)

1.22.5 Bug Fixes

• Bug in pivot_table, when using margins and a dict aggfunc (GH8349)
• Bug in read_csv where squeeze=True would return a view (GH8217)
• Bug in checking of table name in read_sql in certain cases (GH7826).
• Bug in DataFrame.groupby where Grouper does not recognize level when frequency is specified (GH7885)
• Bug in multiindexes dtypes getting mixed up when DataFrame is saved to SQL table (GH8021)
• Bug in Series 0-division with a float and integer operand dtypes (GH7785)
• Bug in Series.astype("unicode") not calling unicode on the values correctly (GH7758)
• Bug in DataFrame.as_matrix() with mixed datetime64[ns] and timedelta64[ns] dtypes (GH7778)
• Bug in **HDFStore.select_column()** not preserving UTC timezone info when selecting a **DatetimeIndex** (GH7777)

• Bug in **to_datetime** when format='%Y%m%d' and coerce=True are specified, where previously an object array was returned (rather than a coerced time-series with NaT), (GH7930)

• Bug in **DatetimeIndex** and **PeriodIndex** in-place addition and subtraction cause different result from normal one (GH6527)

• Bug in adding and subtracting **PeriodIndex with PeriodIndex** raise **TypeError** (GH7741)

• Bug in **combine_first** with **PeriodIndex data raises TypeError** (GH3367)

• Bug in multi-index slicing with missing indexers (GH7866)

• Bug in multi-index slicing with various edge cases (GH8132)

• Regression in multi-index indexing with a non-scalar type object (GH7914)

• Bug in **Timestamp comparisons with == and int64 dtype** (GH8058)

• Bug in pickles contains **DateOffset may raise AttributeError when normalize attribute is referred internally** (GH7748)

• Bug in **Panel when using major_xs and copy=False is passed** (deprecation warning fails because of missing warnings) (GH8152).

• Bug in picking deserialization that failed for pre-0.14.1 containers with dup items trying to avoid ambiguity when matching block and manager items, when there’s only one block there’s no ambiguity (GH7794)

• Bug in putting a **PeriodIndex into a Series would convert to int64 dtype, rather than object of Periods** (GH7932)

• Bug in **HDFStore iteration when passing a where** (GH8014)

• Bug in **DataFrameGroupby.transform when transforming with a passed non-sorted key** (GH8046, GH8430)

• Bug in repeated timeseries line and area plot may result in **ValueError or incorrect kind** (GH7733)

• Bug in inference in a **MultiIndex with datetime.date inputs** (GH7888)

• Bug in **get where an IndexError would not cause the default value to be returned** (GH7725)

• Bug in offsets.apply, rollforward and rollback may reset nanosecond (GH7697)

• Bug in offsets.apply, rollforward and rollback may raise **AttributeError if Timestamp has dateutil tzinfo** (GH7697)

• Bug in sorting a multi-index frame with a **Float64Index** (GH8017)

• Bug in **inconsistent panel setitem with a rhs of a DataFrame for alignment** (GH7763)

• Bug in **is_superperiod and is_subperiod cannot handle higher frequencies than S** (GH7760, GH7772, GH7803)

• Bug in **32-bit platforms with Series.shift** (GH8129)

• Bug in **PeriodIndex.unique returns int64 np.ndarray** (GH7540)

• Bug in groupby.apply with a non-affecting mutation in the function (GH8467)

• Bug in **DataFrame.reset_index which has MultiIndex contains PeriodIndex or DateTimeIndex with tz raises ValueError** (GH7746, GH7793)

• Bug in **DataFrame.plot with subplots=True may draw unnecessary minor xticks and yticks** (GH7801)
- Bug in `StataReader` which did not read variable labels in 117 files due to difference between Stata documentation and implementation (GH7816)
- Bug in `StataReader` where strings were always converted to 244 characters-fixed width irrespective of underlying string size (GH7858)
- Bug in `DataFrame.plot` and `Series.plot` may ignore `rot` and `fontsize` keywords (GH7844)
- Bug in `DatetimeIndex.value_counts` doesn’t preserve tz (GH7735)
- Bug in `PeriodIndex.value_counts` results in `Int64Index` (GH7735)
- Bug in `DataFrame.join` when doing left join on index and there are multiple matches (GH5391)
- Bug in `GroupBy.transform()` where int groups with a transform that didn’t preserve the index were incorrectly truncated (GH7972)
- Bug in `groupby` where callable objects without name attributes would take the wrong path, and produce a `DataFrame` instead of a `Series` (GH7929)
- Bug in `groupby` error message when a DataFrame grouping column is duplicated (GH7511)
- Bug in `read_html` where the `infer_types` argument forced coercion of date-likes incorrectly (GH7762, GH7032)
- Bug in `Series.str.cat` with an index which was filtered as to not include the first item (GH7857)
- Bug in `Timestamp` cannot parse nanosecond from string (GH7878)
- Bug in `Timestamp` with string offset and tz results incorrect (GH7833)
- Bug in `tslib.tz_convert` and `tslib.tz_convert_single` may return different results (GH7798)
- Bug in `DatetimeIndex.intersection` of non-overlapping timestamps with tz raises IndexError (GH7880)
- Bug in `alignment` with TimeOps and non-unique indexes (GH8363)
- Bug in `GroupBy.filter()` where fast path vs. slow path made the filter return a non scalar value that appeared valid but wasn’t (GH7870)
- Bug in `date_range()`/`DatetimeIndex()` when the timezone was inferred from input dates yet incorrect times were returned when crossing DST boundaries (GH7835, GH7901)
- Bug in `to_excel()` where a negative sign was being prepended to positive infinity and was absent for negative infinity (GH7949)
- Bug in `area` plot draws legend with incorrect `alpha` when `stacked=True` (GH8027)
- `Period` and `PeriodIndex` addition/subtraction with `np.timedelta64` results in incorrect internal representations (GH7740)
- Bug in `Holiday` with no offset or observance (GH7987)
- Bug in `DataFrame.to_latex` formatting when columns or index is a `MultiIndex` (GH7982)
- Bug in `DateOffset` around Daylight Savings Time produces unexpected results (GH5175)
- Bug in `DataFrame.shift` where empty columns would throw `ZeroDivisionError` on numpy 1.7 (GH8019)
- Bug in installation where `html_encoding/*_.html` wasn’t installed and therefore some tests were not running correctly (GH7927)
- Bug in `read_html` where `bytes` objects were not tested for `in _read` (GH7927)
- Bug in `DataFrame.stack()` when one of the column levels was a datelike (GH8039)
• Bug in broadcasting numpy scalars with DataFrame (GH8116)
• Bug in pivot_table performed with nameless index and columns raises KeyError (GH8103)
• Bug in DataFrame.plot(kind='scatter') draws points and errorbars with different colors when the color is specified by c keyword (GH8081)
• Bug in Float64Index where iat and at were not testing and were failing (GH8092).
• Bug in DataFrame.boxplot() where y-limits were not set correctly when producing multiple axes (GH7528, GH5517).
• Bug in read_csv where line comments were not handled correctly given a custom line terminator or delim_whitespace=True (GH8122).
• Bug in read_html where empty tables caused a StopIteration (GH7575)
• Bug in casting when setting a column in a same-dtype block (GH7704)
• Bug in accessing groups from a GroupBy when the original grouper was a tuple (GH8121).
• Bug in .at that would accept integer indexers on a non-integer index and do fallback (GH7814)
• Bug with kde plot and NaNs (GH8182)
• Bug in GroupBy.count with float32 data type were nan values were not excluded (GH8169).
• Bug with stacked barplots and NaNs (GH8175).
• Bug in resample with non evenly divisible offsets (e.g. ‘7s’) (GH8371)
• Bug in interpolation methods with the limit keyword when no values needed interpolating (GH7173).
• Bug where col_space was ignored in DataFrame.to_string() when header=False (GH8230).
• Bug with DatetimeIndex.asof incorrectly matching partial strings and returning the wrong date (GH8245).
• Bug in plotting methods modifying the global matplotlib rcParams (GH8242).
• Bug in DataFrame.__setitem__ that caused errors when setting a dataframe column to a sparse array (GH8131)
• Bug where DataFrame.boxplot() failed when entire column was empty (GH8181).
• Bug with messed variables in radviz visualization (GH8199).
• Bug in interpolation methods with the limit keyword when no values needed interpolating (GH7173).
• Bug where col_space was ignored in DataFrame.to_string() when header=False (GH8230).
• Bug in to_clipboard that would clip long column data (GH8305)
• Bug in DataFrame terminal display: Setting max_column/max_rows to zero did not trigger auto-resizing of dfs to fit terminal width/height (GH7180).
• Bug in OLS where running with “cluster” and “nw_lags” parameters did not work correctly, but also did not throw an error (GH5884).
• Bug in DataFrame.dropna that interpreted non-existent columns in the subset argument as the ‘last column’ (GH8303)
• Bug in Index.intersection on non-monotonic non-unique indexes (GH8362).
• Bug in masked series assignment where mismatching types would break alignment (GH8387)
• Bug in NDFrame.equals gives false negatives with dtype=object (GH8437)
• Bug in assignment with indexer where type diversity would break alignment (GH8258)
pandas: powerful Python data analysis toolkit, Release 0.23.2

- Bug in `NDFrame.loc` indexing when row/column names were lost when target was a list/ndarray (GH6552)
- Regression in `NDFrame.loc` indexing when rows/columns were converted to Float64Index if target was an empty list/ndarray (GH7774)
- Bug in `Series` that allows it to be indexed by a `DataFrame` which has unexpected results. Such indexing is no longer permitted (GH8444)
- Bug in item assignment of a `DataFrame` with multi-index columns where right-hand-side columns were not aligned (GH7655)
- Suppress FutureWarning generated by NumPy when comparing object arrays containing NaN for equality (GH7065)
- Bug in `DataFrame.eval()` where the dtype of the `not` operator (~) was not correctly inferred as `bool`.

1.23 v0.14.1 (July 11, 2014)

This is a minor release from 0.14.0 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

- Highlights include:
  - New methods `select_dtypes()` to select columns based on the dtype and `sem()` to calculate the standard error of the mean.
  - Support for dateutil timezones (see docs).
  - Support for ignoring full line comments in the `read_csv()` text parser.
  - New documentation section on `Options and Settings`.
  - Lots of bug fixes.

- Enhancements
- API Changes
- Performance Improvements
- Experimental Changes
- Bug Fixes

1.23.1 API changes

- Openpyxl now raises a ValueError on construction of the openpyxl writer instead of warning on pandas import (GH7284).
- For `StringMethods.extract`, when no match is found, the result - only containing NaN values - now also has `dtype=object` instead of `float` (GH7242)
- `Period` objects no longer raise a `TypeError` when compared using `==` with another object that isn’t a `Period`. Instead when comparing a `Period` with another object using `==` if the other object isn’t a `Period` `False` is returned. (GH7376)
• Previously, the behaviour on resetting the time or not in offsets.apply, rollforward and rollback operations differed between offsets. With the support of the normalize keyword for all offsets (see below) with a default value of False (preserve time), the behaviour changed for certain offsets (BusinessMonthBegin, MonthEnd, BusinessMonthEnd, CustomBusinessMonthEnd, BusinessYearBegin, LastWeekOfMonth, FY5253Quarter, LastWeekOfMonth, Easter):

```python
from pandas.tseries import offsets

d = pd.Timestamp('2014-01-01 09:00')

# old behaviour < 0.14.1
In [8]: d + offsets.MonthEnd()
Out[8]: Timestamp('2014-01-31 00:00:00')

Starting from 0.14.1 all offsets preserve time by default. The old behaviour can be obtained with normalize=True

# new behaviour
In [1]: d + offsets.MonthEnd()
Out[1]: Timestamp('2014-01-31 09:00:00')

In [2]: d + offsets.MonthEnd(normalize=True)
Out[2]: Timestamp('2014-01-31 00:00:00')
```

Note that for the other offsets the default behaviour did not change.

• Add back #N/A N/A as a default NA value in text parsing, (regression from 0.12) (GH5521)

• Raise a TypeError on inplace-setting with a .where and a non np.nan value as this is inconsistent with a set-item expression like df[mask] = None (GH7656)

### 1.23.2 Enhancements

• Add dropna argument to `value_counts` and `nunique` (GH5569).

• Add `select_dtypes()` method to allow selection of columns based on dtype (GH7316). See the docs.

• All offsets supports the normalize keyword to specify whether offsets.apply, rollforward and rollback resets the time (hour, minute, etc) or not (default False, preserves time) (GH7156):

```python
import pandas.tseries.offsets as offsets

day = offsets.Day()

In [5]: day.apply(Timestamp('2014-01-01 09:00'))
Out[5]: Timestamp('2014-01-02 09:00:00')

In [6]: day = offsets.Day(normalize=True)

In [7]: day.apply(Timestamp('2014-01-01 09:00'))
Out[7]: Timestamp('2014-01-02 00:00:00')
```

• PeriodIndex is represented as the same format as DatetimeIndex (GH7601)

• StringMethods now work on empty Series (GH7242)

• The file parsers `read_csv` and `read_table` now ignore line comments provided by the parameter `comment`, which accepts only a single character for the C reader. In particular, they allow for comments before file data begins (GH2685)
• Add **NotImplementedError** for simultaneous use of **chunksize** and **nrows** for read_csv() (GH6774).

• Tests for basic reading of public S3 buckets now exist (GH7281).

• read_html now sports an **encoding** argument that is passed to the underlying parser library. You can use this to read non-ascii encoded web pages (GH7323).

• read_excel now supports reading from URLs in the same way that read_csv does. (GH6809)

• Support for dateutil timezones, which can now be used in the same way as pytz timezones across pandas. (GH4688)

```python
In [8]: rng = date_range('3/6/2012 00:00', periods=10, freq='D',
                      tz='dateutil/Europe/London')

In [9]: rng.tz
Out[9]: tzfile('/usr/share/zoneinfo/Europe/London')
```

See the docs.

• Implemented **sem** (standard error of the mean) operation for Series, DataFrame, Panel, and Groupby (GH6897)

• Add **nlargest** and **nsmallest** to the Series groupby whitelist, which means you can now use these methods on a SeriesGroupBy object (GH7053).

• All offsets apply, rollforward and rollback can now handle np.datetime64, previously results in ApplyTypeError (GH7452)

• **Period** and **PeriodIndex** can contain NaT in its values (GH7485)

• Support pickling Series, DataFrame and Panel objects with non-unique labels along **item** axis (index, columns and items respectively) (GH7370).

• Improved inference of datetime/timedelta with mixed null objects. Regression from 0.13.1 in interpretation of an object Index with all null elements (GH7431)

### 1.23.3 Performance

• Improvements in dtype inference for numeric operations involving yielding performance gains for dtypes: int64, timedelta64, datetime64 (GH7223)

• Improvements in Series.transform for significant performance gains (GH6496)

• Improvements in DataFrame.transform with ufuncs and built-in grouper functions for significant performance gains (GH7383)

• Regression in groupby aggregation of datetime64 dtypes (GH7555)

• Improvements in MultiIndex.from_product for large iterables (GH7627)

### 1.23.4 Experimental

• pandas.io.data.Options has a new method, get_all_data method, and now consistently returns a multi-indexed DataFrame (GH5602)

• io.gbq.read_gbq and io.gbq.to_gbq were refactored to remove the dependency on the Google bq.py command line client. This submodule now uses httplib2 and the Google apiclient and oauth2client API client libraries which should be more stable and, therefore, reliable than bq.py. See the docs. (GH6937).
1.23.5 Bug Fixes

- Bug in DataFrame.where with a symmetric shaped frame and a passed other of a DataFrame (GH7506)
- Bug in Panel indexing with a multi-index axis (GH7516)
- Regression in datetime-like slice indexing with a duplicated index and non-exact end-points (GH7523)
- Bug in setitem with list-of-lists and single vs mixed types (GH7551)
- Bug in timeops with non-aligned Series (GH7500)
- Bug in timedelta inference when assigning an incomplete Series (GH7592)
- Bug in groupby .nth with a Series and integer-like column name (GH7559)
- Bug in Series.get with a boolean accessor (GH7407)
- Bug in value_counts where NaT did not qualify as missing (NaN) (GH7423)
- Bug in to_timedelta that accepted invalid units and misinterpreted ‘m/h’ (GH7611, GH6423)
- Bug in line plot doesn’t set correct xlim if secondary_y=True (GH7459)
- Bug in grouped hist and scatter plots use old figsize default (GH7394)
- Bug in plotting subplots with DataFrame.plot, hist clears passed ax even if the number of subplots is one (GH7391)
- Bug in plotting subplots with DataFrame.boxplot with by kw raises ValueError if the number of subplots exceeds 1 (GH7391)
- Bug in subplots displays ticklabels and labels in different rule (GH5897)
- Bug in Panel.apply with a multi-index as an axis (GH7469)
- Bug in DatetimeIndex.insert doesn’t preserve name and tz (GH7299)
- Bug in DatetimeIndex.asobject doesn’t preserve name (GH7299)
- Bug in multi-index slicing with datetime-like ranges (strings and Timestamps), (GH7429)
- Bug in Index.min and max doesn’t handle nan and NaT properly (GH7261)
- Bug in PeriodIndex.min/max results in int (GH7609)
- Bug in resample where fill_method was ignored if you passed how (GH2073)
- Bug in TimeGrouper doesn’t exclude column specified by key (GH7227)
- Bug in DataFrame and Series bar and barh plot raises TypeError when bottom and left keyword is specified (GH7226)
- Bug in DataFrame.hist raises TypeError when it contains non numeric column (GH7277)
- Bug in Index.delete does not preserve name and freq attributes (GH7302)
- Bug in DataFrame.query() / eval where local string variables with the @ sign were being treated as temporaries attempting to be deleted (GH7300).
- Bug in Float64Index which didn’t allow duplicates (GH7149).
- Bug in DataFrame.replace() where truthy values were being replaced (GH7140).
- Bug in StringMethods.extract() where a single match group Series would use the matcher’s name instead of the group name (GH7313).
- Bug in isnull() when mode.use_inf_as_null == True where isnull wouldn’t test True when it encountered an inf/-inf (GH7315).
- Bug in inferred_freq results in None for eastern hemisphere timezones (GH7310)
- Bug in Easter returns incorrect date when offset is negative (GH7195)
- Bug in broadcasting with .div, integer dtypes and divide-by-zero (GH7325)
- Bug in CustomBusinessDay.apply raises NameError when np.datetime64 object is passed (GH7196)
- Bug in MultiIndex.append, concat and pivot_table don’t preserve timezone (GH6606)
- Bug in .loc with a list of indexers on a single-multi index level (that is not nested) (GH7349)
- Bug in Series.map when mapping a dict with tuple keys of different lengths (GH7333)
- Bug all StringMethods now work on empty Series (GH7242)
- Fix delegation of read_sql to read_sql_query when query does not contain ‘select’ (GH7324).
- Bug where a string column name assignment to a DataFrame with a Float64Index raised a TypeError during a call to np.isnan (GH7366).
- Bug where NDFrame.replace() didn’t correctly replace objects with Period values (GH7379).
- Bug in .ix getitem should always return a Series (GH7150)
- Bug in multi-index slicing with incomplete indexers (GH7399)
- Bug in multi-index slicing with a step in a sliced level (GH7400)
- Bug where negative indexers in DatetimeIndex were not correctly sliced (GH7408)
- Bug where NaT wasn’t repr’d correctly in a MultiIndex (GH7406, GH7409).  
- Bug where bool objects were converted to nan in convert_objects (GH7416).
- Bug in quantile ignoring the axis keyword argument (GH7306)
- Bug where nanops._maybe_null_out doesn’t work with complex numbers (GH7353)
- Bug in several nanops functions when axis==0 for 1-dimensional nan arrays (GH7354)
- Bug where nanops.nanmedian doesn’t work when axis==None (GH7352)
- Bug where nanops._has_infs doesn’t work with many dtypes (GH7357)
- Bug in StataReader.data where reading a 0-observation dta failed (GH7369)
- Bug in StataReader when reading Stata 13 (117) files containing fixed width strings (GH7360)
- Bug in StataWriter where encoding was ignored (GH7286)
- Bug in DatetimeIndex comparison doesn’t handle NaT properly (GH7529)
- Bug in passing input with tzinfo to some offsets apply, rollforward or rollback resets tzinfo or raises ValueError (GH7465)
- Bug in DatetimeIndex.to_period, PeriodIndex.asobject, PeriodIndex.to_timestamp doesn’t preserve name (GH7485)
- Bug in DatetimeIndex.to_period and PeriodIndex.to_timestamp handle NaT incorrectly (GH7228)
- Bug in offsets.apply, rollforward and rollback may return normal datetime (GH7502)
- Bug in resample raises ValueError when target contains NaT (GH7227)
- Bug in Timestamp.tz_localize resets nanosecond info (GH7534)
- Bug in DatetimeIndex.asobject raises ValueError when it contains NaT (GH7539)
• Bug in Timestamp.__new__ doesn’t preserve nanosecond properly (GH7610)
• Bug in Index.astype(float) where it would return an object dtype Index (GH7464).
• Bug in DataFrame.reset_index loses tz (GH3950)
• Bug in DatetimeIndex.freqstr raises AttributeError when freq is None (GH7606)
• Bug in GroupBy.size created by TimeGrouper raises AttributeError (GH7453)
• Bug in single column bar plot is misaligned (GH7498).
• Bug in area plot with tz-aware time series raises ValueError (GH7471)
• Bug in non-monotonic Index.union may preserve name incorrectly (GH7458)
• Bug in DatetimeIndex.intersection doesn’t preserve timezone (GH4690)
• Bug in rolling_var where a window larger than the array would raise an error (GH7297)
• Bug with last plotted timeseries dictating xlim (GH2960)
• Bug with secondary_y axis not being considered for timeseries xlim (GH3490)
• Bug in Float64Index assignment with a non scalar indexer (GH7586)
• Bug in pandas.core.strings.str_contains does not properly match in a case insensitive fashion when regex=False and case=False (GH7505)
• Bug in expanding_cov, expanding_corr, rolling_cov, and rolling_corr for two arguments with mismatched index (GH7512)
• Bug in to_sql taking the boolean column as text column (GH7678)
• Bug in grouped hist doesn’t handle rot kw and sharex kw properly (GH7234)
• Bug in .loc performing fallback integer indexing with object dtype indices (GH7496)
• Bug (regression) in PeriodIndex constructor when passed Series objects (GH7701).

1.24 v0.14.0 (May 31, 2014)

This is a major release from 0.13.1 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

• Highlights include:
  – Officially support Python 3.4
  – SQL interfaces updated to use sqlalchemy, See Here.
  – Display interface changes, See Here
  – MultiIndexing Using Slicers, See Here.
  – Ability to join a singly-indexed DataFrame with a multi-indexed DataFrame, see Here
  – More consistency in groupby results and more flexible groupby specifications, See Here
  – Holiday calendars are now supported in CustomBusinessDay, see Here
  – Several improvements in plotting functions, including: hexbin, area and pie plots, see Here.
  – Performance doc section on I/O operations, See Here

• Other Enhancements


• API Changes
  • Text Parsing API Changes
  • Groupby API Changes
  • Performance Improvements
  • Prior Deprecations
  • Deprecations
  • Known Issues
  • Bug Fixes

**Warning:** In 0.14.0 all NDFrame based containers have undergone significant internal refactoring. Before that each block of homogeneous data had its own labels and extra care was necessary to keep those in sync with the parent container’s labels. This should not have any visible user/API behavior changes (GH6745)

### 1.24.1 API changes

• `read_excel` uses 0 as the default sheet (GH6573)

• `iloc` will now accept out-of-bounds indexers for slices, e.g. a value that exceeds the length of the object being indexed. These will be excluded. This will make pandas conform more with python/numpy indexing of out-of-bounds values. A single indexer that is out-of-bounds and drops the dimensions of the object will still raise `IndexError` (GH6296, GH6299). This could result in an empty axis (e.g. an empty DataFrame being returned)

```
In [1]: df1 = DataFrame(np.random.randn(5,2),columns=list('AB'))

In [2]: df1
Out[2]:
     A    B
0  1.58  -0.438
1 -0.403  -0.781
2 -0.142   0.542
3  0.371  -0.252
4  0.79  1.667

In [3]: df1.iloc[:,2:3]

Empty DataFrame
Columns: []
Index: [0, 1, 2, 3, 4]

In [4]: df1.iloc[:,1:3]

     B
0  -0.438
1  -0.781
2   0.542
3  -0.252
4   1.667
```

(continues on next page)
In [5]: df1.iloc[4:6]

\[
\begin{array}{cc}
\text{A} & \text{B} \\
4 & 0.787484 & 1.666563 \\
\end{array}
\]

These are out-of-bounds selections

\[
\begin{array}{l}
dfl.iloc[[4,5,6]]
\text{IndexError: positional indexers are out-of-bounds}

dfl.iloc[:,4]
\text{IndexError: single positional indexer is out-of-bounds}
\end{array}
\]

- Slicing with negative start, stop & step values handles corner cases better (GH6531):
  - `df.iloc[:-len(df)]` is now empty
  - `df.iloc[len(df)::1]` now enumerates all elements in reverse

- The `DataFrame.interpolate()` keyword downcast default has been changed from `infer` to `None`. This is to preserve the original dtype unless explicitly requested otherwise (GH6290).

- When converting a dataframe to HTML it used to return `Empty DataFrame`. This special case has been removed, instead a header with the column names is returned (GH6062).

- `Series` and `Index` now internally share more common operations, e.g. `factorize()`, `nunique()`, `value_counts()` are now supported on `Index` types as well. The `Series.weekday` property from is removed from `Series` for API consistency. Using a `DatetimeIndex/PeriodIndex` method on a `Series` will now raise a `TypeError`. (GH4551, GH4056, GH5519, GH6380, GH7206).

- Add `is_month_start`, `is_month_end`, `is_quarter_start`, `is_quarter_end`, `is_year_start`, `is_year_end` accessors for `DateTimeIndex / Timestamp` which return a boolean array of whether the timestamp(s) are at the start/end of the month/quarter/year defined by the frequency of the `DateTimeIndex / Timestamp` (GH4565, GH6998)

- Local variable usage has changed in `pandas.eval()/DataFrame.eval()/DataFrame.query()` (GH5987). For the `DataFrame` methods, two things have changed
  - Column names are now given precedence over locals
  - Local variables must be referred to explicitly. This means that even if you have a local variable that is `not` a column you must still refer to it with the `@` prefix.
  - You can have an expression like `df.query('a < a')` with no complaints from `pandas` about ambiguity of the name `a`.
  - The top-level `pandas.eval()` function does not allow you use the `@` prefix and provides you with an error message telling you so.
  - `NameResolutionError` was removed because it isn’t necessary anymore.

- Define and document the order of column vs index names in `query/eval` (GH6676)

- `concat` will now concatenate mixed `Series` and `DataFrames` using the `Series` name or numbering columns as needed (GH2385). See the docs

- Slicing and advanced/boolean indexing operations on `Index` classes as well as `Index.delete()` and `Index.drop()` methods will no longer change the type of the resulting index (GH6440, GH7040)
Previously, the above operation would return `Int64Index`. If you’d like to do this manually, use `Index.astype()`

```
In [9]: i[[0,1,2]].astype(np.int_)
Out [9]: Int64Index([1, 2, 3], dtype='int64')
```

• `set_index` no longer converts MultiIndexes to an Index of tuples. For example, the old behavior returned an Index in this case (GH6459):

```
# Old behavior, casted MultiIndex to an Index
In [10]: tuple_ind
Out [10]: Index([('a', 'c'), ('a', 'd'), ('b', 'c'), ('b', 'd')], dtype='object')

In [11]: df_multi.set_index(tuple_ind)
Out [11]:
       0 1
(a, c) 0.471435 -1.190976
(a, d) 1.432707 -0.312652
(b, c) -0.720589  0.887163
(b, d)  0.859588  0.636524
```

# New behavior
```
In [12]: mi

MultiIndex(levels=[['a', 'b'], ['c', 'd']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]])

In [13]: df_multi.set_index(mi)
```

```
       0 1
a c  0.471435 -1.190976
d  1.432707 -0.312652
(b, c) -0.720589  0.887163
(b, d)  0.859588  0.636524
```

This also applies when passing multiple indices to `set_index`:

```
# Old output, 2-level MultiIndex of tuples
In [14]: df_multi.set_index([df_multi.index, df_multi.index])
Out [14]:
       0 1
(a, c) (a, c) 0.471435 -1.190976
(a, d) (a, d) 1.432707 -0.312652
(b, c) (b, c) -0.720589  0.887163
(b, d) (b, d)  0.859588  0.636524
```
# New output, 4-level MultiIndex
```
In [15]: df_multi.set_index([df_multi.index, df_multi.index])
Out[15]:
   0    1
a c a c  0.471435 -1.190976
   a d a d  1.432707  0.312652
b c b c -0.720589  0.887163
d b d b   0.859588 -0.636524
```

- **pairwise** keyword was added to the statistical moment functions `rolling_cov`, `rolling_corr`, `ewmcov`, `ewmcorr`, `expanding_cov`, `expanding_corr` to allow the calculation of moving window covariance and correlation matrices (GH4950). See *Computing rolling pairwise covariances and correlations* in the docs.

```
In [1]: df = DataFrame(np.random.randn(10,4),columns=list('ABCD'))
In [4]: covs = pd.rolling_cov(df[['A','B','C']], df[['B','C','D']], 5, pairwise=True)
In [5]: covs[df.index[-1]]
```

```
   B    C    D
A  0.035310  0.326593 -0.505430
B  0.137748 -0.006888 -0.005383
C -0.006888  0.861040  0.020762
```

- `Series.iteritems()` is now lazy (returns an iterator rather than a list). This was the documented behavior prior to 0.14. (GH6760)
- Added **nunique** and **value_counts** functions to `Index` for counting unique elements. (GH6734)
- `stack` and `unstack` now raise a `ValueError` when the `level` keyword refers to a non-unique item in the `Index` (previously raised a `KeyError`). (GH6738)
- `drop` unused order argument from `Series.sort`; args now are in the same order as `Series.order`; add `na_position` arg to conform to `Series.order` (GH6847)
- default sorting algorithm for `Series.order` is now `quicksort`, to conform with `Series.sort` (and `numpy` defaults)
- add `inplace` keyword to `Series.order/sort` to make them inverses (GH6859)
- `DataFrame.sort` now places NaNs at the beginning or end of the sort according to the `na_position` parameter. (GH3917)
- accept `TextFileReader` in `concat`, which was affecting a common user idiom (GH6583), this was a regression from 0.13.1
- Added `factorize` functions to `Index` and `Series` to get indexer and unique values (GH7090)
- `describe` on a `DataFrame` with a mix of `Timestamp` and string like objects returns a different `Index` (GH7088). Previously the index was unintentionally sorted.
- Arithmetic operations with only `bool` dtypes now give a warning indicating that they are evaluated in Python space for `+`, `-`, and `*` operations and raise for all others (GH7011, GH6762, GH7015, GH7210)

```
x = pd.Series(np.random.rand(10) > 0.5)
y = True
x + y  # warning generated: should do x | y instead
```

1.24. v0.14.0 (May 31, 2014) 331
x / y  # this raises because it doesn't make sense

NotImplementedError: operator '/' not implemented for bool dtypes

- In HDFStore, select_as_multiple will always raise a KeyError, when a key or the selector is not found (GH6177)
- df['col'] = value and df.loc[:, 'col'] = value are now completely equivalent; previously the .loc would not necessarily coerce the dtype of the resultant series (GH6149)
- dtypes and ftypes now return a series with dtype=object on empty containers (GH5740)
- df.to_csv will now return a string of the CSV data if neither a target path nor a buffer is provided (GH6061)
- pd.infer_freq() will now raise a TypeError if given an invalid Series/Index type (GH6407, GH6463)
- A tuple passed to DataFrame.sort_index will be interpreted as the levels of the index, rather than requiring a list of tuple (GH4370)
- all offset operations now return Timestamp types (rather than datetime), Business/Week frequencies were incorrect (GH4069)
- to_excel now converts np.inf into a string representation, customizable by the inf_rep keyword argument (Excel has no native inf representation) (GH6782)
- Replace pandas.compat.scipy.scoreatpercentile with numpy.percentile (GH6810)
- .quantile on a datetime[ns] series now returns Timestamp instead of np.datetime64 objects (GH6810)
- change AssertionError to TypeError for invalid types passed to concat (GH6583)
- Raise a TypeError when DataFrame is passed an iterator as the data argument (GH5357)

1.24.2 Display Changes

- The default way of printing large DataFrames has changed. DataFrames exceeding max_rows and/or max_columns are now displayed in a centrally truncated view, consistent with the printing of a pandas.Series (GH5603).

In previous versions, a DataFrame was truncated once the dimension constraints were reached and an ellipse (...) signaled that part of the data was cut off.
In [1]: import pandas as pd
In [2]: import numpy as np
In [3]: pd.options.display.max_rows = 6
In [4]: pd.options.display.max_columns = 6
In [5]: index = pd.DatetimeIndex(start='2001-01-01',freq='D',periods=10)
In [6]: pd.DataFrame(np.arange(10*10).reshape((10,10)),index=index)
Out[6]:
   0   1   2   3   4   5
2001-01-01  0   1   2   3   4   5 ...
2001-01-02 10  11  12  13  14  15 ...
2001-01-03 20  21  22  23  24  25 ...
2001-01-04 30  31  32  33  34  35 ...
2001-01-05 40  41  42  43  44  45 ...
2001-01-06 50  51  52  53  54  55 ...
          ... ... ... ... ... ...
[10 rows x 10 columns]

In the current version, large DataFrames are centrally truncated, showing a preview of head and tail in both dimensions.

In [24]: pd.DataFrame(np.arange(10*10).reshape((10,10)),index=index)
Out[24]:
   0   1   2   3   4   5
2001-01-01  0   1   2   3   4   5 ...
2001-01-02 10  11  12   7   8   9 ...
2001-01-03 20  21  22  23  24  25 ...
2001-01-04 30  31  32  33  34  35 ...
2001-01-05 40  41  42  43  44  45 ...
2001-01-06 50  51  52  53  54  55 ...
          ... ... ... ... ... ...
2001-01-08 70  71  72  73  74  75 ...
2001-01-09 80  81  82  83  84  85 ...
2001-01-10 90  91  92  93  94  95 ...
[10 rows x 10 columns]

• allow option 'truncate' for display.show_dimensions to only show the dimensions if the frame is truncated (GH6547).

The default for display.show_dimensions will now be truncate. This is consistent with how Series display length.

In [16]: dfd = pd.DataFrame(np.arange(25).reshape(-1,5), index=[0,1,2,3,4], columns=[0,1,2,3,4])
# show dimensions since this is truncated
In [17]: with pd.option_context('display.max_rows', 2, 'display.max_columns', 2,
                   'display.show_dimensions', 'truncate'):
                   print(dfd)
                   ....:
                   ....:
(continues on next page)
Regression in the display of a MultiIndexed Series with display.max_rows is less than the length of the series (GH7101)

Fixed a bug in the HTML repr of a truncated Series or DataFrame not showing the class name with the large_repr set to ‘info’ (GH7105)

The verbose keyword in DataFrame.info(), which controls whether to shorten the info representation, is now None by default. This will follow the global setting in display.max_info_columns. The global setting can be overridden with verbose=True or verbose=False.

Fixed a bug with the info repr not honoring the display.max_info_columns setting (GH6939)

Offset/freq info now in Timestamp __repr__ (GH4553)

### 1.24.3 Text Parsing API Changes

read_csv() / read_table() will now be noiser w.r.t invalid options rather than falling back to the PythonParser.

- Raise ValueError when sep specified with delim_whitespace=True in read_csv() / read_table() (GH6607)
- Raise ValueError when engine='c' specified with unsupported options in read_csv() / read_table() (GH6607)
- Raise ValueError when fallback to python parser causes options to be ignored (GH6607)
- Produce ParserWarning on fallback to python parser when no options are ignored (GH6607)
- Translate sep=’\s+’ to delim_whitespace=True in read_csv() / read_table() if no other C-unsupported options specified (GH6607)

### 1.24.4 Groupby API Changes

More consistent behaviour for some groupby methods:

- groupby head and tail now act more like filter rather than an aggregation:
In [19]: df = pd.DataFrame([[1, 2], [1, 4], [5, 6]], columns=['A', 'B'])
In [20]: g = df.groupby('A')
In [21]: g.head(1)  # filters DataFrame
Out[21]:
   A  B
0  1  2
2  5  6

In [22]: g.apply(lambda x: x.head(1))  # used to simply fall-through
Out[22]:
   A  B
A  1  2
5  6

• groupby head and tail respect column selection:

In [23]: g[['B']].head(1)
Out[23]:
   B
0  2
2  6

• groupby nth now reduces by default; filtering can be achieved by passing `as_index=False`. With an optional `dropna` argument to ignore NaN. See the docs.

Reducing

In [24]: df = DataFrame([[1, np.nan], [1, 4], [5, 6]], columns=['A', 'B'])
In [25]: g = df.groupby('A')
In [26]: g.nth(0)
Out[26]:
   B
A
1  NaN
5  6.0

# this is equivalent to g.first()
In [27]: g.nth(0, dropna='any')
Out[27]:
   B
A
1  4.0
5  6.0

# this is equivalent to g.last()
In [28]: g.nth(-1, dropna='any')
Out[28]:
   B
A
1  4.0
5  6.0
Filtering

```python
In [29]: gf = df.groupby('A',as_index=False)
In [30]: gf.nth(0)
Out[30]:
   A  B
0  1  NaN
2  5  6.0
In [31]: gf.nth(0, dropna='any')
```

- `groupby` will now not return the grouped column for non-cython functions (GH5610, GH5614, GH6732), as its already the index

```python
In [32]: df = DataFrame([[1, np.nan], [1, 4], [5, 6], [5, 8]], columns=['A', 'B'])
In [33]: g = df.groupby('A')
In [34]: g.count()
Out[34]:
   A  B
0  1  1
1  5  2
In [35]: g.describe()
```

- passing `as_index` will leave the grouped column in-place (this is not change in 0.14.0)

```python
In [36]: df = DataFrame([[1, np.nan], [1, 4], [5, 6], [5, 8]], columns=['A', 'B'])
In [37]: g = df.groupby('A',as_index=False)
In [38]: g.count()
Out[38]:
   A  B
0  1  1
1  5  2
In [39]: g.describe()
```

(continues on next page)
• Allow specification of a more complex groupby via `pd.Grouper`, such as grouping by a Time and a string field simultaneously. See the docs. (GH3794)

• Better propagation/preservation of Series names when performing groupby operations:
  – `SeriesGroupBy.agg` will ensure that the name attribute of the original series is propagated to the result (GH6265).
  – If the function provided to `GroupBy.apply` returns a named series, the name of the series will be kept as the name of the column index of the DataFrame returned by `GroupBy.apply` (GH6124). This facilitates `DataFrame.stack` operations where the name of the column index is used as the name of the inserted column containing the pivoted data.

### 1.24.5 SQL

The SQL reading and writing functions now support more database flavors through SQLAlchemy (GH2717, GH4163, GH5950, GH6292). All databases supported by SQLAlchemy can be used, such as PostgreSQL, MySQL, Oracle, Microsoft SQL server (see documentation of SQLAlchemy on included dialects).

The functionality of providing DBAPI connection objects will only be supported for sqlite3 in the future. The 'mysql' flavor is deprecated.

The new functions `read_sql_query()` and `read_sql_table()` are introduced. The function `read_sql()` is kept as a convenience wrapper around the other two and will delegate to specific function depending on the provided input (database table name or sql query).

In practice, you have to provide a SQLAlchemy engine to the sql functions. To connect with SQLAlchemy you use the `create_engine()` function to create an engine object from database URI. You only need to create the engine once per database you are connecting to. For an in-memory sqlite database:

```python
In [40]: from sqlalchemy import create_engine
# Create your connection.
In [41]: engine = create_engine('sqlite:///:memory:)
```

This engine can then be used to write or read data to/from this database:

```python
In [42]: df = pd.DataFrame({'A': [1,2,3], 'B': ['a', 'b', 'c']})
In [43]: df.to_sql('db_table', engine, index=False)
```

You can read data from a database by specifying the table name:

```python
In [44]: pd.read_sql_table('db_table', engine)
Out[44]:
   A  B
0  a  1
1  b  2
2  c  3
```

or by specifying a sql query:
Some other enhancements to the sql functions include:

- support for writing the index. This can be controlled with the index keyword (default is True).
- specify the column label to use when writing the index with index_label.
- specify string columns to parse as datetimes with the parse_dates keyword in read_sql_query() and read_sql_table().

**Warning:** Some of the existing functions or function aliases have been deprecated and will be removed in future versions. This includes: tquery, uquery, read_frame, frame_query, write_frame.

**Warning:** The support for the 'mysql' flavor when using DBAPI connection objects has been deprecated. MySQL will be further supported with SQLAlchemy engines (GH6900).

### 1.24.6 MultiIndexing Using Slicers

In 0.14.0 we added a new way to slice multi-indexed objects. You can slice a multi-index by providing multiple indexers.

You can provide any of the selectors as if you are indexing by label, see Selection by Label, including slices, lists of labels, labels, and boolean indexers.

You can use slice(None) to select all the contents of that level. You do not need to specify all the deeper levels, they will be implied as slice(None).

As usual, both sides of the slicers are included as this is label indexing.

See the docs See also issues (GH6134, GH4036, GH3057, GH2598, GH5641, GH7106)

**Warning:** You should specify all axes in the .loc specifier, meaning the indexer for the index and for the columns. Their are some ambiguous cases where the passed indexer could be mis-interpreted as indexing both axes, rather than into say the MultiIndex for the rows.

You should do this:

```
df.loc[{'slice('A1','A3'),.....},:]  
```

rather than this:

```
df.loc[{'slice('A1','A3'),.....}]  
```

**Warning:** You will need to make sure that the selection axes are fully lexsorted!
In [46]: def mklbl(prefix, n):
    .....:      return ["%s%s" % (prefix, i) for i in range(n)]
    .....:

In [47]: index = MultiIndex.from_product([mklbl('A', 4),
    .....:           mklbl('B', 2),
    .....:           mklbl('C', 4),
    .....:           mklbl('D', 2)])
    .....:

In [48]: columns = MultiIndex.from_tuples([('a', 'foo'), ('a', 'bar'),
    .....:           ('b', 'foo'), ('b', 'bah')],
           names=['lvl0', 'lvl1'])
           .....:

In [49]: df = DataFrame(np.arange(len(index) * len(columns)).reshape((len(index),
    .....:           len(columns))),
           index=index,
           columns=columns).sort_index().sort_index(axis=1)
           .....:

In [50]: df

Out[50]:
lvl0  a  b
lvl1  bar  foo  bah  foo
A0  B0  C0  D0  1  0  3  2
D1  5  4  7  6
C1  D0  9  8  11  10
D1  13  12  15  14
C2  D0  17  16  19  18
D1  21  20  23  22
C3  D0  25  24  27  26
...  ...  ...  ...  ...
A3  B1  C0  D1  229  228  231  230
C1  D0  233  232  235  234
D1  237  236  239  238
C2  D0  241  240  243  242
D1  245  244  247  246
C3  D0  249  248  251  250
D1  253  252  255  254
[64 rows x 4 columns]

Basic multi-index slicing using slices, lists, and labels.

In [51]: df.loc[(slice('A1', 'A3'), slice(None), ['C1', 'C3']), :]

Out[51]:
lvl0  a  b
lvl1  bar  foo  bah  foo
A1  B0  C1  D0  73  72  75  74
D1  77  76  79  78
C3  D0  89  88  91  90
D1  93  92  95  94
B1  C0  D1  105  104  107  106
D1  109  108  111  110
C3  D0  121  120  123  122
...  ...  ...  ...
(continues on next page)
You can use a `pd.IndexSlice` to shortcut the creation of these slices

```
In [52]: idx = pd.IndexSlice

In [53]: df.loc[idx,:,:,['C1','C3'],idx[:,'foo']]
Out [53]:
   lvl0  lvl1
  a   b   foo   foo
A0  B0  C0  D0    8   10
    D1  12  14
  C3  D0  24  26
    D1  28  30
B1  C0  D0  40  42
    D1  44  46
  C3  D0  56  58
...  ...  ...  ...  ...
A3  B0  C0  D1  204  206
    C3  D0  216  218
    D1  220  222
B1  C0  D0  232  234
    D1  236  238
  C3  D0  248  250
    D1  252  254
```

[32 rows x 2 columns]

It is possible to perform quite complicated selections using this method on multiple axes at the same time.

```
In [54]: df.loc[['A1',slice(None),'foo']]
Out [54]:
   lvl0  lvl1
  a   b   foo   foo
A0  B0  C0  D0    64   66
    D1  68  70
  C1  D0  72  74
    D1  76  78
C2  D0  80  82
    D1  84  86
  C3  D0  88  90
...  ...  ...  ...  ...
B1  C0  D1  100  102
  C1  D0  104  106
    D1  108  110
  C2  D0  112  114
    D1  116  118
  C3  D0  120  122
    D1  124  126
```

(continues on next page)
Using a boolean indexer you can provide selection related to the values.

```python
In [56]: mask = df[('a','foo')]>200
In [57]: df.loc[idx[mask,:,['C1','C3']],idx[:, 'foo']]
```

```
Out[57]:
  lvl0  a  b
  lvl1 foo foo
      A0  B0  C1  D0 8 10
          D1  12 14
          C3  D0 24 26
          D1  28 30
      B1  C1  D0 40 42
          D1  44 46
          C3  D0 56 58
      ... ... ... ...
      A3  B0  C1  D1 204 206
          C3  D0 216 218
          D1  220 222
      B1  C1  D0 232 234
          D1  236 238
          C3  D0 248 250
          D1  252 254
[32 rows x 2 columns]
```

You can also specify the axis argument to .loc to interpret the passed slicers on a single axis.

```python
In [58]: df.loc(axis=0)[:,:,['C1','C3']]
```

```
Out[58]:
  lvl0  a  b
  lvl1  bar  foo  bah  foo
      A0  B0  C1  D0 9  8 11 10
          D1  13 12 15 14
          C3  D0 25 24 27 26
          D1  29 28 31 30
      B1  C1  D0 41 40 43 42
          D1  45 44 47 46
          C3  D0 57 56 59 58
      ... ... ... ... ...
      A3  B0  C1  D1 205 204 207 206
```
Furthermore you can set the values using these methods

```
In [59]: df2 = df.copy()

In [60]: df2.loc(axis=0)[:, :, ['C1', 'C3']] = -10

In [61]: df2
```

```
Out[61]:
```

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

You can use a right-hand-side of an alignable object as well.

```
In [62]: df2 = df.copy()

In [63]: df2.loc[idx[::, :, ['C1', 'C3']]] = df2*1000

In [64]: df2
```

```
Out[64]:
```

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

... ... ... ...

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(continues on next page)
1.24.7 Plotting

- Hexagonal bin plots from DataFrame.plot with kind='hexbin' (GH5478), See the docs.
- DataFrame.plot and Series.plot now supports area plot with specifying kind='area' (GH6656), See the docs
- Pie plots from Series.plot and DataFrame.plot with kind='pie' (GH6976), See the docs.
- Plotting with Error Bars is now supported in the .plot method of DataFrame and Series objects (GH3796, GH6834), See the docs.
- DataFrame.plot and Series.plot now support a table keyword for plotting matplotlib.Table, See the docs. The table keyword can receive the following values.
  - False: Do nothing (default).
  - True: Draw a table using the DataFrame or Series called plot method. Data will be transposed to meet matplotlib's default layout.
  - DataFrame or Series: Draw matplotlib.table using the passed data. The data will be drawn as displayed in print method (not transposed automatically). Also, helper function pandas.tools.plotting.table is added to create a table from DataFrame and Series, and add it to an matplotlib.Axes.
- plot(legend='reverse') will now reverse the order of legend labels for most plot kinds. (GH6014)
- Line plot and area plot can be stacked by stacked=True (GH6656)
- Following keywords are now acceptable for DataFrame.plot() with kind='bar' and kind='barh':
  - width: Specify the bar width. In previous versions, static value 0.5 was passed to matplotlib and it cannot be overwritten. (GH6604)
  - align: Specify the bar alignment. Default is center (different from matplotlib). In previous versions, pandas passes align='edge' to matplotlib and adjust the location to center by itself, and it results align keyword is not applied as expected. (GH4525)
  - position: Specify relative alignments for bar plot layout. From 0 (left/bottom-end) to 1(right/top-end). Default is 0.5 (center). (GH6604)

Because of the default align value changes, coordinates of bar plots are now located on integer values (0.0, 1.0, 2.0 ...). This is intended to make bar plot be located on the same coordinates as line plot. However, bar plot may differs unexpectedly when you manually adjust the bar location or drawing area, such as using set_xlim, set_ylim, etc. In this cases, please modify your script to meet with new coordinates.

- The parallel_coordinates() function now takes argument color instead of colors. A FutureWarning is raised to alert that the old colors argument will not be supported in a future release. (GH6956)
- The parallel_coordinates() and andrews_curves() functions now take positional argument frame instead of data. A FutureWarning is raised if the old data argument is used by name. (GH6956)
• DataFrame.boxplot() now supports layout keyword (GH6769)
• DataFrame.boxplot() has a new keyword argument, return_type. It accepts 'dict', 'axes', or 'both', in which case a namedtuple with the matplotlib axes and a dict of matplotlib Lines is returned.

1.24.8 Prior Version Deprecations/Changes

There are prior version deprecations that are taking effect as of 0.14.0.
• Remove DateRange in favor of DatetimeIndex (GH6816)
• Remove column keyword from DataFrame.sort (GH4370)
• Remove precision keyword from set_eng_float_format() (GH395)
• Remove force_unicode keyword from DataFrame.to_string(), DataFrame.to_latex(), and DataFrame.to_html(); these function encode in unicode by default (GH2224, GH2225)
• Remove nanRep keyword from DataFrame.to_csv() and DataFrame.to_string() (GH275)
• Remove unique keyword from HDFStore.select_column() (GH3256)
• Remove inferTimeRule keyword from Timestamp.offset() (GH391)
• Remove name keyword from get_data_yahoo() and get_data_google() (commit b921d1a)
• Remove offset keyword from DatetimeIndex constructor (commit 3136390)
• Remove time_rule from several rolling-moment statistical functions, such as rolling_sum() (GH1042)
• Removed neg – boolean operations on numpy arrays in favor of inv ~, as this is going to be deprecated in numpy 1.9 (GH6960)

1.24.9 Deprecations

• The pivot_table()/DataFrame.pivot_table() and crosstab() functions now take arguments index and columns instead of rows and cols. A FutureWarning is raised to alert that the old rows and cols arguments will not be supported in a future release (GH5505)
• The DataFrame.drop_duplicates() and DataFrame.duplicated() methods now take argument subset instead of cols to better align with DataFrame.dropna(). A FutureWarning is raised to alert that the old cols arguments will not be supported in a future release (GH6680)
• The DataFrame.to_csv() and DataFrame.to_excel() functions now take argument columns instead of cols. A FutureWarning is raised to alert that the old cols arguments will not be supported in a future release (GH6645)
• Indexers will warn FutureWarning when used with a scalar indexer and a non-floating point Index (GH4892, GH6960)

```python
# non-floating point indexes can only be indexed by integers / labels
In [1]: Series(1,np.arange(5))[3.0]
  pandas/core/index.py:469: FutureWarning: scalar indexers for index type Int64Index should be integers and not floating point
     →Int64Index
Out[1]: 1

In [2]: Series(1,np.arange(5)).iloc[3.0]
  pandas/core/index.py:469: FutureWarning: scalar indexers for index type Int64Index should be integers and not floating point
     →Int64Index
Out[2]: 1
```
(continues on next page)
In [3]: Series(1, np.arange(5)).iloc[3.0:4]
   pandas/core/index.py:527: FutureWarning: slice indexers when using iloc should be integers and not floating point
Out[3]:
   3  1
   dtype: int64

# these are Float64Indexes, so integer or floating point is acceptable
In [4]: Series(1, np.arange(5.))[3]
Out[4]: 1

In [5]: Series(1, np.arange(5.))[3.0]
Out[6]: 1

• Numpy 1.9 compat w.r.t. deprecation warnings (GH6960)
• Panel.shift() now has a function signature that matches DataFrame.shift(). The old positional argument lags has been changed to a keyword argument periods with a default value of 1. A FutureWarning is raised if the old argument lags is used by name. (GH6910)
• The order keyword argument of factorize() will be removed. (GH6926).
• Remove the copy keyword from DataFrame.xs(), Panel.major_xs(), Panel.minor_xs(). A view will be returned if possible, otherwise a copy will be made. Previously the user could think that copy=False would ALWAYS return a view. (GH6894)
• The parallel_coordinates() function now takes argument color instead of colors. A FutureWarning is raised to alert that the old colors argument will not be supported in a future release. (GH6956)
• The parallel_coordinates() and andrews_curves() functions now take positional argument frame instead of data. A FutureWarning is raised if the old data argument is used by name. (GH6956)
• The support for the 'mysql' flavor when using DBAPI connection objects has been deprecated. MySQL will be further supported with SQLAlchemy engines (GH6900).
• The following io.sql functions have been deprecated: tquery, uquery, read_frame, frame_query, write_frame.
• The percentile_width keyword argument in describe() has been deprecated. Use the percentiles keyword instead, which takes a list of percentiles to display. The default output is unchanged.
• The default return type of boxplot() will change from a dict to a matplotlib Axes in a future release. You can use the future behavior now by passing return_type='axes' to boxplot.

1.24.10 Known Issues

• OpenPyXL 2.0.0 breaks backwards compatibility (GH7169)

1.24.11 Enhancements

• DataFrame and Series will create a MultiIndex object if passed a tuples dict, See the docs (GH3323)
In [65]: Series({('a', 'b'): 1, ('a', 'a'): 0,  
    ....:  ('a', 'c'): 2, ('b', 'a'): 3, ('b', 'b'): 4})  
    ....:  
Out[65]:  
    a b 1  
a 0 2  
c 3  
b a 4  
    dtype: int64

In [66]: DataFrame({('a', 'b'): {('A', 'B'): 1, ('A', 'C'): 2},  
    ....:  ('a', 'a'): {('A', 'C'): 3, ('A', 'B'): 4},  
    ....:  ('a', 'c'): {('A', 'B'): 5, ('A', 'C'): 6},  
    ....:  ('b', 'a'): {('A', 'C'): 7, ('A', 'B'): 8},  
    ....:  ('b', 'b'): {('A', 'D'): 9, ('A', 'B'): 10}})

...

Out[66]:  
    a b  
    b a  
    c a  
    b  
    NaNaNaNNaNNaN NaN

• Added the sym_diff method to Index (GH5543)

• DataFrame.to_latex now takes a longtable keyword, which if True will return a table in a longtable environment. (GH6617)

• Add option to turn off escaping in DataFrame.to_latex (GH6472)

• pd.read_clipboard will, if the keyword sep is unspecified, try to detect data copied from a spreadsheet and parse accordingly. (GH6223)

• Joining a singly-indexed DataFrame with a multi-indexed DataFrame (GH3662)  

See the docs. Joining multi-index DataFrames on both the left and right is not yet supported ATM.

In [67]: household = DataFrame(dict(household_id = [1,2,3],  
    ....:  male = [0,1,0],  
    ....:  wealth = [196087.3,316478.7,294750]),  
    ....:  columns = ['household_id','male','wealth'])  
    ....:  ).set_index('household_id')  
    ....:  

In [68]: household

Out[68]:  

<table>
<thead>
<tr>
<th>household_id</th>
<th>male</th>
<th>wealth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>196087.3</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>316478.7</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>294750.0</td>
</tr>
</tbody>
</table>

In [69]: portfolio = DataFrame(dict(household_id = [1,2,2,3,3,3,4],  
    ....:  asset_id = ["nl0000301109","nl0000289783","gb00b03mlx29",  
    ....:  "gb00b03mlx29","nl0000289965",np.nan],  
    ....:  name = ["ABN Amro","Robeco","Royal Dutch Shell",  
    ....:  "Royal Dutch Shell",  
    ....:  "Royal Dutch Shell",  
    ....:  ],  
    ....:  )  

...
In [70]: portfolio
Out[70]:

<table>
<thead>
<tr>
<th>household_id</th>
<th>asset_id</th>
<th>name</th>
<th>share</th>
</tr>
</thead>
<tbody>
<tr>
<td>nl0000301109</td>
<td></td>
<td>ABN Amro</td>
<td>1.00</td>
</tr>
<tr>
<td>nl0000289783</td>
<td></td>
<td>Robeco</td>
<td>0.40</td>
</tr>
<tr>
<td>gb00b03mlx29</td>
<td></td>
<td>Royal Dutch Shell</td>
<td>0.60</td>
</tr>
<tr>
<td>gb00b03mlx29</td>
<td></td>
<td>Royal Dutch Shell</td>
<td>0.15</td>
</tr>
<tr>
<td>lu0197800237</td>
<td>AAB Eastern Europe Equity Fund</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td>n10000289965</td>
<td>Postbank BioTech Fonds</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>NaN</td>
<td>NaN</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

In [71]: household.join(portfolio, how='inner')

<table>
<thead>
<tr>
<th>household_id</th>
<th>asset_id</th>
<th>male</th>
<th>wealth</th>
<th>name</th>
<th>share</th>
</tr>
</thead>
<tbody>
<tr>
<td>nl0000301109</td>
<td></td>
<td>0</td>
<td>196087.3</td>
<td>ABN Amro</td>
<td>1.00</td>
</tr>
<tr>
<td>nl0000289783</td>
<td></td>
<td>1</td>
<td>316478.7</td>
<td>Robeco</td>
<td>0.40</td>
</tr>
<tr>
<td>gb00b03mlx29</td>
<td></td>
<td>1</td>
<td>316478.7</td>
<td>Royal Dutch Shell</td>
<td>0.60</td>
</tr>
<tr>
<td>gb00b03mlx29</td>
<td></td>
<td>0</td>
<td>294750.0</td>
<td>Royal Dutch Shell</td>
<td>0.15</td>
</tr>
<tr>
<td>lu0197800237</td>
<td>AAB Eastern Europe Equity Fund</td>
<td>0</td>
<td>294750.0</td>
<td>AAB Eastern Europe Equity Fund</td>
<td>0.60</td>
</tr>
<tr>
<td>n10000289965</td>
<td>Postbank BioTech Fonds</td>
<td>0</td>
<td>294750.0</td>
<td>Postbank BioTech Fonds</td>
<td>0.25</td>
</tr>
</tbody>
</table>

• `quotechar`, `doublequote`, and `escapechar` can now be specified when using `DataFrame.to_csv` (GH5414, GH4528)

• Partially sort by only the specified levels of a MultiIndex with the `sort_remaining` boolean kwarg. (GH3984)

• Added `to_julian_date` to `TimeStamp` and `DatetimeIndex`. The Julian Date is used primarily in astronomy and represents the number of days from noon, January 1, 4713 BC. Because nanoseconds are used to define the time in pandas the actual range of dates that you can use is 1678 AD to 2262 AD. (GH4041)

• `DataFrame.to_stata` will now check data for compatibility with Stata data types and will upcast when needed. When it is not possible to losslessly upcast, a warning is issued (GH6327)

• `DataFrame.to_stata` and `StataWriter` will accept keyword arguments `time_stamp` and `data_label` which allow the time stamp and dataset label to be set when creating a file. (GH6545)

• `pandas.io.gbq` now handles reading unicode strings properly. (GH5940)

• `Holidays Calendars` are now available and can be used with the `CustomBusinessDay` offset (GH6719)

• `Float64Index` is now backed by a `float64` dtype ndarray instead of an `object` dtype array (GH4741).

• Implemented `Panel.pct_change` (GH6904)

• Added how option to rolling-moment functions to dictate how to handle resampling: `rolling_max()` defaults to max, `rolling_min()` defaults to min, and all others default to mean (GH6297)

• `CustomBusinessMonthBegin` and `CustomBusinessMonthEnd` are now available (GH6866)
• **Series.quantile()** and **DataFrame.quantile()** now accept an array of quantiles.
• **describe()** now accepts an array of percentiles to include in the summary statistics (GH4196)
• **pivot_table** can now accept `Grouper` by index and columns keywords (GH6913)

```python
In [72]: import datetime
In [73]: df = DataFrame(
   ....:     'Branch': ['A A A A A B'].split(),
   ....:     'Buyer': ['Carl Mark Carl Carl Joe Joe'].split(),
   ....:     'Quantity': [1, 3, 5, 1, 8, 1],
   ....:     'Date': [datetime.datetime(2013,11,1,13,0),
               datetime.datetime(2013,9,1,13,0),
               datetime.datetime(2013,10,1,20,0),
               datetime.datetime(2013,9,1,13,0),
               datetime.datetime(2013,10,1,20,0),
               datetime.datetime(2013,10,1,20,0)],
   ....:     'PayDay': [datetime.datetime(2013,10,4,0,0),
                 datetime.datetime(2013,9,5,20,0),
                 datetime.datetime(2013,10,7,20,0),
                 datetime.datetime(2013,9,5,10,0)]
   ....: )
```

```python
In [74]: df
Out[74]:
  Branch Buyer Quantity Date PayDay
0     A  Carl      1 2013-11-01 13:00:00 2013-10-04 00:00:00
1     A  Mark      3 2013-09-01 13:05:00 2013-10-15 13:05:00
2     A  Carl      5 2013-10-01 20:00:00 2013-09-05 20:00:00
3     A  Carl      1 2013-10-02 10:00:00 2013-11-02 10:00:00
4     A   Joe      8 2013-11-01 20:00:00 2013-10-07 20:00:00
5     B   Joe      1 2013-10-02 10:00:00 2013-09-05 10:00:00
```

```python
In [75]: pivot_table(df, index=Grouper(freq='M', key='Date'),
   ....:             columns=Grouper(freq='M', key='PayDay'),
   ....:             values='Quantity', aggfunc=np.sum)
Out[75]:
Date                                    NaN         3.0        NaN
2013-09-30                                NaN        NaN        NaN
2013-10-31                                6.0        NaN        1.0
2013-11-30                                NaN        9.0        NaN
```

• Arrays of strings can be wrapped to a specified width (`str.wrap`) (GH6999)
• Add `nsmallest()` and `Series.nlargest()` methods to `Series`, See the docs (GH3960)
• **PeriodIndex** fully supports partial string indexing like `DatetimeIndex` (GH7043)

```python
In [76]: prng = period_range('2013-01-01 09:00', periods=100, freq='H')
In [77]: ps = Series(np.random.randn(len(prng)), index=prng)
In [78]: ps
```

(continues on next page)
Out[78]:
2013-01-01 09:00  0.015696
2013-01-01 10:00 -2.242685
2013-01-01 11:00  1.150036
2013-01-01 12:00  0.991946
2013-01-01 13:00  0.953324
2013-01-01 14:00 -2.021255
2013-01-01 15:00 -0.334077
...  2013-01-05 06:00  0.566534
2013-01-05 07:00  0.503592
2013-01-05 08:00  0.285296
2013-01-05 09:00  0.484288
2013-01-05 10:00  1.363482
2013-01-05 11:00 -0.781105
2013-01-05 12:00 -0.468018
Freq: H, Length: 100, dtype: float64

In[79]: ps['2013-01-02']

Out[79]:
2013-01-02 00:00  0.553439
2013-01-02 01:00  1.318152
2013-01-02 02:00 -0.469305
2013-01-02 03:00  0.675554
2013-01-02 04:00 -1.817027
2013-01-02 05:00 -0.183109
2013-01-02 06:00  1.058969
...  2013-01-02 17:00  0.076200
2013-01-02 18:00 -0.566446
2013-01-02 19:00  0.036142
2013-01-02 20:00 -2.074978
2013-01-02 21:00  0.247792
2013-01-02 22:00 -0.897157
2013-01-02 23:00 -0.136795
Freq: H, Length: 24, dtype: float64

- **read_excel** can now read milliseconds in Excel dates and times with xlrd >= 0.9.3. (GH5945)
- **pd.stats.moments.rolling_var** now uses Welford’s method for increased numerical stability (GH6817)
- **pd.expanding_apply** and **pd.rolling_apply** now take args and kwargs that are passed on to the func (GH6289)
- **DataFrame.rank()** now has a percentage rank option (GH5971)
- **Series.rank()** now has a percentage rank option (GH5971)
- **Series.rank()** and **DataFrame.rank()** now accept method='dense' for ranks without gaps (GH6514)
- Support passing **encoding** with xlwt (GH3710)
- Refactor **Block classes** removing **Block.items** attributes to avoid duplication in item handling (GH6745, GH6988).
- Testing statements updated to use specialized asserts (GH6175)
1.24.12 Performance

- Performance improvement when converting DatetimeIndex to floating ordinals using DatetimeConverter (GH6636)
- Performance improvement for DataFrame.shift (GH5609)
- Performance improvement in indexing into a multi-indexed Series (GH5567)
- Performance improvements in single-dtyped indexing (GH6484)
- Improve performance of DataFrame construction with certain offsets, by removing faulty caching (e.g. MonthEnd, BusinessMonthEnd), (GH6479)
- Improve performance of CustomBusinessDay (GH6584)
- Improve performance of slice indexing on Series with string keys (GH6341, GH6372)
- Performance improvement for DataFrame.from_records when reading a specified number of rows from an iterable (GH6700)
- Performance improvements in timedelta conversions for integer dtypes (GH6754)
- Improved performance of compatible pickles (GH6899)
- Improve performance in certain reindexing operations by optimizing take_2d (GH6749)
- GroupBy.count() is now implemented in Cython and is much faster for large numbers of groups (GH7016).

1.24.13 Experimental

There are no experimental changes in 0.14.0

1.24.14 Bug Fixes

- Bug in Series ValueError when index doesn’t match data (GH6532)
- Prevent segfault due to MultiIndex not being supported in HDFStore table format (GH1848)
- Bug in pd.DataFrame.sort_index where mergesort wasn’t stable when ascending=False (GH6399)
- Bug in pd.tseries.frequencies.to_offset when argument has leading zeroes (GH6391)
- Bug in version string gen. for dev versions with shallow clones / install from tarball (GH6127)
- Inconsistent tz parsing Timestamp/to_datetime for current year (GH5958)
- Indexing bugs with reordered indexes (GH6252, GH6254)
- Bug in .xs with a Series multiindex (GH6258, GH5684)
- Bug in conversion of a string types to a DatetimeIndex with a specified frequency (GH6273, GH6274)
- Bug in eval where type-promotion failed for large expressions (GH6205)
- Bug in interpolate with inplace=True (GH6281)
- HDFStore.remove now handles start and stop (GH6177)
- HDFStore.select_as_multiple handles start and stop the same way as select (GH6177)
- HDFStore.select_as_coordinates and select_column works with a where clause that results in filters (GH6177)
• Regression in join of non_unique_indexes (GH6329)
• Issue with groupby agg with a single function and a mixed-type frame (GH6337)
• Bug in DataFrame.replace() when passing a non-bool to_replace argument (GH6332)
• Raise when trying to align on different levels of a multi-index assignment (GH3738)
• Bug in setting complex dtypes via boolean indexing (GH6345)
• Bug in TimeGrouper/resample when presented with a non-monotonic DatetimeIndex that would return invalid results. (GH4161)
• Bug in index name propagation in TimeGrouper/resample (GH4161)
• TimeGrouper has a more compatible API to the rest of the groupers (e.g. groups was missing) (GH3881)
• Bug in multiple grouping with a TimeGrouper depending on target column order (GH6764)
• Bug in pd.eval when parsing strings with possible tokens like ' & ' (GH6351)
• Bug correctly handle placements of -inf in Panels when dividing by integer 0 (GH6178)
• DataFrame.shift with axis=1 was raising (GH6371)
• Disabled clipboard tests until release time (run locally with nosetests -A disabled) (GH6048).
• Bug in DataFrame.replace() when passing a nested dict that contained keys not in the values to be replaced (GH6342)
• str.match ignored the na flag (GH6609).
• Bug in take with duplicate columns that were not consolidated (GH6240)
• Bug in interpolate changing dtypes (GH6290)
• Bug in Series.get was using a buggy access method (GH6383)
• Bug in hdfstore queries of the form where=[('date', '>=', datetime(2013,1,1)), ('date', '<=', datetime(2014,1,1))] (GH6313)
• Bug in DataFrame.dropna with duplicate indices (GH6355)
• Regression in chained getitem indexing with embedded list-like from 0.12 (GH6394)
• Float64Index with nans not comparing correctly (GH6401)
• eval/query expressions with strings containing the @ character will now work (GH6366).
• Bug in Series.reindex when specifying a method with some nan values was inconsistent (noted on a resample) (GH6418)
• Bug in DataFrame.replace() where nested dicts were erroneously depending on the order of dictionary keys and values (GH5338).
• Perf issue in concatting with empty objects (GH3259)
• Clarify sorting of sym_diff on Index objects with NaN values (GH444)
• Regression in MultiIndex.from_product with a DatetimeIndex as input (GH439)
• Bug in str.extract when passed a non-default index (GH6348)
• Bug in str.split when passed pat=None and n=1 (GH6466)
• Bug in io.data.DataReader when passed "F-F_Momentum_Factor" and data_source="famafrench" (GH6460)
• Bug in sum of a timedelta64 [ns] series (GH6462)
• Bug in resample with a timezone and certain offsets (GH6397)
• Bug in iat/iloc with duplicate indices on a Series (GH6493)
• Bug in read_html where nan’s were incorrectly being used to indicate missing values in text. Should use the empty string for consistency with the rest of pandas (GH5129).
• Bug in read_html tests where redirected invalid URLs would make one test fail (GH6445).
• Bug in multi-axis indexing using .loc on non-unique indices (GH6504)
• Bug that caused _ref_locs corruption when slice indexing across columns axis of a DataFrame (GH6525)
• Regression from 0.13 in the treatment of numpy datetime64 non-ns dtypes in Series creation (GH6529)
• .names attribute of MultiIndexes passed to set_index are now preserved (GH6459).
• Bug in setitem with a duplicate index and an alignable rhs (GH6541)
• Bug in setitem with .loc on mixed integer Indexes (GH6546)
• Bug in pd.read_stata which would use the wrong data types and missing values (GH6327)
• Bug in DataFrame.to_stata that lead to data loss in certain cases, and could be exported using the wrong data types and missing values (GH6335)
• StataWriter replaces missing values in string columns by empty string (GH6802)
• Inconsistent types in Timestamp addition/subtraction (GH6543)
• Bug in preserving frequency across Timestamp addition/subtraction (GH4547)
• Bug in empty list lookup caused IndexError exceptions (GH6536, GH6551)
• Series.quantile raising on an object dtype (GH6555)
• Bug in .xs with a nan in level when dropped (GH6574)
• Bug in fillna with method='bfill/ffill' and datetime64[ns] dtype (GH6587)
• Bug in sql writing with mixed dtypes possibly leading to data loss (GH6509)
• Bug in Series.pop (GH6600)
• Bug in iloc indexing when positional indexer matched Int64Index of the corresponding axis and no re-ordering happened (GH6612)
• Bug in fillna with limit and value specified
• Bug in DataFrame.to_stata when columns have non-string names (GH4558)
• Bug in compat with np.compress, surfaced in (GH6658)
• Bug in binary operations with a rhs of a Series not aligning (GH6681)
• Bug in DataFrame.to_stata which incorrectly handles nan values and ignores with_index keyword argument (GH6685)
• Bug in resample with extra bins when using an evenly divisible frequency (GH4076)
• Bug in consistency of groupby aggregation when passing a custom function (GH6715)
• Bug in resample when how=None resample freq is the same as the axis frequency (GH5955)
• Bug in downcasting inference with empty arrays (GH6733)
• Bug in obj.blocks on sparse containers dropping all but the last items of same for dtpe (GH6748)
• Bug in unpickling NaT (NaTTtype) (GH4606)
- Bug in `DataFrame.replace()` where regex metacharacters were being treated as regexs even when `regex=False` (GH6777).
- Bug in timedelta ops on 32-bit platforms (GH6808).
- Bug in setting a tz-aware index directly via `.index` (GH6785).
- Bug in `expressions.py` where numexpr would try to evaluate arithmetic ops (GH6762).
- Bug in `Makefile` where it didn’t remove Cython generated C files with `make clean` (GH6768).
- Bug with `numpy < 1.7.2` when reading long strings from `HDFStore` (GH6166).
- Bug in `DataFrame._reduce` where non bool-like (0/1) integers were being converted into bools. (GH6806).
- Regression from 0.13 with `fillna` and a Series on datetime-like (GH6344).
- Bug in adding `np.timedelta64` to `DatetimeIndex` with timezone outputs incorrect results (GH6818).
- Bug in `DataFrame.replace()` where changing a dtype through replacement would only replace the first occurrence of a value (GH6689).
- Better error message when passing a frequency of ‘MS’ in `Period` construction (GH5332).
- Bug in `Series.__unicode__` when `max_rows=None` and the Series has more than 1000 rows. (GH6863).
- Bug in `groupby.get_group` where a datetlike wasn’t always accepted (GH5267).
- Bug in `groupBy.get_group` created by `TimeGrouper` raises `AttributeError` (GH6914).
- Bug in `DatetimeIndex.tz_localize` and `DatetimeIndex.tz_convert` converting `NaT` incorrectly (GH5546).
- Bug in arithmetic operations affecting `NaT` (GH6873).
- Bug in `Series.str.extract` where the resulting Series from a single group match wasn’t renamed to the group name.
- Bug in `DataFrame.to_csv` where setting `index=False` ignored the header kwarg (GH6186).
- Bug in `DataFrame.plot` and `Series.plot`, where the legend behave inconsistently when plotting to the same axes repeatedly (GH6678).
- Internal tests for patching `__finalize__` / bug in merge not finalizing (GH6923, GH6927).
- accept `TextFileReader` in `concat`, which was affecting a common user idiom (GH6583).
- Bug in C parser with leading whitespace (GH3374).
- Bug in C parser with `delim_whitespace=True` and `\r`-delimited lines.
- Bug in python parser with explicit multi-index in row following column header (GH6893).
- Bug in `Series.rank` and `DataFrame.rank` that caused small floats (<1e-13) to all receive the same rank (GH6886).
- Bug in `DataFrame.apply` with functions that used `*args` or `**kwargs` and returned an empty result (GH6952).
- Bug in `sum/mean` on 32-bit platforms on overflows (GH6915).
- Moved `Panel.shift` to `NDFrame.slice_shift` and fixed to respect multiple dtypes. (GH6959).
- Bug in enabling `subplots=True` in `DataFrame.plot` only has single column raises `TypeError`, and `Series.plot` raises `AttributeError` (GH6951).
- Bug in `DataFrame.plot` draws unnecessary axes when enabling `subplots` and `kind=scatter` (GH6951).
• Bug in `read_csv` from a filesystem with non-utf-8 encoding (GH6807)
• Bug in `iloc` when setting / aligning (GH6766)
• Bug causing UnicodeEncodeError when `get_dummies` called with unicode values and a prefix (GH6885)
• Bug in timeseries-with-frequency plot cursor display (GH5453)
• Bug surfaced in `groupby.plot` when using a `Float64Index` (GH7025)
• Stopped tests from failing if options data isn’t able to be downloaded from Yahoo (GH7034)
• Bug in `parallel_coordinates` and `radviz` where reordering of class column caused possible color/class mismatch (GH6956)
• Bug in `radviz` and `andrews_curves` where multiple values of ‘color’ were being passed to plotting method (GH6956)
• Bug in `Float64Index.isin()` where containing `nans` would make indices claim that they contained all the things (GH7066).
• Bug in `DataFrame.boxplot` where it failed to use the axis passed as the `ax` argument (GH3578)
• Bug in the `XlsxWriter` and `XlwtWriter` implementations that resulted in datetime columns being formatted without the time (GH7075) were being passed to plotting method
• `read_fwf()` treats `None` in `colspec` like regular python slices. It now reads from the beginning or until the end of the line when `colspec` contains a `None` (previously raised a `TypeError`)
• Bug in cache coherence with chained indexing and slicing; add `_is_view` property to `NDFrame` to correctly predict views; mark `is_copy` on `xs` only if it's an actual copy (and not a view) (GH7084)
• Bug in `DatetimeIndex` creation from string ndarray with `dayfirst=True` (GH5917)
• Bug in `MultiIndex.from_arrays` created from `DatetimeIndex` doesn’t preserve freq and tz (GH7090)
• Bug in `unstack` raises `ValueError` when `MultiIndex` contains `PeriodIndex` (GH4342)
• Bug in boxplot and hist draws unnecessary axes (GH6769)
• Regression in `groupby.nth()` for out-of-bounds indexers (GH6621)
• Bug in `quantile` with datetime values (GH6965)
• Bug in `Dataframe.set_index`, `reindex` and `pivot` don’t preserve `DatetimeIndex` and `PeriodIndex` attributes (GH3950, GH5878, GH6631)
• Bug in `MultiIndex.get_level_values` doesn’t preserve `DatetimeIndex` and `PeriodIndex` attributes (GH7092)
• Bug in `Groupby` doesn’t preserve tz (GH3950)
• Bug in `PeriodIndex` partial string slicing (GH6716)
• Bug in the HTML repr of a truncated Series or DataFrame not showing the class name with the `large_repr` set to ‘info’ (GH7105)
• Bug in `DatetimeIndex` specifying freq raises `ValueError` when passed value is too short (GH7098)
• Fixed a bug with the `info` repr not honoring the `display.max_info_columns` setting (GH6939)
• Bug `PeriodIndex` string slicing with out of bounds values (GH5407)
• Fixed a memory error in the hashtable implementation/factorizer on resizing of large tables (GH7157)
• Bug in `isnull` when applied to 0-dimensional object arrays (GH7176)
• Bug in `query/eval` where global constants were not looked up correctly (GH7178)
• Bug in recognizing out-of-bounds positional list indexers with `iloc` and a multi-axis tuple indexer (GH7189)
• Bug in `setitem` with a single value, multi-index and integer indices (GH7190, GH7218)
• Bug in expressions evaluation with reversed ops, showing in `series-dataframe` ops (GH7198, GH7192)
• Bug in multi-axis indexing with > 2 ndim and a multi-index (GH7199)
• Fix a bug where invalid eval/query operations would blow the stack (GH5198)

1.25 v0.13.1 (February 3, 2014)

This is a minor release from 0.13.0 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

• Added `infer_datetime_format` keyword to `read_csv/to_datetime` to allow speedups for homogeneously formatted datetimes.
• Will intelligently limit display precision for `datetime/timedelta` formats.
• Enhanced Panel `apply()` method.
• Suggested tutorials in new `Tutorials` section.
• Our pandas ecosystem is growing. We now feature related projects in a new `Pandas Ecosystem` section.
• Much work has been taking place on improving the docs, and a new `Contributing` section has been added.
• Even though it may only be of interest to devs, we <3 our new CI status page: `ScatterCI`.

**Warning:** 0.13.1 fixes a bug that was caused by a combination of having numpy < 1.8, and doing chained assignment on a string-like array. Please review the docs, chained indexing can have unexpected results and should generally be avoided.

This would previously segfault:

```
In [1]: df = DataFrame(dict(A = np.array(['foo','bar','bah','foo','bar'])))
In [2]: df['A'].iloc[0] = np.nan

In [3]: df
Out[3]:
   A
0  NaN
1  bar
2  bah
3  foo
4  bar
```

The recommended way to do this type of assignment is:
In [4]: df = DataFrame(dict(A = np.array(['foo','bar','bah','foo','bar'])))

In [5]: df.loc[0,'A'] = np.nan

In [6]: df
Out[6]:
   A
0  NaN
1  bar
2  bah
3  foo
4  bar

1.25.1 Output Formatting Enhancements

• df.info() view now display dtype info per column (GH5682)
• df.info() now honors the option max_info_rows, to disable null counts for large frames (GH5974)

In [7]: max_info_rows = pd.get_option('max_info_rows')

In [8]: df = DataFrame(dict(A = np.random.randn(10),
   ...: B = np.random.randn(10),
   ...: C = date_range('20130101',periods=10)))

In [9]: df.iloc[3:6,[0,2]] = np.nan

# set to not display the null counts
In [10]: pd.set_option('max_info_rows',0)

In [11]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10 entries, 0 to 9
Data columns (total 3 columns):
A float64
B float64
C datetime64[ns]
dtypes: datetime64[ns](1), float64(2)
memory usage: 320.0 bytes

# this is the default (same as in 0.13.0)
In [12]: pd.set_option('max_info_rows',max_info_rows)

In [13]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10 entries, 0 to 9
Data columns (total 3 columns):
A 7 non-null float64
B 10 non-null float64
C 7 non-null datetime64[ns]
dtypes: datetime64[ns](1), float64(2)
memory usage: 320.0 bytes

• Add show_dimensions display option for the new DataFrame repr to control whether the dimensions print.
In [14]: df = DataFrame([[1, 2], [3, 4]])

In [15]: pd.set_option('show_dimensions', False)

In [16]: df
Out[16]:
   0 1
0 1 2
1 3 4

In [17]: pd.set_option('show_dimensions', True)

In [18]: df
Out[18]:
   0 1
0 1 2
1 3 4

[2 rows x 2 columns]

• The ArrayFormatter for datetime and timedelta64 now intelligently limit precision based on the values in the array (GH3401)

Previously output might look like:

<table>
<thead>
<tr>
<th>age</th>
<th>today</th>
<th>diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>00:00:00</td>
<td>00:00:00</td>
</tr>
<tr>
<td>1</td>
<td>00:00:00</td>
<td>00:00:00</td>
</tr>
<tr>
<td></td>
<td>2001-01-01</td>
<td>2013-04-19</td>
</tr>
<tr>
<td></td>
<td>4491 days, 00:00:00</td>
<td>3244 days, 00:00:00</td>
</tr>
</tbody>
</table>

Now the output looks like:

In [19]: df = DataFrame([Timestamp('20010101'),
                      Timestamp('20040601')], columns=['age'])

In [20]: df['today'] = Timestamp('20130419')

In [21]: df['diff'] = df['today']-df['age']

In [22]: df
Out[22]:
     age   today   diff
0 2001-01-01 2013-04-19 4491 days
1 2004-06-01 2013-04-19 3244 days

[2 rows x 3 columns]

1.25.2 API changes

• Add -NaN and -nan to the default set of NA values (GH5952). See NA Values.

• Added Series.str.get_dummies vectorized string method (GH6021), to extract dummy/indicator variables for separated string columns:

In [23]: s = Series(['a', 'a|b', np.nan, 'a|c'])

(continues on next page)
In [24]: s.str.get_dummies(sep='|')
Out[24]:
a b c
0 1 0 0
1 1 1 0
2 0 0 0
3 1 0 1
[4 rows x 3 columns]

• Added the NDFrame.equals() method to compare if two NDFrames are equal have equal axes, dtypes, and values. Added the array_equivalent function to compare if two ndarrays are equal. NaNs in identical locations are treated as equal. (GH5283) See also the docs for a motivating example.

In [25]: df = DataFrame({'col': ['foo', 0, np.nan]})
In [26]: df2 = DataFrame({'col': [np.nan, 0, 'foo']}, index=[2,1,0])
In [27]: df.equals(df2)
Out[27]: False
In [28]: df.equals(df2.sort_index())
Out[28]: True

In [29]: import pandas.core.common as com
In [30]: com.array_equivalent(np.array([0, np.nan]), np.array([0, np.nan]))
---------------------------------------------------------------------------
AttributeError                      Traceback (most recent call last)
<ipython-input-30-18a036193b45> in
----> 1 com.array_equivalent(np.array([0, np.nan]), np.array([0, np.nan]))

AttributeError: module 'pandas.core.common' has no attribute 'array_equivalent'
In [31]: np.array_equal(np.array([0, np.nan]), np.array([0, np.nan]))
False

• DataFrame.apply will use the reduce argument to determine whether a Series or a DataFrame should be returned when the DataFrame is empty (GH6007).

Previously, calling DataFrame.apply an empty DataFrame would return either a DataFrame if there were no columns, or the function being applied would be called with an empty Series to guess whether a Series or DataFrame should be returned:

In [32]: def applied_func(col):
.....:     print("Apply function being called with: ", col)
.....:     return col.sum()
.....: 
In [33]: empty = DataFrame(columns=['a', 'b'])
In [34]: empty.apply(applied_func)
Apply function being called with: Series([], Length: 0, dtype: float64)
Out[34]:
a  NaN

(continues on next page)
Now, when `apply` is called on an empty DataFrame: if the `reduce` argument is `True` a Series will returned, if it is `False` a DataFrame will be returned, and if it is `None` (the default) the function being applied will be called with an empty series to try and guess the return type.

```
In [35]: empty.apply(applied_func, reduce=True)
Out[35]:
a    NaN
b    NaN
Length: 2, dtype: float64

In [36]: empty.apply(applied_func, reduce=False)
Out[36]:
Empty DataFrame
Columns: [a, b]
Index: []
[0 rows x 2 columns]
```

1.25.3 Prior Version Deprecations/Changes

There are no announced changes in 0.13 or prior that are taking effect as of 0.13.1

1.25.4 Deprecations

There are no deprecations of prior behavior in 0.13.1

1.25.5 Enhancements

• `pd.read_csv` and `pd.to_datetime` learned a new `infer_datetime_format` keyword which greatly improves parsing perf in many cases. Thanks to @lexical for suggesting and @danbirken for rapidly implementing. (GH5490, GH6021)

  If `parse_dates` is enabled and this flag is set, pandas will attempt to infer the format of the datetime strings in the columns, and if it can be inferred, switch to a faster method of parsing them. In some cases this can increase the parsing speed by ~5-10x.

```
# Try to infer the format for the index column
df = pd.read_csv('foo.csv', index_col=0, parse_dates=True,
                 infer_datetime_format=True)
```

• `date_format` and `datetime_format` keywords can now be specified when writing to excel files (GH4133)

• `MultiIndex.from_product` convenience function for creating a MultiIndex from the cartesian product of a set of iterables (GH6055):

```
In [32]: shades = ['light', 'dark']
In [33]: colors = ['red', 'green', 'blue']
```
In [34]: MultiIndex.from_product([shades, colors], names=['shade', 'color'])
Out[34]:
MultiIndex(levels=[['dark', 'light'], ['blue', 'green', 'red']], labels=[[1, 1, 1, 0, 0, 0], [2, 1, 0, 2, 1, 0]], names=['shade', 'color'])

• Panel apply() will work on non-ufuncs. See the docs.

In [35]: import pandas.util.testing as tm
In [36]: panel = tm.makePanel(5)
In [37]: panel
Out[37]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: A to D
In [38]: panel['ItemA']

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-03</td>
<td>0.694103</td>
<td>1.893534</td>
<td>-1.735349</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>0.678630</td>
<td>0.639633</td>
<td>1.210384</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>0.239556</td>
<td>-0.962029</td>
<td>0.797435</td>
</tr>
<tr>
<td>2000-01-06</td>
<td>0.151227</td>
<td>-2.085266</td>
<td>-0.379811</td>
</tr>
<tr>
<td>2000-01-07</td>
<td>0.816127</td>
<td>1.930247</td>
<td>0.702562</td>
</tr>
</tbody>
</table>

[5 rows x 4 columns]

Specifying an apply that operates on a Series (to return a single element)

In [39]: panel.apply(lambda x: x.dtype, axis='items')
Out[39]:
A    float64
B    float64
C    float64
D    float64

[5 rows x 4 columns]

A similar reduction type operation

In [40]: panel.apply(lambda x: x.sum(), axis='major_axis')
Out[40]:
       ItemA    ItemB     ItemC
A  2.579643  3.062757  0.379252
B  1.416120 -1.960855  0.923558
C  0.595222 -1.079772 -3.118269
D  1.487226 -0.734611 -1.979310

[4 rows x 3 columns]
This is equivalent to

```python
In [41]: panel.sum('major_axis')
Out[41]:
ItemA    ItemB    ItemC
A  2.579643  3.062757  0.379252
B  1.416120 -1.960855  0.923558
C  0.595222 -1.079772 -3.118269
D  1.487226 -0.734611 -1.979310
[4 rows x 3 columns]
```

A transformation operation that returns a Panel, but is computing the z-score across the major_axis

```python
In [42]: result = panel.apply(
    ....:     lambda x: (x-x.mean())/x.std(),
    ....:     axis='major_axis')
    ....:
In [43]: result
Out[43]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: A to D
In [44]: result['ItemA']
```

- Panel `apply()` operating on cross-sectional slabs. (GH1148)

```python
In [45]: f = lambda x: ((x.T-x.mean(1))/x.std(1)).T
In [46]: result = panel.apply(f, axis = ['items','major_axis'])
In [47]: result
Out[47]:
<class 'pandas.core.panel.Panel'>
Dimensions: 4 (items) x 5 (major_axis) x 3 (minor_axis)
Items axis: A to D
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: ItemA to ItemC
In [48]: result.loc[:,:, 'ItemA']
```

(continues on next page)
This is equivalent to the following

```
In [49]: result = Panel(dict(
      (ax,f(panel.loc[:,:ax]))
      for ax in panel.minor_axis ))

In [50]: result
Out[50]:
<class 'pandas.core.panel.Panel'>
Dimensions: 4 (items) x 5 (major_axis) x 3 (minor_axis)
Items axis: A to D
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: ItemA to ItemC

In [51]: result.loc[:,:,'ItemA']
```

```
\|
→   A    B    C    D
2000-01-03 0.331409 1.071034 -0.914540 -0.510587
2000-01-04 -0.741017 -0.118794 0.383277 0.537212
2000-01-05 0.065042 -0.767353 0.655436 0.069467
2000-01-06 0.027932 -0.569477 0.908202 0.610585
2000-01-07 1.116434 1.133591 0.871287 1.004064
\|
[5 rows x 4 columns]
```

### 1.25.6 Performance

Performance improvements for 0.13.1
- Series datetime/timedelta binary operations ([GH5801](https://github.com/pandas-dev/pandas/pull/5801))
- `DataFrame` `count/dropna` for `axis=1`
- Series\.str\.contains now has a `regex=False` keyword which can be faster for plain (non-regex) string patterns. ([GH5879](https://github.com/pandas-dev/pandas/pull/5879))
- Series\.str\.extract ([GH5944](https://github.com/pandas-dev/pandas/pull/5944))
- `dtypes/ftypes` methods ([GH5968](https://github.com/pandas-dev/pandas/pull/5968))
- indexing with object dtypes ([GH5968](https://github.com/pandas-dev/pandas/pull/5968))
- `DataFrame\.apply` ([GH6013](https://github.com/pandas-dev/pandas/pull/6013))
- Regression in JSON IO ([GH5765](https://github.com/pandas-dev/pandas/pull/5765))
- Index construction from Series ([GH6150](https://github.com/pandas-dev/pandas/pull/6150))
1.25.7 Experimental
There are no experimental changes in 0.13.1

1.25.8 Bug Fixes
See V0.13.1 Bug Fixes for an extensive list of bugs that have been fixed in 0.13.1.
See the full release notes or issue tracker on GitHub for a complete list of all API changes, Enhancements and Bug Fixes.

1.26 v0.13.0 (January 3, 2014)
This is a major release from 0.12.0 and includes a number of API changes, several new features and enhancements along with a large number of bug fixes.
Highlights include:
- support for a new index type Float64Index, and other Indexing enhancements
- HDFStore has a new string based syntax for query specification
- support for new methods of interpolation
- updated timedelta operations
- a new string manipulation method extract
- Nanosecond support for Offsets
- isin for DataFrames

Several experimental features are added, including:
- new eval/query methods for expression evaluation
- support for msgpack serialization
- an i/o interface to Google’s BigQuery

There are several new or updated docs sections including:
- Comparison with SQL, which should be useful for those familiar with SQL but still learning pandas.
- Comparison with R, idiom translations from R to pandas.
- Enhancing Performance, ways to enhance pandas performance with eval/query.

**Warning:** In 0.13.0 Series has internally been refactored to no longer sub-class ndarray but instead subclass NDFrame, similar to the rest of the pandas containers. This should be a transparent change with only very limited API implications. See Internal Refactoring

1.26.1 API changes
- read_excel now supports an integer in its sheetname argument giving the index of the sheet to read in (GH4301).
- Text parser now treats anything that reads like inf ("inf", "Inf", "-Inf", "iNf", etc.) as infinity. (GH4220, GH4219), affecting read_table, read_csv, etc.

- pandas now is Python 2/3 compatible without the need for 2to3 thanks to @jtratner. As a result, pandas now uses iterators more extensively. This also led to the introduction of substantive parts of the Benjamin Peterson’s six library into compat. (GH4384, GH4375, GH4372)

- pandas.util.compat and pandas.util.py3compat have been merged into pandas.compat. pandas.compat now includes many functions allowing 2/3 compatibility. It contains both list and iterator versions of range, filter, map and zip, plus other necessary elements for Python 3 compatibility. lmap, lzip, lrange and lfilter all produce lists instead of iterators, for compatibility with numpy, subscripting and pandas constructors.(GH4384, GH4375, GH4372)

- Series.get with negative indexers now returns the same as [] (GH4390)

- Changes to how Index and MultiIndex handle metadata (levels, labels, and names)(GH4039):

```python
# previously, you would have set levels or labels directly
index.levels = [[1, 2, 3, 4], [1, 2, 4, 4]]

# now, you use the set_levels or set_labels methods
index = index.set_levels([1, 2, 3, 4], [1, 2, 4, 4])

# similarly, for names, you can rename the object
# but setting names is not deprecated
index = index.set_names(["bob", "cranberry"])

# and all methods take an inplace kwarg - but return None
index.set_names(["bob", "cranberry"], inplace=True)
```

- All division with NDFrame objects is now truedivision, regardless of the future import. This means that operating on pandas objects will by default use floating point division, and return a floating point dtype. You can use // and floordiv to do integer division.

**Integer division**

```python
In [3]: arr = np.array([1, 2, 3, 4])
In [4]: arr2 = np.array([5, 3, 2, 1])
In [5]: arr / arr2
Out[5]: array([0, 0, 1, 4])
In [6]: Series(arr) // Series(arr2)
Out[6]:
   0    0
  1    0
  2    1
  3    4
dtype: int64
```

**True Division**

```python
In [7]: pd.Series(arr) / pd.Series(arr2) # no future import required
Out[7]:
   0    0.200000
  1    0.666667
  2    1.500000
```

(continues on next page)
• Infer and downcast dtype if downcast='infer' is passed to fillna/ffill/bfill (GH4604)

• __nonzero__ for all NDFrame objects, will now raise a ValueError, this reverts back to (GH1073, GH4633) behavior. See gotchas for a more detailed discussion.

This prevents doing boolean comparison on entire pandas objects, which is inherently ambiguous. These all will raise a ValueError.

```python
if df:
    ....
df1 and df2
s1 and s2
```

Added the .bool() method to NDFrame objects to facilitate evaluating of single-element boolean Series:

```python
In [1]: Series([True]).bool()
Out[1]: True

In [2]: Series([False]).bool()
Out[2]: False

In [3]: DataFrame([[True]]).bool()
Out[3]: True

In [4]: DataFrame([[False]]).bool()
Out[4]: False
```

• All non-Index NDFrames (Series, DataFrame, Panel, Panel4D, SparsePanel, etc.), now support the entire set of arithmetic operators and arithmetic flex methods (add, sub, mul, etc.). SparsePanel does not support pow or mod with non-scalars. (GH3765)

• Series and DataFrame now have a mode() method to calculate the statistical mode(s) by axis/Series. (GH5367)

• Chained assignment will now by default warn if the user is assigning to a copy. This can be changed with the option mode.chained_assignment, allowed options are raise/warn/None. See the docs.

```python
In [5]: dfc = DataFrame({'A': ['aaa', 'bbb', 'ccc'], 'B': [1, 2, 3]})
In [6]: pd.set_option('chained_assignment', 'warn')
```

The following warning / exception will show if this is attempted.

```python
In [7]: dfc.loc[0]['A'] = 1111
Traceback (most recent call last)
  ...  
SettingWithCopyWarning:
    A value is trying to be set on a copy of a slice from a DataFrame.
    Try using .loc[row_index,col_indexer] = value instead
```

Here is the correct method of assignment.
In [8]: dfc.loc[0, 'A'] = 11

In [9]: dfc
Out[9]:
     A  B
0   11  1
1  bbb  2
2   ccc  3

[3 rows x 2 columns]

• Panel.reindex has the following call signature Panel.reindex(items=None, major_axis=None, minor_axis=None, **kwargs) to conform with other NDFrame objects. See Internal Refactoring for more information.

• Series.argmin and Series.argmax are now aliased to Series.idxmin and Series.idxmax. These return the index of the min or max element respectively. Prior to 0.13.0 these would return the position of the min / max element. (GH6214)

1.26.2 Prior Version Deprecations/Changes

These were announced changes in 0.12 or prior that are taking effect as of 0.13.0

• Remove deprecated Factor (GH3650)
• Remove deprecated set_printoptions/reset_printoptions (GH3046)
• Remove deprecated _verbose_info (GH3215)
• Remove deprecated read_clipboard/to_clipboard/ExcelFile/ExcelWriter from pandas.io.parsers (GH3717) These are available as functions in the main pandas namespace (e.g. pd.read_clipboard)
• default for tupleize_cols is now False for both to_csv and read_csv. Fair warning in 0.12 (GH3604)
• default for display.max_seq_len is now 100 rather then None. This activates truncated display (“…” of long sequences in various places. (GH3391)

1.26.3 Deprecations

Deprecated in 0.13.0

• deprecated iterkv, which will be removed in a future release (this was an alias of iteritems used to bypass 2to3’s changes). (GH4384, GH4375, GH4372)

• deprecated the string method match, whose role is now performed more idiomatically by extract. In a future release, the default behavior of match will change to become analogous to contains, which returns a boolean indexer. (Their distinction is strictness: match relies on re.match while contains relies on re.search.) In this release, the deprecated behavior is the default, but the new behavior is available through the keyword argument as_indexer=True.

1.26.4 Indexing API Changes

Prior to 0.13, it was impossible to use a label indexer (.loc/.ix) to set a value that was not contained in the index of a particular axis. (GH2578). See the docs

In the Series case this is effectively an appending operation
In [10]: s = Series([1,2,3])

In [11]: s
Out[11]:
0  1
1  2
2  3
Length: 3, dtype: int64


In [13]: s
Out[13]:
0  1.0
1  2.0
2  3.0
5  5.0
Length: 4, dtype: float64

In [14]: dfi = DataFrame(np.arange(6).reshape(3,2),
   ....:     columns=['A','B'])
   ....:

In [15]: dfi
Out[15]:
   A  B
0  0  1
1  2  3
2  4  5
[3 rows x 2 columns]

This would previously KeyError

In [16]: dfi.loc[:, 'C'] = dfi.loc[:, 'A']

In [17]: dfi
Out[17]:
   A  B  C
0  0  1  0
1  2  3  2
2  4  5  4
[3 rows x 3 columns]

This is like an append operation.

In [18]: dfi.loc[3] = 5

In [19]: dfi
Out[19]:
   A  B  C
0  0  1  0
1  2  3  2
2  4  5  4
3  5  5  5

(continues on next page)
A Panel setting operation on an arbitrary axis aligns the input to the Panel

```
In [20]: p = pd.Panel(np.arange(16).reshape(2,4,2),
                   items=['Item1','Item2'],
                   major_axis=pd.date_range('2001/1/12',periods=4),
                   minor_axis=['A','B'],dtype='float64')
```

```
In [21]: p
Out[21]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 4 (major_axis) x 2 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2001-01-12 00:00:00 to 2001-01-15 00:00:00
Minor_axis axis: A to B
```

```
In [22]: p.loc[:,:,'C'] = Series([30,32],index=p.items)
```

```
In [23]: p
Out[23]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 4 (major_axis) x 3 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2001-01-12 00:00:00 to 2001-01-15 00:00:00
Minor_axis axis: A to C
```

```
In [24]: p.loc[:,:,'C']
```

```
   Item1  Item2
2001-01-12   30.0   32.0
2001-01-13   30.0   32.0
2001-01-14   30.0   32.0
2001-01-15   30.0   32.0
```

1.26.5 Float64Index API Change

- Added a new index type, Float64Index. This will be automatically created when passing floating values in index creation. This enables a pure label-based slicing paradigm that makes [],ix,loc for scalar indexing and slicing work exactly the same. See the docs, (GH263)

Construction is by default for floating type values.

```
In [25]: index = Index([1.5, 2, 3, 4.5, 5])
In [26]: index
Out[26]: Float64Index([1.5, 2.0, 3.0, 4.5, 5.0], dtype='float64')
In [27]: s = Series(range(5),index=index)
In [28]: s
```

(continues on next page)
Scalar selection for [], `.ix`, `.loc` will always be label based. An integer will match an equal float index (e.g. 3 is equivalent to 3.0)

The only positional indexing is via `iloc`

A scalar index that is not found will raise `KeyError`

Slicing is ALWAYS on the values of the index, for [], `.ix`, `.loc` and ALWAYS positional with `iloc`

In float indexes, slicing using floats are allowed
Indexing on other index types are preserved (and positional fallback for [], ix), with the exception, that floating point slicing on indexes on non Float64Index will now raise a TypeError.

In [1]: Series(range(5))[3.5]
TypeError: the label [3.5] is not a proper indexer for this index type
→(Int64Index)

In [1]: Series(range(5))[3.5:4.5]
TypeError: the slice start [3.5] is not a proper indexer for this index type
→(Int64Index)

Using a scalar float indexer will be deprecated in a future version, but is allowed for now.

In [3]: Series(range(5))[3.0]
Out[3]:

1.26.6 HDFStore API Changes

• Query Format Changes. A much more string-like query format is now supported. See the docs.

In [37]: path = 'test.h5'

In [38]: dfq = DataFrame(randn(10,4),
    ....: columns=list('ABCD'),
    ....: index=date_range('20130101',periods=10))
    ....:

In [39]: dfq.to_hdf(path,'dfq',format='table',data_columns=True)

Use boolean expressions, with in-line function evaluation.

In [40]: read_hdf(path,'dfq',
    ....: where="index>Timestamp('20130104') & columns=['A', 'B']")
    ....:

Out[40]:

Use an inline column reference

In [41]: read_hdf(path,'dfq',
    ....: where="A>0 or C>0")
    ....:

Out[41]:

(continues on next page)
• the **format** keyword now replaces the **table** keyword; allowed values are **fixed(f)** or **table(t)** the same defaults as prior < 0.13.0 remain, e.g. put implies fixed format and append implies table format. This default format can be set as an option by setting **io.hdf.default_format**.

```
In [42]: path = 'test.h5'
In [43]: df = pd.DataFrame(np.random.randn(10,2))
In [44]: df.to_hdf(path,'df_table',format='table')
In [45]: df.to_hdf(path,'df_table2',append=True)
In [46]: df.to_hdf(path,'df_fixed')
In [47]: with pd.HDFStore(path) as store: ....:     print(store) ....: <class 'pandas.io.pytables.HDFStore'> File path: test.h5
```

• Significant table writing performance improvements

• handle a passed **Series** in table format (**GH4330**)  

• can now serialize a **timedelta64 [ns]** dtype in a table (**GH3577**), See the docs.

• added an **is_open** property to indicate if the underlying file handle is_open; a closed store will now report 'CLOSED' when viewing the store (rather than raising an error) (**GH4409**)  

• a close of a HDFStore now will close that instance of the HDFStore but will only close the actual file if the ref count (by PyTables) w.r.t. all of the open handles are 0. Essentially you have a local instance of HDFStore referenced by a variable. Once you close it, it will report closed. Other references (to the same file) will continue to operate until they themselves are closed. Performing an action on a closed file will raise ClosedFileError

```
In [48]: path = 'test.h5'
In [49]: df = DataFrame(randn(10,2))
In [50]: store1 = HDFStore(path)
In [51]: store2 = HDFStore(path)
In [52]: store1.append('df',df)
```

(continues on next page)
In [53]: store2.append('df2', df)

In [54]: store1

Out[54]:
<class 'pandas.io.pytables.HDFStore'>
File path: test.h5

In [55]: store2

Out[55]:
<class 'pandas.io.pytables.HDFStore'>
File path: test.h5

In [56]: store1.close()

In [57]: store2

Out[57]:
<class 'pandas.io.pytables.HDFStore'>
File path: test.h5

In [58]: store2.close()

In [59]: store2

Out[59]:
<class 'pandas.io.pytables.HDFStore'>
File path: test.h5

- removed the _quiet attribute, replace by a DuplicateWarning if retrieving duplicate rows from a table (GH4367)
- removed the warn argument from open. Instead a PossibleDataLossError exception will be raised if you try to use mode='w' with an OPEN file handle (GH4367)
- allow a passed locations array or mask as a where condition (GH4467). See the docs for an example.
- add the keyword dropna=True to append to change whether ALL nan rows are not written to the store (default is True, ALL nan rows are NOT written), also settable via the option io.hdf.dropna_table (GH4625)
- pass thru store creation arguments; can be used to support in-memory stores

**1.26.7 DataFrame repr Changes**

The HTML and plain text representations of DataFrame now show a truncated view of the table once it exceeds a certain size, rather than switching to the short info view (GH4886, GH5550). This makes the representation more consistent as small DataFrames get larger.
To get the info view, call `DataFrame.info()`. If you prefer the info view as the repr for large DataFrames, you can set this by running `set_option('display.large_repr', 'info')`.

### 1.26.8 Enhancements

- `df.to_clipboard()` learned a new excel keyword that let’s you paste df data directly into excel (enabled by default). (GH5070).
- `read_html` now raises a `URLError` instead of catching and raising a `ValueError` (GH4303, GH4305)
- Added a test for `read_clipboard()` and `to_clipboard()` (GH4282)
- Clipboard functionality now works with PySide (GH4282)
- Added a more informative error message when plot arguments contain overlapping color and style arguments (GH4402)
- `to_dict` now takes `records` as a possible outtype. Returns an array of column-keyed dictionaries. (GH4936)
- NaN handing in `get_dummies` (GH4446) with `dummy_na`

```
# previously, nan was erroneously counted as 2 here
# now it is not counted at all
In [60]: get_dummies([1, 2, np.nan])
Out[60]:
   1.0  2.0
 0   1   0
 1   0   1
 2   0   0

[3 rows x 2 columns]
```

```
# unless requested
In [61]: get_dummies([1, 2, np.nan], dummy_na=True)
Out[61]:
   1.0  2.0   NaN
 0   1   0   0
 1   0   1   0
 2   0   0   1

[3 rows x 3 columns]
```

- `timedelta64[ns]` operations. See the docs.
Warning: Most of these operations require numpy >= 1.7

Using the new top-level `to_timedelta`, you can convert a scalar or array from the standard timedelta format (produced by `to_csv`) into a timedelta type (`np.timedelta64` in nanoseconds).

```python
In [62]: to_timedelta('1 days 06:05:01.00003')
Out[62]: Timedelta('1 days 06:05:01.000030')

In [63]: to_timedelta('15.5us')
Out[63]: Timedelta('0 days 00:00:00.000015')

In [64]: to_timedelta(['1 days 06:05:01.00003','15.5us','nan'])
Out[64]: TimedeltaIndex(['1 days 06:05:01.000030', '0 days 00:00:00.000015', NaT], dtype='timedelta64[ns]', freq=None)

In [65]: to_timedelta(np.arange(5),unit='s')
Out[65]: TimedeltaIndex(['00:00:00', '00:00:01', '00:00:02', '00:00:03', '00:00:04'], dtype='timedelta64[ns]', freq=None)

In [66]: to_timedelta(np.arange(5),unit='d')
Out[66]: TimedeltaIndex(['0 days', '1 days', '2 days', '3 days', '4 days'], dtype='timedelta64[ns]', freq=None)
```

A Series of dtype `timedelta64[ns]` can now be divided by another `timedelta64[ns]` object, or astyped to yield a `float64` dtyped Series. This is frequency conversion. See the docs for the docs.

```python
In [67]: from datetime import timedelta

In [68]: td = Series(date_range('20130101',periods=4))-Series(date_range('20121201',periods=4))

In [69]: td[2] += np.timedelta64(timedelta(minutes=5,seconds=3))

In [70]: td[3] = np.nan

In [71]: td
Out[71]:
0  31 days 00:00:00
1  31 days 00:00:00
2  31 days 00:05:03
3  NaT
Length: 4, dtype: timedelta64[ns]

# to days
In [72]: td / np.timedelta64(1,'D')
```

(continues on next page)
Dividing or multiplying a `timedelta64[ns]` Series by an integer or integer Series

```
In [76]: td * -1
Out[76]:
0   -31 days +00:00:00
1   -31 days +00:00:00
2   -32 days +23:54:57
3      NaT
Length: 4, dtype: timedelta64[ns]
```

```
In [77]: td * Series([1,2,3,4])
Out[77]:
0   31 days 00:00:00
1   62 days 00:00:00
2   93 days 00:15:09
3      NaT
Length: 4, dtype: timedelta64[ns]
```

Absolute DateOffset objects can act equivalently to `timedeltas`

```
In [78]: from pandas import offsets

In [79]: td + offsets.Minute(5) + offsets.Milli(5)
Out[79]:
0   31 days 00:05:00.005000
1   31 days 00:05:00.005000
2   31 days 00:10:03.005000
```

(continues on next page)
Fillna is now supported for timedeltas

```
In [80]: td.fillna(0)
Out[80]:
0   31 days 00:00:00
1   31 days 00:00:00
2   31 days 00:05:03
3     0 days 00:00:00
Length: 4, dtype: timedelta64[ns]

In [81]: td.fillna(timedelta(days=1, seconds=5))
```

You can do numeric reduction operations on timedeltas.

```
In [82]: td.mean()
Out[82]: Timedelta('31 days 00:01:41')

In [83]: td.quantile(.1)
```

- `plot(kind='kde')` now accepts the optional parameters `bw_method` and `ind`, passed to `scipy.stats.gaussian_kde()` (for scipy >= 0.11.0) to set the bandwidth, and to `gkde.evaluate()` to specify the indices at which it is evaluated, respectively. See scipy docs. (GH4298)
- DataFrame constructor now accepts a numpy masked record array (GH3478)
- The new vectorized string method `extract` return regular expression matches more conveniently.

```
In [84]: Series(['a1', 'b2', 'c3']).str.extract('[ab](\d)')
Out[84]:
0   a 1
1   b 2
2   NaN
[3 rows x 1 columns]

Elements that do not match return NaN. Extracting a regular expression with more than one group returns a DataFrame with one column per group.

```
In [85]: Series(['a1', 'b2', 'c3']).str.extract('([ab])(\d)')
Out[85]:
0   a 1
1   b 2
2  NaN NaN
```

(continues on next page)
Elements that do not match return a row of NaN. Thus, a Series of messy strings can be converted into a like-indexed Series or DataFrame of cleaned-up or more useful strings, without necessitating get() to access tuples or re.match objects.

Named groups like

```python
In [86]: Series(['a1', 'b2', 'c3']).str.extract(
    ....:    '(?P<letter>[ab])(?P<digit>\d)')
Out[86]:
    letter digit
   0    a    1
   1    b    2
   2  NaN   NaN
```

and optional groups can also be used.

```python
In [87]: Series(['a1', 'b2', '3']).str.extract(
    ....:    '(?P<letter>[ab]?)(?P<digit>\d)')
Out[87]:
    letter digit
   0    a    1
   1    b    2
   2  NaN    3
```

- `read_stata` now accepts Stata 13 format (GH4291)
- `read_fwf` now infers the column specifications from the first 100 rows of the file if the data has correctly separated and properly aligned columns using the delimiter provided to the function (GH4488).
- support for nanosecond times as an offset

**Warning:** These operations require `numpy >= 1.7`

Period conversions in the range of seconds and below were reworked and extended up to nanoseconds. Periods in the nanosecond range are now available.

```python
In [88]: date_range('2013-01-01', periods=5, freq='5N')
Out[88]:
DatetimeIndex([ '2013-01-01 00:00:00',
    '2013-01-01 00:00:00.000000005',
    '2013-01-01 00:00:00.000000010',
    '2013-01-01 00:00:00.000000015',
    '2013-01-01 00:00:00.000000020'],
   dtype='datetime64[ns]', freq='5N')
```

or with frequency as offset
In [89]: date_range('2013-01-01', periods=5, freq=pd.offsets.Nano(5))
Out[89]:
DatetimeIndex(['2013-01-01 00:00:00',
                '2013-01-01 00:00:00.000000005',
                '2013-01-01 00:00:00.000000010',
                '2013-01-01 00:00:00.000000015',
                '2013-01-01 00:00:00.000000020'],
dtype='datetime64[ns]', freq='5N')

Timestamps can be modified in the nanosecond range

In [90]: t = Timestamp('20130101 09:01:02')
In [91]: t + pd.tseries.offsets.Nano(123)
Out[91]: Timestamp('2013-01-01 09:01:02.000000123')

• A new method, `isin` for DataFrames, which plays nicely with boolean indexing. The argument to `isin`, what we’re comparing the DataFrame to, can be a DataFrame, Series, dict, or array of values. See the docs for more.

To get the rows where any of the conditions are met:

In [92]: dfi = DataFrame({'A': [1, 2, 3, 4], 'B': ['a', 'b', 'f', 'n']})
In [93]: dfi
Out[93]:
  A B
0 1 a
1 2 b
2 3 f
3 4 n

[4 rows x 2 columns]

In [94]: other = DataFrame({'A': [1, 3, 3, 7], 'B': ['e', 'f', 'f', 'e']})
In [95]: mask = dfi.isin(other)
In [96]: mask
Out[96]:
  A   B
0  True False
1  False False
2   True  True
3  False  False

[4 rows x 2 columns]

In [97]: dfi[mask.any(1)]

→
  A B
0 1 a
2 3 f

[2 rows x 2 columns]

• Series now supports a `to_frame` method to convert it to a single-column DataFrame (GH5164)

• All R datasets listed here http://stat.ethz.ch/R-manual/R-devel/library/datasets/html/00Index.html can now be
loaded into Pandas objects

```python
# note that pandas.rpy was deprecated in v0.16.0
import pandas.rpy.common as com
com.load_data('Titanic')
```

- `tz_localize` can infer a fall daylight savings transition based on the structure of the unlocalized data (GH4230), see [the docs](#)
- `DatetimeIndex` is now in the API documentation, see [the docs](#)
- `json_normalize()` is a new method to allow you to create a flat table from semi-structured JSON data. See [the docs](#)
- Added PySide support for the qtpandas DataFrameModel and DataFrameWidget.
- Python csv parser now supports usecols (GH4335)
- Frequencies gained several new offsets:
  - `LastWeekOfMonth` (GH4637)
  - `FY5253`, and `FY5253Quarter` (GH4511)
- DataFrame has a new `interpolate` method, similar to Series (GH4434, GH1892)

```python
In [98]: df = DataFrame({'A': [1, 2.1, np.nan, 4.7, 5.6, 6.8],
                   'B': [.25, np.nan, np.nan, 4, 12.2, 14.4]})
...
In [99]: df.interpolate()
```

Additionally, the method argument to `interpolate` has been expanded to include 'nearest', 'zero', 'slinear', 'quadratic', 'cubic', 'barycentric', 'krogh', 'piecewise_polynomial', 'pchip', 'polynomial', 'spline'. The new methods require scipy. Consult the Scipy reference guide and documentation for more information about when the various methods are appropriate. See [the docs](#).

Interpolate now also accepts a `limit` keyword argument. This works similar to `fillna`'s limit:

```python
In [100]: ser = Series([1, 3, np.nan, np.nan, np.nan, 11])
In [101]: ser.interpolate(limit=2)
```

1.26. v0.13.0 (January 3, 2014) 379
• Added `wide_to_long` panel data convenience function. See the docs.

```
In [102]: np.random.seed(123)

In [103]: df = pd.DataFrame({
     ....:     "A1970" : ["a", "b", "c"],
     ....:     "A1980" : ["d", "e", "f"],
     ....:     "B1970" : [2.5, 1.2, 0.7],
     ....:     "B1980" : [3.2, 1.3, 0.1],
     ....:     "X" : dict(zip(range(3), np.random.randn(3)))
     ....:     })

In [104]: df["id"] = df.index

In [105]: df
Out[105]:
0     a     d     2.5    3.2 -1.085631 0
1     b     e     1.2    1.3  0.997345 1
2     c     f     0.7    0.1  0.282978 2

[3 rows x 6 columns]

In [106]: wide_to_long(df, ["A", "B"], i="id", j="year")

<table>
<thead>
<tr>
<th>id year</th>
<th>X</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 1970</td>
<td>-1.085631 a 2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 1970</td>
<td>0.997345 b 1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 1980</td>
<td>0.282978 c 0.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 1980</td>
<td>-1.085631 d 3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 1980</td>
<td>0.997345 e 1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 1980</td>
<td>0.282978 f 0.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[6 rows x 3 columns]

• `to_csv` now takes a `date_format` keyword argument that specifies how output datetime objects should be formatted. Datetimes encountered in the index, columns, and values will all have this formatting applied. (GH4313)

• `DataFrame.plot` will scatter plot x versus y by passing `kind='scatter'` (GH2215)

• Added support for Google Analytics v3 API segment IDs that also supports v2 IDs. (GH5271)

1.26.9 Experimental

• The new `eval()` function implements expression evaluation using `numexpr` behind the scenes. This results in large speedups for complicated expressions involving large DataFrames/Series. For example,
# eval with NumExpr backend

```python
In [109]: %timeit pd.eval('df1 + df2 + df3 + df4')
8.07 ms +- 212 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

# pure Python evaluation

```python
In [110]: %timeit df1 + df2 + df3 + df4
11.4 ms +- 752 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

For more details, see the [docs](#).

- Similar to pandas.eval, DataFrame has a new DataFrame.eval method that evaluates an expression in the context of the DataFrame. For example,

  ```python
  In [111]: df = DataFrame(randn(10, 2), columns=['a', 'b'])
  In [112]: df.eval('a + b')
  Out[112]:
   0   -0.685204
   1    1.589745
   2    0.325441
   3   -1.784153
   4    0.432893
   5    0.171850
   6    1.895919
   7    3.065587
   8   -0.092759
   9    1.391365
Length: 10, dtype: float64
  ```

- `query()` method has been added that allows you to select elements of a DataFrame using a natural query syntax nearly identical to Python syntax. For example,

  ```python
  In [113]: n = 20
  In [114]: df = DataFrame(np.random.randint(n, size=(n, 3)), columns=['a', 'b', 'c'])
  In [115]: df.query('a < b < c')
  Out[115]:
    a  b  c
   11 1   5  8
   15 8  16 19
  [2 rows x 3 columns]
  ```

selects all the rows of df where `a < b < c` evaluates to `True`. For more details see the [docs](#).

- `pd.read_msgpack()` and `pd.to_msgpack()` are now a supported method of serialization of arbitrary pandas (and python objects) in a lightweight portable binary format. See [docs](#).

**Warning**: Since this is an EXPERIMENTAL LIBRARY, the storage format may not be stable until a future release.

```python
In [116]: df = DataFrame(np.random.rand(5,2),columns=list('AB'))
```

(continues on next page)
In [117]: df.to_msgpack('foo.msg')

In [118]: pd.read_msgpack('foo.msg')
Out[118]:
   A     B
0 0.251082 0.017357
1 0.347915 0.929879
2 0.546233 0.203368
3 0.064942 0.031722
4 0.355309 0.524575

[5 rows x 2 columns]

In [119]: s = Series(np.random.rand(5), index=date_range('20130101', periods=5))

In [120]: pd.to_msgpack('foo.msg', df, s)

In [121]: pd.read_msgpack('foo.msg')
Out[121]:
   A     B
0 0.251082 0.017357
1 0.347915 0.929879
2 0.546233 0.203368
3 0.064942 0.031722
4 0.355309 0.524575
Freq: D, Length: 5, dtype: float64

You can pass iterator=True to iterator over the unpacked results

In [122]: for o in pd.read_msgpack('foo.msg', iterator=True):
    print(o)
    
    A     B
    0 0.251082 0.017357
    1 0.347915 0.929879
    2 0.546233 0.203368
    3 0.064942 0.031722
    4 0.355309 0.524575
    
    [5 rows x 2 columns]
    2013-01-01 0.227025
    2013-01-02 0.383282
    2013-01-03 0.193225
    2013-01-04 0.110977
    Freq: D, Length: 5, dtype: float64

• pandas.io.gbq provides a simple way to extract from, and load data into, Google’s BigQuery Data Sets by way of pandas DataFrames. BigQuery is a high performance SQL-like database service, useful for performing ad-hoc queries against extremely large datasets. See the docs
from pandas.io import gbq

# A query to select the average monthly temperatures in the
# in the year 2000 across the USA. The dataset,
# publicdata:samples.gsod, is available on all BigQuery accounts,
# and is based on NOAA gsod data.

query = """SELECT station_number as STATION,
month as MONTH, AVG(mean_temp) as MEAN_TEMP
FROM publicdata:samples.gsod
WHERE YEAR = 2000
GROUP BY STATION, MONTH
ORDER BY STATION, MONTH ASC""

# Fetch the result set for this query
# Your Google BigQuery Project ID
# To find this, see your dashboard:
# https://console.developers.google.com/iam-admin/projects?authuser=0
projectid = xxxxxxxxx;

df = gbq.read_gbq(query, project_id = projectid)

# Use pandas to process and reshape the dataset

df2 = df.pivot(index='STATION', columns='MONTH', values='MEAN_TEMP')
df3 = pandas.concat([df2.min(), df2.mean(), df2.max()],
                                 axis=1,keys=['Min Tem', "Mean Temp", "Max Temp"])

The resulting DataFrame is:

```
> df3
       Min Tem  Mean Temp  Max Temp
MONTH
 1   -53.336667   39.827892   89.770968
 2   -49.837500   43.685219   93.437932
 3   -77.926087   48.708355   96.099998
 4   -82.892858   55.070087   97.317240
 5   -92.378261   61.428117  102.042856
 6   -77.703334   65.858888  102.900000
 7   -87.821428  68.169663  106.510714
 8   -89.431999  68.614215  105.500000
 9   -86.611112  63.436935  107.142856
 10  -78.209677  56.880838  92.103333
 11  -50.125000  48.861228  94.996428
 12  -50.332258  42.286879  94.396774
```

Warning: To use this module, you will need a BigQuery account. See <https://cloud.google.com/products/big-query> for details.

As of 10/10/13, there is a bug in Google’s API preventing result sets from being larger than 100,000 rows. A patch is scheduled for the week of 10/14/13.
1.26.10 Internal Refactoring

In 0.13.0 there is a major refactor primarily to subclass Series from NDFrame, which is the base class currently for DataFrame and Panel, to unify methods and behaviors. Series formerly subclassed directly from ndarray. (GH4080, GH3862, GH816)

**Warning:** There are two potential incompatibilities from < 0.13.0

- Using certain numpy functions would previously return a Series if passed a Series as an argument. This seems only to affect np.ones_like, np.empty_like, np.diff and np.where. These now return ndarrays.

```python
In [123]: s = Series([1,2,3,4])

Numpy Usage

In [124]: np.ones_like(s)
Out[124]: array([1, 1, 1, 1])

In [125]: np.diff(s)
Out[125]: array([1, 1, 1])

In [126]: np.where(s>1,s,np.nan)
Out[126]: array([ nan, 2., 3., 4.])
```

Pandonic Usage

```python
In [127]: Series(1,index=s.index)
Out[127]:
0 1
1 1
2 1
3 1
Length: 4, dtype: int64

In [128]: s.diff()
Out[128]:
0 NaN
1 1.0
2 1.0
3 1.0
Length: 4, dtype: float64

In [129]: s.where(s>1)
Out[129]:
0 NaN
1 2.0
2 3.0
3 4.0
Length: 4, dtype: float64
```

- Passing a Series directly to a cython function expecting an ndarray type will no long work directly, you must pass Series.values, See Enhancing Performance
- Series(0.5) would previously return the scalar 0.5, instead this will return a 1-element Series
- This change breaks rpy2<=2.3.8. an Issue has been opened against rpy2 and a workaround is detailed in GH5698. Thanks @JanSchulz.
• Pickle compatibility is preserved for pickles created prior to 0.13. These must be unpickled with pd.read_pickle, see Pickling.

• Refactor of series.py/frame.py/panel.py to move common code to generic.py
  – added _setup_axes to created generic NDFrame structures
  – moved methods
    * from_axes, _wrap_array, axes, ix, loc, iloc, shape, empty, swapaxes, transpose, pop
    * _iter__, keys, _contains__, _len__, _neg__, _invert__
    * convert_objects, as_blocks, as_matrix, values
    * __getstate__, __setstate__ (compat remains in frame/panel)
    * __getattr__, __setattr__
    * _indexed_same, reindex_like, align, where, mask
    * fillna, replace (Series replace is now consistent with DataFrame)
    * filter (also added axis argument to selectively filter on a different axis)
    * reindex, reindex_axis, take
    * truncate (moved to become part of NDFrame)

• These are API changes which make Panel more consistent with DataFrame
  – swapaxes on a Panel with the same axes specified now return a copy
  – support attribute access for setting
  – filter supports the same API as the original DataFrame filter

• Reindex called with no arguments will now return a copy of the input object

• TimeSeries is now an alias for Series. the property is_time_series can be used to distinguish (if desired)

• Refactor of Sparse objects to use BlockManager
  – Created a new block type in internals, SparseBlock, which can hold multi-dtypes and is non-consolidatable. SparseSeries and SparseDataFrame now inherit more methods from there hierarchy (Series/DataFrame), and no longer inherit from SparseArray (which instead is the object of the SparseBlock)
  – Sparse suite now supports integration with non-sparse data. Non-float sparse data is supportable (partially implemented)
  – Operations on sparse structures within DataFrames should preserve sparseness, merging type operations will convert to dense (and back to sparse), so might be somewhat inefficient
  – enable setitem on SparseSeries for boolean/integer/slices
  – SparsePanels implementation is unchanged (e.g. not using BlockManager, needs work)

• added ftypes method to Series/DataFrame, similar to dtypes, but indicates if the underlying is sparse/dense (as well as the dtype)

• All NDFrame objects can now use __finalize__() to specify various values to propagate to new objects from an existing one (e.g. name in Series will follow more automatically now)

• Internal type checking is now done via a suite of generated classes, allowing isinstance(value, klass) without having to directly import the klass, courtesy of @jtratner
• Bug in Series update where the parent frame is not updating its cache based on changes (GH4080) or types (GH3217), fillna (GH3386)
• Indexing with dtype conversions fixed (GH4463, GH4204)
• Refactor Series.reindex to core/generic.py (GH4604, GH4618), allow method= in reindexing on a Series to work
• Series.copy no longer accepts the order parameter and is now consistent with NDFrame copy
• Refactor rename methods to core/generic.py; fixes Series.rename for (GH4605), and adds rename with the same signature for Panel
• Refactor clip methods to core/generic.py (GH4798)
• Refactor of _get_numeric_data/_get_bool_data to core/generic.py, allowing Series/Panel functionality
• Series (for index) / Panel (for items) now allow attribute access to its elements (GH1903)

```
In [130]: s = Series([1,2,3],index=list('abc'))

In [131]: s.b
Out[131]: 2

In [132]: s.a = 5

In [133]: s
Out[133]:
   a 5
   b 2
   c 3
Length: 3, dtype: int64
```

1.26.11 Bug Fixes

See V0.13.0 Bug Fixes for an extensive list of bugs that have been fixed in 0.13.0.

See the full release notes or issue tracker on GitHub for a complete list of all API changes, Enhancements and Bug Fixes.

1.27 v0.12.0 (July 24, 2013)

This is a major release from 0.11.0 and includes several new features and enhancements along with a large number of bug fixes.

Highlights include a consistent I/O API naming scheme, routines to read html, write multi-indexes to csv files, read & write STATA data files, read & write JSON format files, Python 3 support for HDFStore, filtering of groupby expressions via filter, and a revamped replace routine that accepts regular expressions.

1.27.1 API changes

• The I/O API is now much more consistent with a set of top level reader functions accessed like pd.read_csv() that generally return a pandas object.
  - read_csv
- read_excel
- read_hdf
- read_sql
- read_json
- read_html
- read_stata
- read_clipboard

The corresponding writer functions are object methods that are accessed like df.to_csv()

- to_csv
- to_excel
- to_hdf
- to_sql
- to_json
- to_html
- to_stata
- to_clipboard

- Fix modulo and integer division on Series,DataFrames to act similarly to float dtypes to return np.nan or np.inf as appropriate (GH3590). This correct a numpy bug that treats integer and float dtypes differently.

```
In [1]: p = DataFrame({'first': [4,5,8], 'second': [0,0,3]})
In [2]: p % 0
Out[2]:
   first  second
0   NaN    NaN
1   NaN    NaN
2   NaN    NaN
[3 rows x 2 columns]
In [3]: p % p
    →
   first  second
0   0.0    NaN
1   0.0    NaN
2   0.0    0.0
[3 rows x 2 columns]
In [4]: p / p
    →
   first  second
0   1.0    NaN
1   1.0    NaN
2   1.0    1.0
```
pandas: powerful Python data analysis toolkit, Release 0.23.2

(continued from previous page)

[3 rows x 2 columns]

In [5]: p / 0
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
˓→

0
1
2

first
inf
inf
inf

second
NaN
NaN
inf

[3 rows x 2 columns]

• Add squeeze keyword to groupby to allow reduction from DataFrame -> Series if groups are unique. This
is a Regression from 0.10.1. We are reverting back to the prior behavior. This means groupby will return the
same shaped objects whether the groups are unique or not. Revert this issue (GH2893) with (GH3596).
In [6]: df2 = DataFrame([{"val1": 1, "val2" : 20}, {"val1":1, "val2": 19},
...:
{"val1":1, "val2": 27}, {"val1":1, "val2": 12}])
...:
In [7]: def func(dataf):
...:
return dataf["val2"]
...:

- dataf["val2"].mean()

# squeezing the result frame to a series (because we have unique groups)
In [8]: df2.groupby("val1", squeeze=True).apply(func)
Out[8]:
0
0.5
1
-0.5
2
7.5
3
-7.5
Name: 1, Length: 4, dtype: float64
# no squeezing (the default, and behavior in 0.10.1)
In [9]: df2.groupby("val1").apply(func)
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[9]:
˓→

val2
val1
1

0

1

0.5 -0.5

2

3

7.5 -7.5

[1 rows x 4 columns]

• Raise on iloc when boolean indexing with a label based indexer mask e.g. a boolean Series, even with integer
labels, will raise. Since iloc is purely positional based, the labels on the Series are not alignable (GH3631)
This case is rarely used, and there are plently of alternatives. This preserves the iloc API to be purely positional
based.
In [10]: df = DataFrame(lrange(5), list('ABCDE'), columns=['a'])
In [11]: mask = (df.a%2 == 0)
In [12]: mask
Out[12]:
A
True
(continues on next page)

388

Chapter 1. What’s New


df.iloc[mask] will raise a ValueError

- The `raise_on_error` argument to plotting functions is removed. Instead, plotting functions raise a `TypeError` when the `dtype` of the object is `object` to remind you to avoid `object` arrays whenever possible and thus you should cast to an appropriate numeric `dtype` if you need to plot something.

- Add `colormap` keyword to DataFrame plotting methods. Accepts either a matplotlib colormap object (ie, `matplotlib.cm.jet`) or a string name of such an object (ie, 'jet'). The colormap is sampled to select the color for each column. Please see `Colormaps` for more information. (GH3860)

- `DataFrame.interpolate()` is now deprecated. Please use `DataFrame.fillna()` and `DataFrame.replace()` instead. (GH3582, GH3675, GH3676)

- the `method` and `axis` arguments of `DataFrame.replace()` are deprecated

- `DataFrame.replace`'s `infer_types` parameter is removed and now performs conversion by default. (GH3907)

- Add the keyword `allow_duplicates` to `DataFrame.insert` to allow a duplicate column to be inserted if True, default is False (same as prior to 0.12) (GH3679)

- Implement `__nonzero__` for NDFrame objects (GH3691, GH3696)

- IO api

  - added top-level function `read_excel` to replace the following. The original API is deprecated and will be removed in a future version

```python
from pandas.io.parsers import ExcelFile
xls = ExcelFile('path_to_file.xls')
xls.parse('Sheet1', index_col=None, na_values=['NA'])
```
With

```python
import pandas as pd
pd.read_excel('path_to_file.xls', 'Sheet1', index_col=None, na_values=['NA'])
```

- added top-level function `read_sql` that is equivalent to the following

```python
from pandas.io.sql import read_frame
read_frame(....)
```

- DataFrame.to_html and DataFrame.to_latex now accept a path for their first argument (GH3702)
- Do not allow astypes on `datetime64[ns]` except to object, and `timedelta64[ns]` to object/int (GH3425)
- The behavior of `datetime64` dtypes has changed with respect to certain so-called reduction operations (GH3726). The following operations now raise a `TypeError` when performed on a Series and return an `empty` Series when performed on a DataFrame similar to performing these operations on, for example, a DataFrame of slice objects:
  - sum, prod, mean, std, var, skew, kurt, corr, and cov
- `read_html` now defaults to None when reading, and falls back on bs4 + html5lib when lxml fails to parse. a list of parsers to try until success is also valid
- The internal pandas class hierarchy has changed (slightly). The previous `PandasObject` now is called `PandasContainer` and a new `PandasObject` has become the baseclass for `PandasContainer` as well as `Index`, `Categorical`, `GroupBy`, `SparseList`, and `SparseArray` (+ their base classes). Currently, `PandasObject` provides string methods (from `StringMixin`). (GH4090, GH4092)
- New `StringMixin` that, given a `__unicode__` method, gets python 2 and python 3 compatible string methods (`__str__`, `__bytes__`, and `__repr__`). Plus string safety throughout. Now employed in many places throughout the pandas library. (GH4090, GH4092)

### 1.27.2 I/O Enhancements

- `pd.read_html()` can now parse HTML strings, files or urls and return DataFrames, courtesy of @cpcloud. (GH3477, GH3605, GH3606, GH3616). It works with a single parser backend: BeautifulSoup4 + html5lib See the docs

You can use `pd.read_html()` to read the output from DataFrame.to_html() like so

```python
In [15]: df = DataFrame({'a': range(3), 'b': list('abc')})

In [16]: print(df)
a b
0 0 a
1 1 b
2 2 c
[3 rows x 2 columns]
In [17]: html = df.to_html()
In [18]: alist = pd.read_html(html, index_col=0)
In [19]: print(df == alist[0])
a b
```

(continues on next page)
Note that **alist** here is a Python list so `pd.read_html()` and `DataFrame.to_html()` are not inverses.

- `pd.read_html()` no longer performs hard conversion of date strings (GH3656).

**Warning:** You may have to install an older version of BeautifulSoup4, [See the installation docs](#).

- Added module for reading and writing Stata files: `pandas.io.stata` (GH1512) accessible via `read_stata` top-level function for reading, and `to_stata` DataFrame method for writing, [See the docs](#).
- Added module for reading and writing json format files: `pandas.io.json` accessible via `read_json` top-level function for reading, and `to_json` DataFrame method for writing, [See the docs](#) various issues (GH1226, GH3804, GH3876, GH3867, GH1305)
- **MultiIndex** column support for reading and writing csv format files
  - The **header option** in `read_csv` now accepts a list of the rows from which to read the index.
  - The option, `tupleize_cols` can now be specified in both `to_csv` and `read_csv`, to provide compatibility for the pre 0.12 behavior of writing and reading **MultiIndex** columns via a list of tuples. The default in 0.12 is to write lists of tuples and **not** interpret list of tuples as a **MultiIndex** column.

  Note: The default behavior in 0.12 remains unchanged from prior versions, but starting with 0.13, the default to write and read **MultiIndex** columns will be in the new format. (GH3571, GH1651, GH3141)
- **If an index_col is not specified** (e.g. you don’t have an index, or wrote it with `df.to_csv(..., index=False)`), then any names on the columns index will be lost.

```python
In [20]: from pandas.util.testing import makeCustomDataframe as mkdf
In [21]: df = mkdf(5, 3, r_idx_nlevels=2, c_idx_nlevels=4)
In [22]: df.to_csv('mi.csv')
In [23]: print(open('mi.csv').read())
C0,,C_l0_g0,C_l0_g1,C_l0_g2
C1,,C_l1_g0,C_l1_g1,C_l1_g2
C2,,C_l2_g0,C_l2_g1,C_l2_g2
C3,,C_l3_g0,C_l3_g1,C_l3_g2
R0,R1,,
  R_l0_g0,R_l1_g0,R0C0,R0C1,R0C2
  R_l0_g1,R_l1_g1,R1C0,R1C1,R1C2
  R_l0_g2,R_l1_g2,R2C0,R2C1,R2C2
  R_l0_g3,R_l1_g3,R3C0,R3C1,R3C2
  R_l0_g4,R_l1_g4,R4C0,R4C1,R4C2

In [24]: pd.read_csv('mi.csv', header=[0,1,2,3], index_col=[0,1])
```

(continues on next page)
• Support for HDFStore (via PyTables 3.0.0) on Python3

• Iterator support via `read_hdf` that automatically opens and closes the store when iteration is finished. This is only for `tables`

```python
In [25]: path = 'store_iterator.h5'

In [26]: DataFrame(randn(10,2)).to_hdf(path,'df',table=True)

In [27]: for df in read_hdf(path,'df', chunksize=3):
    ....:     print df
    ....:
     0  1
  0  0.713216 -0.778461
  1 -0.661062  0.862877
  2  0.344342  0.149565
     0  1
  3 -0.626968 -0.875772
  4 -0.930687 -0.218983
  5  0.949965 -0.442354
     0  1
  6 -0.402985  1.113358
  7 -0.241527  0.670477
  8  0.049355  0.632633
     0  1
  9 -1.502767 -1.225492
```

• `read_csv` will now throw a more informative error message when a file contains no columns, e.g., all newline characters

### 1.27.3 Other Enhancements

• `DataFrame.replace()` now allows regular expressions on contained `Series` with object dtype. See the examples section in the regular docs *Replacing via String Expression*

For example you can do

```python
In [25]: df = DataFrame({'a': list('ab..'), 'b': [1, 2, 3, 4]})

In [26]: df.replace(regex=r'\s*\..\s*', value=np.nan)
Out[26]:
       a  b
 0   a  1
 1   b  2
```

(continues on next page)
[4 rows x 2 columns]

to replace all occurrences of the string '. ' with zero or more instances of surrounding whitespace with NaN. Regular string replacement still works as expected. For example, you can do

```
In [27]: df.replace('.', np.nan)
Out[27]:
  a  b
0  a  1
1  b  2
2  NaN  3
3  NaN  4
[4 rows x 2 columns]
```

to replace all occurrences of the string '. ' with NaN.

- `pd.melt()` now accepts the optional parameters `var_name` and `value_name` to specify custom column names of the returned DataFrame.
- `pd.set_option()` now allows N option, value pairs (GH3667).
  
  Let's say that we had an option 'a.b' and another option 'b.c'. We can set them at the same time:

```
In [28]: pd.get_option('a.b')
Out[28]: 2

In [29]: pd.get_option('b.c')
Out[29]: 3

In [30]: pd.set_option('a.b', 1, 'b.c', 4)

In [31]: pd.get_option('a.b')
Out[31]: 1

In [32]: pd.get_option('b.c')
Out[32]: 4
```

- The `filter` method for group objects returns a subset of the original object. Suppose we want to take only elements that belong to groups with a group sum greater than 2.

```
In [33]: sf = Series([1, 1, 2, 3, 3, 3])

In [34]: sf.groupby(sf).filter(lambda x: x.sum() > 2)
Out[34]:
          3
3  3
4  3
5  3
Length: 3, dtype: int64
```

The argument of `filter` must a function that, applied to the group as a whole, returns True or False. Another useful operation is filtering out elements that belong to groups with only a couple members.
In [35]:
dff = DataFrame({'A': np.arange(8), 'B': list('aabbbbcc')})

In [36]:
dff.groupby('B').filter(lambda x: len(x) > 2)
Out[36]:
     A  B
0    2  b
1    3  b
2    4  b
3    5  b

[4 rows x 2 columns]

Alternatively, instead of dropping the offending groups, we can return a like-indexed objects where the groups that do not pass the filter are filled with NaNs.

In [37]:
dff.groupby('B').filter(lambda x: len(x) > 2, dropna=False)
Out[37]:
     A  B
0  NaN NaN
1  NaN NaN
2  2.0  b
3  3.0  b
4  4.0  b
5  5.0  b
6  NaN NaN
7  NaN NaN

[8 rows x 2 columns]

- Series and DataFrame hist methods now take a figsize argument (GH3834)
- DatetimeIndexes no longer try to convert mixed-integer indexes during join operations (GH3877)
- Timestamp.min and Timestamp.max now represent valid Timestamp instances instead of the default datetime.min and datetime.max (respectively), thanks @SleepingPills
- read_html now raises when no tables are found and BeautifulSoup==4.2.0 is detected (GH4214)

### 1.27.4 Experimental Features

- Added experimental CustomBusinessDay class to support DateOffsets with custom holiday calendars and custom weekmasks. (GH2301)

Note: This uses the numpy.busdaycalendar API introduced in Numpy 1.7 and therefore requires Numpy 1.7.0 or newer.

In [38]:
   from pandas.tseries.offsets import CustomBusinessDay

In [39]:
   from datetime import datetime

# As an interesting example, let's look at Egypt where
# a Friday-Saturday weekend is observed.
In [40]:
   weekmask_egypt = 'Sun Mon Tue Wed Thu'

# They also observe International Workers' Day so let's
# add that for a couple of years
In [41]: holidays = ['2012-05-01', datetime(2013, 5, 1), np.datetime64('2014-05-01 →')]

In [42]: bday_egypt = CustomBusinessDay(holidays=holidays, weekmask=weekmask_ →egypt)

In [43]: dt = datetime(2013, 4, 30)

In [44]: print (dt + 2 * bday_egypt)
2013-05-05 00:00:00

In [45]: dts = date_range(dt, periods=5, freq=bday_egypt)

In [46]: print(Series(dts.weekday, dts).map(Series('Mon Tue Wed Thu Fri Sat Sun'. →split())))
2013-04-30 Tue
2013-05-02 Thu
2013-05-05 Sun
2013-05-06 Mon
2013-05-07 Tue
Freq: C, Length: 5, dtype: object

1.27.5 Bug Fixes

- Plotting functions now raise a TypeError before trying to plot anything if the associated objects have have a
dtype of object (GH1818, GH3572, GH3911, GH3912), but they will try to convert object arrays to numeric
arrays if possible so that you can still plot, for example, an object array with floats. This happens before any
drawing takes place which eliminates any spurious plots from showing up.

- fillna methods now raise a TypeError if the value parameter is a list or tuple.

- Series.str now supports iteration (GH3638). You can iterate over the individual elements of each string in
the Series. Each iteration yields yields a Series with either a single character at each index of the original
Series or NaN. For example,

In [47]: strs = 'go', 'bow', 'joe', 'slow'

In [48]: ds = Series(strs)

In [49]: for s in ds.str:
   ....:     print(s)
   ....:
0  g
1  b
2  j
3  s
Length: 4, dtype: object
0  o
1  o
2  o
3  l
Length: 4, dtype: object
0  NaN
1  w
(continues on next page)
The last element yielded by the iterator will be a `Series` containing the last element of the longest string in the `Series` with all other elements being NaN. Here since 'slow' is the longest string and there are no other strings with the same length 'w' is the only non-null string in the yielded `Series`.

- HDFStore
  - will retain index attributes (freq.tz.name) on recreation (GH3499)
  - will warn with an `AttributeConflictWarning` if you are attempting to append an index with a different frequency than the existing, or attempting to append an index with a different name than the existing
  - support datelike columns with a timezone as data_columns (GH2852)

- Non-unique index support clarified (GH3468).
  - Fix assigning a new index to a duplicate index in a DataFrame would fail (GH3468)
  - Fix construction of a DataFrame with a duplicate index
  - `ref_locs` support to allow duplicative indices across dtypes, allows `iget` support to always find the index (even across dtypes) (GH2194)
  - `applymap` on a DataFrame with a non-unique index now works (removed warning) (GH2786), and fix (GH3230)
  - Fix to `.csv` to handle non-unique columns (GH3495)
  - Duplicate indexes with getitem will return items in the correct order (GH3455, GH3457) and handle missing elements like unique indices (GH3561)
  - Duplicate indexes with and empty DataFrame.from_records will return a correct frame (GH3562)
  - Concat to produce a non-unique columns when duplicates are across dtypes is fixed (GH3602)
  - Allow insert/delete to non-unique columns (GH3679)
  - Non-unique indexing with a slice via `loc` and friends fixed (GH3659)
  - Allow insert/delete to non-unique columns (GH3679)
- Extend `reindex` to correctly deal with non-unique indices (GH3679)
- `DataFrame.itertuples()` now works with frames with duplicate column names (GH3873)
- Bug in non-unique indexing via `iloc` (GH4017); added takeable argument to `reindex` for location-based taking
- Allow non-unique indexing in series via `.ix/.loc` and `__getitem__` (GH4246)
- Fixed non-unique indexing memory allocation issue with `.ix/.loc` (GH4280)

- `DataFrame.from_records` did not accept empty recarrays (GH3682)
- `read_html` now correctly skips tests (GH3741)
- Fixed a bug where `DataFrame.replace` with a compiled regular expression in the `to_replace` argument wasn’t working (GH3907)
- Improved network test decorator to catch `IOError` (and therefore `URLError` as well). Added `with_connectivity_check` decorator to allow explicitly checking a website as a proxy for seeing if there is network connectivity. Plus, new `optional_args` decorator factory for decorators. (GH3910, GH3914)
- Fixed testing issue where too many sockets where open thus leading to a connection reset issue (GH3982, GH3985, GH4028, GH4054)
- Fixed failing tests in test_yahoo, test_google where symbols were not retrieved but were being accessed (GH3982, GH3985, GH4028, GH4054)
- `Series.hist` will now take the figure from the current environment if one is not passed
- Fixed bug where a 1xN DataFrame would barf on a 1xN mask (GH4071)
- Fixed running of `tox` under python3 where the pickle import was getting rewritten in an incompatible way (GH4062, GH4063)
- Fixed bug where `sharex` and `sharey` were not being passed to `grouped_hist` (GH4089)
- Fixed bug in `DataFrame.replace` where a nested dict wasn’t being iterated over when `regex=False` (GH4115)
- Fixed bug in the parsing of microseconds when using the `format` argument in `to_datetime` (GH4152)
- Fixed bug in `PandasAutoDateLocator` where `invert_xaxis` triggered incorrectly `MilliSecondLocator` (GH3990)
- Fixed bug in plotting that wasn’t raising on invalid colormap for matplotlib 1.1.1 (GH4215)
- Fixed the legend displaying in `DataFrame.plot` (`kind='kde'`) (GH4216)
- Fixed bug where Index slices weren’t carrying the name attribute (GH4226)
- Fixed bug in initializing `DatetimeIndex` with an array of strings in a certain time zone (GH4229)
- Fixed bug where `html5lib` wasn’t being properly skipped (GH4265)
- Fixed bug where `get_data_famafrench` wasn’t using the correct file edges (GH4281)

See the full release notes or issue tracker on GitHub for a complete list.

1.28  v0.11.0 (April 22, 2013)

This is a major release from 0.10.1 and includes many new features and enhancements along with a large number of bug fixes. The methods of Selecting Data have had quite a number of additions, and Dtype support is now full-fledged. There are also a number of important API changes that long-time pandas users should pay close attention to.
There is a new section in the documentation, 10 Minutes to Pandas, primarily geared to new users.

There is a new section in the documentation, Cookbook, a collection of useful recipes in pandas (and that we want contributions!).

There are several libraries that are now Recommended Dependencies

1.28.1 Selection Choices

Starting in 0.11.0, object selection has had a number of user-requested additions in order to support more explicit location based indexing. Pandas now supports three types of multi-axis indexing.

- .loc is strictly label based, will raise KeyError when the items are not found, allowed inputs are:
  - A single label, e.g. 5 or 'a', (note that 5 is interpreted as a label of the index. This use is not an integer position along the index)
  - A list or array of labels ['a', 'b', 'c']
  - A slice object with labels 'a':'f', (note that contrary to usual python slices, both the start and the stop are included!)
  - A boolean array

  See more at Selection by Label

- .iloc is strictly integer position based (from 0 to length-1 of the axis), will raise IndexError when the requested indicies are out of bounds. Allowed inputs are:
  - An integer e.g. 5
  - A list or array of integers [4, 3, 0]
  - A slice object with ints 1:7
  - A boolean array

  See more at Selection by Position

- .ix supports mixed integer and label based access. It is primarily label based, but will fallback to integer positional access. .ix is the most general and will support any of the inputs to .loc and .iloc, as well as support for floating point label schemes. .ix is especially useful when dealing with mixed positional and label based hierarchial indexes.

  As using integer slices with .ix have different behavior depending on whether the slice is interpreted as position based or label based, it’s usually better to be explicit and use .iloc or .loc.

  See more at Advanced Indexing and Advanced Hierarchical.

1.28.2 Selection Deprecations

Starting in version 0.11.0, these methods may be deprecated in future versions.

- irow
- icol
- iget_value

See the section Selection by Position for substitutes.
1.28.3 Dtypes

Numeric dtypes will propagate and can coexist in DataFrames. If a dtype is passed (either directly via the `dtype` keyword, a passed `ndarray`, or a passed `Series`, then it will be preserved in DataFrame operations. Furthermore, different numeric dtypes will NOT be combined. The following example will give you a taste.

```python
In [1]: df1 = DataFrame(randn(8, 1), columns = ['A'], dtype = 'float32')
In [2]: df1
Out[2]:
     A
0  1.392665
1 -0.123497
2 -0.402761
3 -0.246604
4 -0.288433
5 -0.763434
6  2.069526
7 -1.203569
[8 rows x 1 columns]
In [3]: df1.dtypes
→
A  float32
Length: 1, dtype: object
In [4]: df2 = DataFrame(dict( A = Series(randn(8),dtype='float16'),
                      B = Series(randn(8)),
                      C = Series(randn(8),dtype='uint8') ))
In [5]: df2
Out[5]:
     A       B       C
0  0.591797 -0.038605   0
1  0.841309 -0.460478   1
2 -0.500977 -0.310458   0
3 -0.816406  0.866493 254
4 -0.207031  0.245972   0
5 -0.664062  0.319442 255
6  0.580566  1.378512   1
7 -0.965820  0.292502 255
[8 rows x 3 columns]
In [6]: df2.dtypes
→
A  float16
B  float64
C   uint8
Length: 3, dtype: object
# here you get some upcasting
In [7]: df3 = df1.reindex_like(df2).fillna(value=0.0) + df2
```

(continues on next page)
In [8]: df3
Out[8]:
    A       B       C
0  1.98446  -0.03861  0.0
1  0.71781  -0.46048  1.0
2 -0.90374  -0.31046  0.0
3 -1.06301  0.86649  254.0
4 -0.49547  0.24597  0.0
5 -1.42749  0.31944  1.0
6  2.65009  1.37851  1.0
7 -2.16939  0.29250  255.0

[8 rows x 3 columns]

In [9]: df3.dtypes

A  float32
B  float64
C  float64
Length: 3, dtype: object

1.2.8.4 Dtype Conversion

This is lower-common-denominator upcasting, meaning you get the dtype which can accommodate all of the types

In [10]: df3.values.dtype
Out[10]: dtype('float64')

Conversion

In [11]: df3.astype('float32').dtypes
Out[11]:
A  float32
B  float32
C  float32
Length: 3, dtype: object

Mixed Conversion

In [12]: df3['D'] = '1.'

In [13]: df3['E'] = '1'

In [14]: df3.convert_objects(convert_numeric=True).dtypes
Out[14]:
A  float32
B  float64
C  float64
D  float64
E  int64
Length: 5, dtype: object

# same, but specific dtype conversion
In [15]: df3['D'] = df3['D'].astype('float16')
In [16]: `df3['E'] = df3['E'].astype('int32')`

In [17]: `df3.dtypes`
Out[17]:
A  float32
B  float64
C  float64
D  float16
E  int32
Length: 5, dtype: object

Forcing Date coercion (and setting NaT when not datelike)

In [18]: `from datetime import datetime`

In [19]: `s = Series([datetime(2001,1,1,0,0), 'foo', 1.0, 1, ....:
   ....:    Timestamp('20010104'), '20010105'],dtype='O')
   ....:
In [20]: `s.convert_objects(convert_dates='coerce')`
Out[20]:
0    2001-01-01
1      NaT
2      NaT
3      NaT
4    2001-01-04
5    2001-01-05
Length: 6, dtype: datetime64[ns]

1.28.5 Dtype Gotchas

Platform Gotchas

Starting in 0.11.0, construction of DataFrame/Series will use default dtypes of int64 and float64, regardless of platform. This is not an apparent change from earlier versions of pandas. If you specify dtypes, they WILL be respected, however (GH2837)

The following will all result in int64 dtypes

In [21]: `DataFrame([1,2],columns=['a']).dtypes`
Out[21]:
a  int64
Length: 1, dtype: object

In [22]: `DataFrame({'a' : [1,2] }).dtypes`

In [23]: `DataFrame({'a' : 1 }, index=range(2)).dtypes`
Keep in mind that `DataFrame(np.array([1,2]))` **WILL** result in `int32` on 32-bit platforms!

**Upcasting Gotchas**

Performing indexing operations on integer type data can easily upcast the data. The dtype of the input data will be preserved in cases where `nans` are not introduced.

```
In [24]: dfi = df3.astype('int32')

In [25]: dfi['D'] = dfi['D'].astype('int64')

In [26]: dfi
Out[26]:
A  B  C  D  E
0  1  0  0  1  1
1  0  0  1  1  1
2  0  0  0  1  1
3 -1  0  254 1  1
4  0  0  0  1  1
5 -1  0  1  1  1
6  2  1  1  1  1
7 -2  0  255 1  1

[8 rows x 5 columns]
```

```
In [27]: dfi.dtypes

Out[27]:
A  int32
B  int32
C  int32
D  int64
E  int32
Length: 5, dtype: object
```

```
In [28]: casted = dfi[dfi>0]

In [29]: casted
Out[29]:
A  B  C  D  E
0  1.0  NaN  NaN  1  1
1  NaN  NaN  1.0  1  1
2  NaN  NaN  NaN  1  1
3  NaN  NaN  254.0  1  1
4  NaN  NaN  NaN  1  1
5  NaN  NaN  1.0  1  1
6  2.0  1.0  1.0  1  1
7  NaN  NaN  255.0  1  1

[8 rows x 5 columns]
```

```
In [30]: casted.dtypes

Out[30]:
A  float64
B  float64
C  float64
D  int64
E  int32
```

While float dtypes are unchanged.

```python
In[31]: df4 = df3.copy()
In[32]: df4['A'] = df4['A'].astype('float32')
In[33]: df4.dtypes
Out[33]:
A  float32
B  float64
C  float64
D  float16
E  int32
Length: 5, dtype: object
In[34]: casted = df4[df4>0]
In[35]: casted
Out[35]:
   A     B    C    D    E
0  1.98  NaN  NaN   1.0   1
1  0.72  NaN   1.0   1.0   1
2  NaN   NaN  NaN   1.0   1
3  NaN  0.87  254.0  1.0   1
4  NaN  0.25  254.0  1.0   1
5  NaN  0.32  1.0  1.0   1
6  2.65  1.38  1.0  1.0   1
7  NaN  0.29  255.0  1.0   1
[8 rows x 5 columns]
In[36]: casted.dtypes
```

### 1.28.6 Datetimes Conversion

Datet ime64[ns] columns in a DataFrame (or a Series) allow the use of np.nan to indicate a nan value, in addition to the traditional NaT, or not-a-time. This allows convenient nan setting in a generic way. Furthermore datetime64[ns] columns are created by default, when passed datetimelike objects (this change was introduced in 0.10.1) (GH2809, GH2810)

```python
In[37]: df = DataFrame(randn(6,2),date_range('20010102',periods=6),columns=['A','B'])
In[38]: df['timestamp'] = Timestamp('20010103')
In[39]: df
```
Out[39]:

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>A</td>
<td>2001-01-02</td>
<td>1.023958</td>
<td>0.660103</td>
</tr>
<tr>
<td>1</td>
<td>B</td>
<td>2001-01-03</td>
<td>1.236475</td>
<td>-2.170629</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>2001-01-03</td>
<td>-0.270630</td>
<td>-1.685677</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>2001-01-03</td>
<td>-0.440747</td>
<td>-0.115070</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>2001-01-03</td>
<td>-0.632102</td>
<td>-0.585977</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>2001-01-03</td>
<td>-1.444787</td>
<td>-0.201135</td>
</tr>
</tbody>
</table>

[6 rows x 3 columns]

# datetime64[ns] out of the box

In [40]: df.get_dtype_counts()

Out[40]:

float64 2
datetime64[ns] 1
Length: 2, dtype: int64

# use the traditional nan, which is mapped to NaT internally

In [41]: df.loc[df.index[2:4], ['A', 'timestamp']] = np.nan

In [42]: df

Out[42]:

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>A</td>
<td>2001-01-02</td>
<td>1.023958</td>
<td>0.660103</td>
</tr>
<tr>
<td>1</td>
<td>B</td>
<td>2001-01-03</td>
<td>1.236475</td>
<td>-2.170629</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>2001-01-03</td>
<td>NaN</td>
<td>NaT</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>2001-01-03</td>
<td>NaN</td>
<td>NaT</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>2001-01-03</td>
<td>-0.632102</td>
<td>-0.585977</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>2001-01-03</td>
<td>-1.444787</td>
<td>-0.201135</td>
</tr>
</tbody>
</table>

[6 rows x 3 columns]

Acaste conversion on datetime64[ns] to object, implicitly converts NaT to np.nan

In [43]: import datetime

In [44]: s = Series([datetime.datetime(2001, 1, 2, 0, 0) for i in range(3)])

In [45]: s.dtype

Out[45]:

<M8[ns]>

In [46]: s[1] = np.nan

In [47]: s

Out[47]:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2001-01-02</td>
</tr>
<tr>
<td>1</td>
<td>NaT</td>
</tr>
<tr>
<td>2</td>
<td>2001-01-02</td>
</tr>
</tbody>
</table>

Length: 3, dtype: datetime64[ns]

In [48]: s.dtype

Out[48]:

<dtype('O')>

In [49]: s = s.astype('O')
1.28.7 API changes

- Added `to_series()` method to indices, to facilitate the creation of indexers (GH3275)
- HDFStore
  - added the method `select_column` to select a single column from a table as a Series.
  - deprecated the `unique` method, can be replicated by `select_column(key, column).unique()`
  - `min_itemsize` parameter to `append` will now automatically create `data_columns` for passed keys

1.28.8 Enhancements

- Improved performance of `df.to_csv()` by up to 10x in some cases. (GH3059)
- Numexpr is now a **Recommended Dependencies**, to accelerate certain types of numerical and boolean operations
- Bottleneck is now a **Recommended Dependencies**, to accelerate certain types of `nan` operations
- HDFStore
  - support `read_hdf/to_hdf` API similar to `read_csv/to_csv`

```
In [52]: df = DataFrame(dict(A=lrange(5), B=lrange(5)))
In [53]: df.to_hdf('store.h5','table',append=True)
In [54]: read_hdf('store.h5', 'table', where = ['index>2'])
```

- provide dotted attribute access to `get` from stores, e.g. `store.df == store['df']`
- new keywords `iterator=boolean, and chunksize=number_in_a_chunk` are provided to support iteration on `select` and `select_as_multiple` (GH3076)

- You can now select timestamps from an `unordered` timeseries similarly to an `ordered` timeseries (GH2437)
- You can now select with a string from a DataFrame with a datelike index, in a similar way to a Series (GH3070)
In [55]: idx = date_range("2001-10-1", periods=5, freq='M')

In [56]: ts = Series(np.random.rand(len(idx)), index=idx)

In [57]: ts['2001']
Out[57]:
2001-10-31  0.663256
2001-11-30 -0.079126
2001-12-31  0.587699
Freq: M, Length: 3, dtype: float64

In [58]: df = DataFrame(dict(A=ts))

In [59]: df['2001']
Out[59]:
   A
2001-10-31  0.663256
2001-11-30 -0.079126
2001-12-31  0.587699
[3 rows x 1 columns]

• Squeeze to possibly remove length 1 dimensions from an object.

In [60]: p = Panel(randn(3, 4, 4), items=["ItemA", 'ItemB', 'ItemC'],
   ...:     major_axis=date_range('20010102', periods=4),
   ...:     minor_axis=['A', 'B', 'C', 'D'])

In [61]: p
Out[61]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 4 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2001-01-02 00:00:00 to 2001-01-05 00:00:00
Minor_axis axis: A to D

In [62]: p.reindex(items=["ItemA"]).squeeze()

   A   B   C   D
2001-01-02  0.203403  0.425882 -0.436045 -0.982462
2001-01-03 -0.963090 -0.963090  0.121731  0.202798
2001-01-04  0.125695 -0.218549 -0.631381 -0.337116
2001-01-05  0.404238  0.907213 -0.865657  0.483186
[4 rows x 4 columns]

In [63]: p.reindex(items=["ItemA"], minor=['B']).squeeze()

   B
2001-01-02  0.425882
2001-01-03 -0.963090
2001-01-04 -0.218549
2001-01-05  0.907213
Freq: D, Name: B, Length: 4, dtype: float64

• In pd.io.data.Options,
- Fix bug when trying to fetch data for the current month when already past expiry.
- Now using lxml to scrape html instead of BeautifulSoup (lxml was faster).
- New instance variables for calls and puts are automatically created when a method that creates them is called. This works for current month where the instance variables are simply calls and puts. Also works for future expiry months and save the instance variable as callsMMYY or putsMMYY, where MMYY are, respectively, the month and year of the option’s expiry.
- Options.get_near_stock_price now allows the user to specify the month for which to get relevant options data.
- Options.get_forward_data now has optional kwargs near and above_below. This allows the user to specify if they would like to only return forward looking data for options near the current stock price. This just obtains the data from Options.get_near_stock_price instead of Options.get_xxx_data() (GH2758).

- Cursor coordinate information is now displayed in time-series plots.
- added option display.max_seq_items to control the number of elements printed per sequence pprinting it. (GH2979)
- added option display.chop_threshold to control display of small numerical values. (GH2739)
- added option display.max_info_rows to prevent verbose_info from being calculated for frames above 1M rows (configurable). (GH2807, GH2918)
- value_counts() now accepts a “normalize” argument, for normalized histograms. (GH2710).
- DataFrame.from_records now accepts not only dicts but any instance of the collections.Mapping ABC.
- added option display.mpl_style providing a sleeker visual style for plots. Based on https://gist.github.com/huyng/816622 (GH3075).
- Treat boolean values as integers (values 1 and 0) for numeric operations. (GH2641)
- to_html() now accepts an optional “escape” argument to control reserved HTML character escaping (enabled by default) and escapes & in addition to < and >. (GH2919)

See the full release notes or issue tracker on GitHub for a complete list.

1.29 v0.10.1 (January 22, 2013)

This is a minor release from 0.10.0 and includes new features, enhancements, and bug fixes. In particular, there is substantial new HDFStore functionality contributed by Jeff Reback.

An undesired API breakage with functions taking the inplace option has been reverted and deprecation warnings added.

1.29.1 API changes

- Functions taking an inplace option return the calling object as before. A deprecation message has been added
- Groupby aggregations Max/Min no longer exclude non-numeric data (GH2700)
- Resampling an empty DataFrame now returns an empty DataFrame instead of raising an exception (GH2640)
- The file reader will now raise an exception when NA values are found in an explicitly specified integer column instead of converting the column to float (GH2631)
- DatetimeIndex.unique now returns a DatetimeIndex with the same name and
pandas: powerful Python data analysis toolkit, Release 0.23.2

- timezone instead of an array (GH2563)

### 1.29.2 New features

- MySQL support for database (contribution from Dan Allan)

### 1.29.3 HDFStore

You may need to upgrade your existing data files. Please visit the compatibility section in the main docs.

You can designate (and index) certain columns that you want to be able to perform queries on a table, by passing a list to `data_columns`

```python
In [1]: store = HDFStore('store.h5')
In [2]: df = DataFrame(randn(8, 3), index=date_range('1/1/2000', periods=8),
...:     columns=['A', 'B', 'C'])
...:
In [3]: df['string'] = 'foo'
In [4]: df.loc[df.index[4:6], 'string'] = np.nan
In [5]: df.loc[df.index[7:9], 'string'] = 'bar'
In [6]: df['string2'] = 'cool'
In [7]: df
Out[7]:
   A     B     C    string    string2
0 2000-01-01  1.885136 -0.183873  foo    cool
1 2000-01-02  0.180759 -1.117089  foo    cool
2 2000-01-03 -0.294467 -0.591411  foo    cool
3 2000-01-04  3.127110  1.451130  foo    cool
4 2000-01-05 -0.242846  1.195819  NaN    cool
5 2000-01-06  0.820521 -0.281201  NaN    cool
6 2000-01-07 -0.034086  0.252394  foo    cool
7 2000-01-08 -2.290958 -1.601262  bar    cool
[8 rows x 5 columns]
```

# on-disk operations
```
In [8]: store.append('df', df, data_columns = ['B','C','string','string2'])
In [9]: store.select('df', "B>0 and string=='foo'")
Out[9]:
   A     B     C    string    string2
0 2000-01-04  3.127110  1.451130  foo    cool
1 2000-01-07 -0.034086  0.252394  foo    cool
[2 rows x 5 columns]
```

# this is in-memory version of this type of selection
```
In [10]: df[(df.B > 0) & (df.string == 'foo')]
```

(continues on next page)
Retrieving unique values in an indexable or data column.

```python
# note that this is deprecated as of 0.14.0
# can be replicated by: store.select_column('df','index').unique()
store.unique('df','index')
store.unique('df','string')
```

You can now store `datetime64` in data columns

```python
In [11]: df_mixed = df.copy()
In [12]: df_mixed['datetime64'] = Timestamp('20010102')
In [13]: df_mixed.loc[df_mixed.index[3:4], ['A','B']] = np.nan
In [14]: store.append('df_mixed', df_mixed)
In [15]: df_mixed1 = store.select('df_mixed')
In [16]: df_mixed1
```

```
A     B     C     string    string2       datetime64
2000-01-01 1.885136 -0.183873 2.550850  foo   cool   2001-01-02
2000-01-02 0.180759 -1.117089 0.061462  foo   cool   2001-01-02
2000-01-03 -0.294467 -0.591411 -0.876691  foo   cool   2001-01-02
2000-01-04 NaN    NaN    0.045152  foo   cool   2001-01-02
2000-01-05 -0.242846 1.195819 1.533294  NaN   cool   2001-01-02
2000-01-06 0.820521 -0.281201 1.651561  NaN   cool   2001-01-02
2000-01-07 -0.034086 0.252394 -0.498772  foo   cool   2001-01-02
2000-01-08 -2.290958 -1.601262 -0.256718  bar   cool   2001-01-02
```

```
[8 rows x 6 columns]
```

```python
In [17]: df_mixed1.get_dtype_counts()
```

```python
float64    3
object     2
datetime64[ns]  1
Length: 3, dtype: int64
```

You can pass columns keyword to select to filter a list of the return columns, this is equivalent to passing a `Term('columns',list_of_columns_to_filter)`

```python
In [18]: store.select('df',columns = ['A','B'])
```

```
   A     B
2000-01-01 1.885136 -0.183873
2000-01-02 0.180759 -1.117089
2000-01-03 -0.294467 -0.591411
(continues on next page)```
pandas: powerful Python data analysis toolkit, Release 0.23.2

2000-01-04  3.127110  1.451130
2000-01-05  -0.242846  1.195819
2000-01-06  0.820521  -0.281201
2000-01-07  -0.034086  0.252394
2000-01-08  -2.290958  -1.601262

[8 rows x 2 columns]

HDFStore now serializes multi-index dataframes when appending tables.

In [19]: index = MultiIndex(levels=[['foo', 'bar', 'baz', 'qux'],
                          ['one', 'two', 'three']],
                          labels=[0, 0, 0, 1, 1, 2, 2, 3, 3, 3],
                          names=['foo', 'bar'])

In [20]: df = DataFrame(np.random.randn(10, 3), index=index,
                     columns=['A', 'B', 'C'])

In [21]: df

Out[21]:
   A         B         C
foo bar
   foo one  0.239369  0.174122 -1.131794
   two   -1.948006  0.980347  0.674429
   three  -0.361633 -0.761218  1.768215
   bar one  0.152288 -0.862613 -0.210968
   two   -0.859278  1.498195  0.462413
   baz two  -0.647604  1.511487 -0.727189
   three  -0.342928 -0.007364  1.427674
   qux one  0.104020  2.052171 -1.230963
   two   -0.019240  1.713238  0.838912
   three  -0.637855  0.215109 -1.515362

[10 rows x 3 columns]

In [22]: store.append('mi', df)

In [23]: store.select('mi')

Out[23]:
   A         B         C
foo bar
   foo one  0.239369  0.174122 -1.131794
   two   -1.948006  0.980347  0.674429
   three  -0.361633 -0.761218  1.768215
   bar one  0.152288 -0.862613 -0.210968
   two   -0.859278  1.498195  0.462413
   baz two  -0.647604  1.511487 -0.727189
   three  -0.342928 -0.007364  1.427674
   qux one  0.104020  2.052171 -1.230963
   two   -0.019240  1.713238  0.838912
   three  -0.637855  0.215109 -1.515362

[10 rows x 3 columns]
# the levels are automatically included as data columns
In [24]: store.select('mi', "foo='bar'")

→
A B C
foo bar
bar one 0.152288 -0.862613 -0.210968
two -0.859278 1.498195 0.462413
[2 rows x 3 columns]

Multi-table creation via `append_to_multiple` and selection via `select_as_multiple` can create/select from multiple tables and return a combined result, by using `where` on a selector table.

In [25]: df_mt = DataFrame(randn(8, 6), index=date_range('1/1/2000', periods=8),
                    columns=['A', 'B', 'C', 'D', 'E', 'F'])

In [26]: df_mt['foo'] = 'bar'

# you can also create the tables individually
In [27]: store.append_to_multiple({'df1_mt': ['A', 'B'], 'df2_mt': None}, df_mt, 
selector = 'df1_mt')

In [28]: store
Out[28]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5

# individual tables were created
In [29]: store.select('df1_mt')

→
A B
2000-01-01 1.586924 -0.447974
2000-01-02 -0.102206 0.870302
2000-01-03 1.249874 1.458210
2000-01-04 -0.616293 0.150468
2000-01-05 -0.431163 0.016640
2000-01-06 0.800353 -0.451572
2000-01-07 1.239198 0.185437
2000-01-08 -0.040863 0.290110
[8 rows x 2 columns]

In [30]: store.select('df2_mt')

→
C D E F foo
2000-01-01 1.573998 0.630925 -0.071659 -1.277640 bar
2000-01-02 1.275280 -1.199212 1.060780 1.673018 bar
2000-01-03 -0.710542 0.825392 1.557329 1.993441 bar
2000-01-04 0.132104 0.580923 -0.128750 1.445964 bar
2000-01-05 0.904578 -1.465852 -0.688741 0.228006 bar
2000-01-06 0.831767 0.228760 0.932498 -2.200069 bar
2000-01-07 -0.540770 -0.370038 1.298390 1.662964 bar
2000-01-08 -0.096145 1.717830 -0.462446 -0.112019 bar

(continues on next page)
In

\[31\]

\[\text{store.select_as_multiple(['df1\_mt','df2\_mt'], where = ['A>0','B>0'], selector = 'df1\_mt')}\]

\[\text{\rightarrow}A B C D E F foo\]

\[2000-01-03\]
\[1.249874\]
\[1.458210\]
\[-0.710542\]
\[0.825392\]
\[1.557329\]
\[1.993441\]
\[\text{bar}\]

\[2000-01-07\]
\[1.239198\]
\[0.185437\]
\[-0.540770\]
\[-0.370038\]
\[1.298390\]
\[1.662964\]
\[\text{bar}\]

Enhancements

- HDFStore now can read native PyTables table format tables
- You can pass nan\_rep = 'my\_nan\_rep' to append, to change the default nan representation on disk (which converts to/from np.nan), this defaults to nan.
- You can pass index to append. This defaults to True. This will automagically create indices on the indexables and data columns of the table
- You can pass chunksize=an integer to append, to change the writing chunksize (default is 50000). This will significantly lower your memory usage on writing.
- You can pass expectedrows=an integer to the first append, to set the TOTAL number of expectedrows that PyTables will expect. This will optimize read/write performance.
- Select now supports passing start and stop to provide selection space limiting in selection.
- Greatly improved ISO8601 (e.g., yyyy-mm-dd) date parsing for file parsers (GH2698)
- Allow DataFrame.merge to handle combinatorial sizes too large for 64-bit integer (GH2690)
- Series now has unary negation (-series) and inversion (~series) operators (GH2686)
- DataFrame.plot now includes a logx parameter to change the x-axis to log scale (GH2327)
- Series arithmetic operators can now handle constant and ndarray input (GH2574)
- ExcelFile now takes a kind argument to specify the file type (GH2613)
- A faster implementation for Series.str methods (GH2602)

Bug Fixes

- HDFStore tables can now store float32 types correctly (cannot be mixed with float64 however)
- Fixed Google Analytics prefix when specifying request segment (GH2713).
- Function to reset Google Analytics token store so users can recover from improperly setup client secrets (GH2687).
- Fixed groupby bug resulting in segfault when passing in MultiIndex (GH2706)
- Fixed bug where passing a Series with datetime64 values into to\_datetime results in bogus output values (GH2699)
- Fixed bug in pattern in HDFStore expressions when pattern is not a valid regex (GH2694)
- Fixed performance issues while aggregating boolean data (GH2692)
• When given a boolean mask key and a Series of new values, Series __setitem__ will now align the incoming values with the original Series (GH2686)
• Fixed MemoryError caused by performing counting sort on sorting MultiIndex levels with a very large number of combinatorial values (GH2684)
• Fixed bug that causes plotting to fail when the index is a DatetimeIndex with a fixed-offset timezone (GH2683)
• Corrected businessday subtraction logic when the offset is more than 5 bdays and the starting date is on a weekend (GH2680)
• Fixed C file parser behavior when the file has more columns than data (GH2668)
• Fixed file reader bug that misaligned columns with data in the presence of an implicit column and a specified usecols value
• DataFrames with numerical or datetime indices are now sorted prior to plotting (GH2609)
• Fixed DataFrame.from_records error when passed columns, index, but empty records (GH2633)
• Several bug fixed for Series operations when dtype is datetime64 (GH2689, GH2629, GH2626)

See the full release notes or issue tracker on GitHub for a complete list.

1.30 v0.10.0 (December 17, 2012)

This is a major release from 0.9.1 and includes many new features and enhancements along with a large number of bug fixes. There are also a number of important API changes that long-time pandas users should pay close attention to.

1.30.1 File parsing new features

The delimited file parsing engine (the guts of read_csv and read_table) has been rewritten from the ground up and now uses a fraction the amount of memory while parsing, while being 40% or more faster in most use cases (in some cases much faster).

There are also many new features:
• Much-improved Unicode handling via the encoding option.
• Column filtering (usecols)
• Dtype specification (dtype argument)
• Ability to specify strings to be recognized as True/False
• Ability to yield NumPy record arrays (as_recarray)
• High performance delim_whitespace option
• Decimal format (e.g. European format) specification
• Easier CSV dialect options: escapechar, lineterminator, quotechar, etc.
• More robust handling of many exceptional kinds of files observed in the wild
1.30.2 API changes

Deprecated DataFrame BINOP TimeSeries special case behavior

The default behavior of binary operations between a DataFrame and a Series has always been to align on the DataFrame’s columns and broadcast down the rows, except in the special case that the DataFrame contains time series. Since there are now method for each binary operator enabling you to specify how you want to broadcast, we are phasing out this special case (Zen of Python: Special cases aren’t special enough to break the rules). Here’s what I’m talking about:

```
In [1]: import pandas as pd

In [2]: df = pd.DataFrame(np.random.randn(6, 4),
   ...:                     index=pd.date_range('1/1/2000', periods=6))

In [3]: df
Out[3]:
   0   1   2   3
2000-01-01 -0.134024 -0.205969 1.348944 -1.198246
2000-01-02 -1.626124  0.982041  0.059493 -0.460111
2000-01-03 -1.565401 -0.025706  0.942864  2.502156
2000-01-04 -0.302741  0.261551 -0.066342  0.897097
2000-01-05  0.268766 -1.225092  0.582752 -1.490764
2000-01-06 -0.639757 -0.952750 -0.892402  0.505987
[6 rows x 4 columns]

# deprecated now
In [4]: df - df[0]
```

```
   →                          2000-01-01 00:00:00 2000-01-02 00:00:00 2000-01-03 00:00:00 2000-01-04 00:00:00 ...
   →                          0 1 2 3
   → 2000-01-01  NaN  NaN  NaN  NaN
   → 2000-01-02  NaN  NaN  NaN  NaN
   → 2000-01-03  NaN  NaN  NaN  NaN
   → 2000-01-04  NaN  NaN  NaN  NaN
   → 2000-01-05  NaN  NaN  NaN  NaN
   → 2000-01-06  NaN  NaN  NaN  NaN
[6 rows x 10 columns]

# Change your code to
In [5]: df.sub(df[0], axis=0) # align on axis 0 (rows)
```

```
   →                          0 1 2 3
   → 2000-01-01  0.0 -0.071946 1.482967 -1.064223
   → 2000-01-02  0.0  2.608165 1.685618  1.166013
   → 2000-01-03  0.0  1.539695 2.508265  4.067556
   → 2000-01-04  0.0  0.564293 0.236399  1.199839
```
Altered resample default behavior

The default time series resample binning behavior of daily D and higher frequencies has been changed to closed='left', label='left'. Lower frequencies are unaffected. The prior defaults were causing a great deal of confusion for users, especially resampling data to daily frequency (which labeled the aggregated group with the end of the interval: the next day).

```
In [1]: dates = pd.date_range('1/1/2000', '1/5/2000', freq='4h')
In [2]: series = Series(np.arange(len(dates)), index=dates)
In [3]: series
Out[3]:
2000-01-01 00:00:00 0
2000-01-01 04:00:00 1
2000-01-01 08:00:00 2
2000-01-01 12:00:00 3
2000-01-01 16:00:00 4
2000-01-02 00:00:00 5
2000-01-02 04:00:00 6
2000-01-02 08:00:00 7
2000-01-02 12:00:00 8
2000-01-02 16:00:00 9
2000-01-03 00:00:00 10
2000-01-03 04:00:00 11
2000-01-03 08:00:00 12
2000-01-03 12:00:00 13
2000-01-03 16:00:00 14
2000-01-04 00:00:00 15
2000-01-04 04:00:00 16
2000-01-04 08:00:00 17
2000-01-04 12:00:00 18
2000-01-04 16:00:00 19
2000-01-05 00:00:00 20
2000-01-05 04:00:00 21
2000-01-05 08:00:00 22
2000-01-05 12:00:00 23
2000-01-05 16:00:00 24
Freq: 4H, dtype: int64
```

```
In [4]: series.resample('D', how='sum')
Out[4]:
2000-01-01    15
2000-01-02    51
2000-01-03    87
2000-01-04   123
2000-01-05     24
Freq: D, dtype: int64
```
• Infinity and negative infinity are no longer treated as NA by isnull and notnull. That they ever were was a relic of early pandas. This behavior can be re-enabled globally by the mode.use_inf_as_null option:

```python
In [6]: s = pd.Series([1.5, np.inf, 3.4, -np.inf])
In [7]: pd.isnull(s)
Out[7]:
0   False
1   False
2   False
3   False
Length: 4, dtype: bool
In [8]: s.fillna(0)
Out[8]:
0   1.500000
1   inf
2   3.400000
3   -inf
Length: 4, dtype: float64
In [9]: pd.set_option('use_inf_as_null', True)
In [10]: pd.isnull(s)
Out[10]:
0   False
1   True
2   False
3   True
Length: 4, dtype: bool
In [11]: s.fillna(0)
Out[11]:
0   1.5
1   0.0
2   3.4
3   0.0
Length: 4, dtype: float64
In [12]: pd.reset_option('use_inf_as_null')
```

• Methods with the inplace option now all return None instead of the calling object. E.g. code written like df = df.fillna(0, inplace=True) may stop working. To fix, simply delete the unnecessary variable assignment.

• pandas.merge no longer sorts the group keys (sort=False) by default. This was done for performance reasons: the group-key sorting is often one of the more expensive parts of the computation and is often unnec-
The default column names for a file with no header have been changed to the integers 0 through $N - 1$. This is to create consistency with the DataFrame constructor with no columns specified. The v0.9.0 behavior (names $X_0, X_1, \ldots$) can be reproduced by specifying `prefix='X'`:

```python
In [6]: data= 'a,b,c
1,Yes,2
3,No,4'
In [7]: print(data)
a,b,c
1,Yes,2
3,No,4
In [8]: pd.read_csv(StringIO(data), header=None)
Out[8]:
   0  1  2
0  a  b  c
1  1  Yes 2
2  3  No  4
[3 rows x 3 columns]
In [9]: pd.read_csv(StringIO(data), header=None, prefix='X')
→ X0 X1 X2
0  a  b  c
1  1  Yes 2
2  3  No  4
[3 rows x 3 columns]
```

Values like 'Yes' and 'No' are not interpreted as boolean by default, though this can be controlled by new `true_values` and `false_values` arguments:

```python
In [10]: print(data)
a,b,c
1,Yes,2
3,No,4
In [11]: pd.read_csv(StringIO(data))
Out[11]:
a  b  c
0  1  Yes 2
1  3  No  4
[2 rows x 3 columns]
In [12]: pd.read_csv(StringIO(data), true_values=['Yes'], false_values=['No'])
Out[12]:
a  b  c
0  1  True 2
1  3  False 4
[2 rows x 3 columns]
```

The file parsers will not recognize non-string values arising from a converter function as NA if passed in the `na_values` argument. It’s better to do post-processing using the `replace` function instead.
• Calling `fillna` on Series or DataFrame with no arguments is no longer valid code. You must either specify a fill value or an interpolation method:

```python
In [13]: s = Series([np.nan, 1., 2., np.nan, 4])
In [14]: s
Out[14]:
0 NaN
1 1.0
2 2.0
3 NaN
4 4.0
Length: 5, dtype: float64

In [15]: s.fillna(0)
Out[15]:
0 0.0
1 1.0
2 2.0
3 0.0
4 4.0
Length: 5, dtype: float64

In [16]: s.fillna(method='pad')
Out[16]:
0 NaN
1 1.0
2 2.0
3 2.0
4 4.0
Length: 5, dtype: float64
```

Convenience methods `ffill` and `bfill` have been added:

```python
In [17]: s.ffill()
Out[17]:
0 NaN
1 1.0
2 2.0
3 2.0
4 4.0
Length: 5, dtype: float64
```

• `Series.apply` will now operate on a returned value from the applied function, that is itself a series, and possibly upcast the result to a DataFrame

```python
In [18]: def f(x):
    ....:     return Series([ x, x**2 ], index = ['x', 'x^2'])
    ....:

In [19]: s = Series(np.random.rand(5))
In [20]: s
Out[20]:
0 0.717478
1 0.815199
(continues on next page)
New API functions for working with pandas options (GH2097):

- get_option / set_option - get/set the value of an option. Partial names are accepted. -
  reset_option - reset one or more options to their default value. Partial names are accepted. -
  describe_option - print a description of one or more options. When called with no arguments. print all registered options.

Note: set_printoptions/ reset_printoptions are now deprecated (but functioning), the print op-

tions now live under “display.XYZ”. For example:

```
In [22]: get_option("display.max_rows")
Out[22]: 15
```

- to_string() methods now always return unicode strings (GH2224).

### 1.30.3 New features

#### 1.30.4 Wide DataFrame Printing

Instead of printing the summary information, pandas now splits the string representation across multiple rows by
default:

```
In [23]: wide_frame = DataFrame(randn(5, 16))
In [24]: wide_frame
```

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>...</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-0.681624</td>
<td>0.191356</td>
<td>1.180274</td>
<td>-0.834179</td>
<td>0.703043</td>
<td>...</td>
<td>-0.941235</td>
<td>0.863067</td>
</tr>
<tr>
<td>1</td>
<td>0.441522</td>
<td>-0.316864</td>
<td>-0.017062</td>
<td>1.570114</td>
<td>-0.360875</td>
<td>...</td>
<td>-0.906840</td>
<td>1.014601</td>
</tr>
<tr>
<td>2</td>
<td>-0.412451</td>
<td>-0.462580</td>
<td>0.422194</td>
<td>0.288403</td>
<td>-0.487393</td>
<td>...</td>
<td>0.246354</td>
<td>-0.727728</td>
</tr>
<tr>
<td>3</td>
<td>-0.277255</td>
<td>1.331263</td>
<td>0.585174</td>
<td>-0.568825</td>
<td>-0.719412</td>
<td>...</td>
<td>-1.425911</td>
<td>-0.548829</td>
</tr>
<tr>
<td>4</td>
<td>-1.642511</td>
<td>0.432560</td>
<td>1.218080</td>
<td>-0.564705</td>
<td>-0.581790</td>
<td>...</td>
<td>-0.471786</td>
<td>0.314510</td>
</tr>
</tbody>
</table>
(continues on next page)
The old behavior of printing out summary information can be achieved via the `expand_frame_repr` print option:

```
In [25]: pd.set_option('expand_frame_repr', False)
In [26]: wide_frame
Out[26]:
   0   1   2   3   4   5   6   7
--|---|---|---|---|---|---|---|--
0  1.180274 -0.834179 -0.583599 -1.201796 -0.882554 1.209871
1  0.441522 0.191356 1.180274 -0.834179 0.703043 0.166568
2  0.441522 -0.316864 -0.017062 1.570114 -0.880096 0.235532
3  0.441522 -0.316864 -0.017062 1.570114 -0.880096 0.235532
```

The width of each line can be changed via `line_width` (80 by default):

```
In [27]: pd.set_option('line_width', 40)
```

```
OptionError Traceback (most recent call last)
<ipython-input-27-b8740c4a0a1b> in <module>()
      1 pd.set_option('line_width', 40)
~/sandbox/pandas-release/pandas-docs/pandas/core/config.py in __call__(self, *args,**kwds)
     225     return self.__func__(*args, **kwds)
     226 @property
~/sandbox/pandas-release/pandas-docs/pandas/core/config.py in __set_option(*args,**kwargs)
    117     raise OptionError('No such keys(s): {pat!r}'.format(pat=pat))
    118     if len(keys) > 1:
    119         raise OptionError('Pattern matched multiple keys')
```

```
OptionError: "No such keys(s): 'line_width'"
```
1.30.5 Updated PyTables Support

Docs for PyTables Table format & several enhancements to the api. Here is a taste of what to expect.

In [29]: store = HDFStore('store.h5')

In [30]: df = DataFrame(randn(8, 3), index=date_range('1/1/2000', periods=8),
    columns=['A', 'B', 'C'])

In [31]: df

Out[31]:
     A       B       C
2000-01-01 -0.369325 -1.502617 -0.376280
2000-01-02  0.511936 -0.116412 -0.625256
2000-01-03 -0.550627  1.261433 -0.552429
2000-01-04  1.695803 -1.025917 -0.910942
2000-01-05  0.426805 -0.131749  0.432600
2000-01-06  0.044671 -0.341265  1.844536
2000-01-07 -2.036047  0.000830 -0.955697
2000-01-08 -0.898872 -0.725411  0.059904

[8 rows x 3 columns]

# appending data frames
In [32]: df1 = df[0:4]

In [33]: df2 = df[4:]

In [34]: store.append('df', df1)

In [35]: store.append('df', df2)

In [36]: store

Out[36]:
<class 'pandas.io.pytables.HDFStore'>

(continues on next page)
File path: store.h5

# selecting the entire store
In [37]: store.select('df')

Out[37]:
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 2000-01-01 | -0.369325 | -1.502617
| 2000-01-02 | 0.511936   | -0.116412
| 2000-01-03 | -0.550627  | 1.261433
| 2000-01-04 | 1.695803   | -1.025917
| 2000-01-05 | 0.426805   | -0.131749
| 2000-01-06 | 0.044671   | -0.341265
| 2000-01-07 | -2.036047  | 0.000830
| 2000-01-08 | -0.898872  | -0.725411

[8 rows x 3 columns]

In [38]: wp = Panel(randn(2, 5, 4), items=['Item1', 'Item2'],
            ....: major_axis=date_range('1/1/2000', periods=5),
            ....: minor_axis=['A', 'B', 'C', 'D'])

In [39]: wp

Out[39]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2000-01-01 00:00:00 to 2000-01-05 00:00:00
Minor_axis axis: A to D

# storing a panel
In [40]: store.append('wp', wp)

# selecting via A QUERY
In [41]: store.select('wp', "major_axis>20000102 and minor_axis=['A','B']")

Out[41]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 3 (major_axis) x 2 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-05 00:00:00
Minor_axis axis: A to B

# removing data from tables
In [42]: store.remove('wp', "major_axis>20000103")

In [43]: store.select('wp')

Out[43]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 3 (major_axis) x 4 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2000-01-01 00:00:00 to 2000-01-03 00:00:00
Minor_axis axis: A to D

(continues on next page)
# deleting a store
In [44]: del store['df']

In [45]: store
Out[45]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5

Enhancements

- added ability to hierarchical keys

In [46]: store.put('foo/bar/bah', df)
In [47]: store.append('food/orange', df)
In [48]: store.append('food/apple', df)
In [49]: store
Out[49]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5

# remove all nodes under this level
In [50]: store.remove('food')
In [51]: store
Out[51]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5

- added mixed-dtype support!

In [52]: df['string'] = 'string'
In [53]: df['int'] = 1
In [54]: store.append('df',df)
In [55]: df1 = store.select('df')
In [56]: df1
Out[56]:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>string</th>
<th>int</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2000-01-01</td>
<td>-0.369325</td>
<td>-1.502617</td>
<td>string</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2000-01-02</td>
<td>0.511936</td>
<td>-0.116412</td>
<td>string</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2000-01-03</td>
<td>-0.550627</td>
<td>1.261433</td>
<td>string</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2000-01-04</td>
<td>1.695803</td>
<td>-1.025917</td>
<td>string</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>2000-01-05</td>
<td>0.426805</td>
<td>-0.131749</td>
<td>string</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>2000-01-06</td>
<td>0.044671</td>
<td>-0.341265</td>
<td>string</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>2000-01-07</td>
<td>-2.036047</td>
<td>0.000830</td>
<td>string</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>2000-01-08</td>
<td>-0.898872</td>
<td>-0.725411</td>
<td>string</td>
<td>1</td>
</tr>
</tbody>
</table>

[8 rows x 5 columns]

In [57]: df1.get_dtype_counts()
• performance improvements on table writing
• support for arbitrarily indexed dimensions
• SparseSeries now has a density property (GH2384)
• enable Series.str.strip/lstrip/rstrip methods to take an input argument to strip arbitrary characters (GH2411)
• implement value_vars in melt to limit values to certain columns and add melt to pandas namespace (GH2412)

Bug Fixes
• added Term method of specifying where conditions (GH1996).
• del store['df'] now call store.remove('df') for store deletion
• deleting of consecutive rows is much faster than before
• min_itemsize parameter can be specified in table creation to force a minimum size for indexing columns (the previous implementation would set the column size based on the first append)
• indexing support via create_table_index (requires PyTables >= 2.3) (GH698).
• appending on a store would fail if the table was not first created via put
• fixed issue with missing attributes after loading a pickled dataframe (GH2431)
• minor change to select and remove: require a table ONLY if where is also provided (and not None)

Compatibility
0.10 of HDFStore is backwards compatible for reading tables created in a prior version of pandas, however, query terms using the prior (undocumented) methodology are unsupported. You must read in the entire file and write it out using the new format to take advantage of the updates.

1.30.6 N Dimensional Panels (Experimental)

Adding experimental support for Panel4D and factory functions to create n-dimensional named panels. Here is a taste of what to expect.

```
In [58]: p4d = Panel4D(randn(2, 2, 5, 4),
....:     labels=['Label1','Label2'],
....:     items=['Item1', 'Item2'],
....:     major_axis=date_range('1/1/2000', periods=5),
....:     minor_axis=['A', 'B', 'C', 'D'])
....:
In [59]: p4d
Out[59]:
<class 'pandas.core.panelnd.Panel4D'>
Dimensions: 2 (labels) x 2 (items) x 5 (major_axis) x 4 (minor_axis)
Labels axis: Label1 to Label2
Items axis: Item1 to Item2
```
See the full release notes or issue tracker on GitHub for a complete list.

### 1.31 v0.9.1 (November 14, 2012)

This is a bugfix release from 0.9.0 and includes several new features and enhancements along with a large number of bug fixes. The new features include by-column sort order for DataFrame and Series, improved NA handling for the rank method, masking functions for DataFrame, and intraday time-series filtering for DataFrame.

#### 1.31.1 New features

- *Series.sort*, *DataFrame.sort*, and *DataFrame.sort_index* can now be specified in a per-column manner to support multiple sort orders (GH928)

```python
In [2]: df = DataFrame(np.random.randint(0, 2, (6, 3)), columns=['A', 'B', 'C'])
In [3]: df.sort(['A', 'B'], ascending=[1, 0])
Out[3]:
   A  B  C
0  0  1  1
1  0  1  1
2  0  0  1
3  1  0  0
4  1  0  0
5  0  0  0
```

- *DataFrame.rank* now supports additional argument values for the *na_option* parameter so missing values can be assigned either the largest or the smallest rank (GH1508, GH2159)

```python
In [1]: df = DataFrame(np.random.randn(6, 3), columns=['A', 'B', 'C'])
In [3]: df.rank()
Out[3]:
   A  B  C
0  3.0 1.0 3.0
1  1.0 3.0 2.0
2  NaN NaN NaN
3  NaN NaN NaN
4  NaN NaN NaN
5  2.0 2.0 1.0
[6 rows x 3 columns]
```

```python
In [4]: df.rank(na_option='top')
```

(continues on next page)
DataFrame has new *where* and *mask* methods to select values according to a given boolean mask (GH2109, GH2151)

Dataframe currently supports slicing via a boolean vector the same length as the DataFrame (inside the []). The returned DataFrame has the same number of columns as the original, but is sliced on its index.

If a DataFrame is sliced with a DataFrame based boolean condition (with the same size as the original DataFrame), then a DataFrame the same size (index and columns) as the original is returned, with elements that do not meet the boolean condition as *NaN*. This is accomplished via the new method *DataFrame.where*. In addition, *where* takes an optional *other* argument for replacement.
Furthermore, *where* now aligns the input boolean condition (ndarray or DataFrame), such that partial selection with setting is possible. This is analogous to partial setting via `.ix` (but on the contents rather than the axis labels)

```python
In [12]: df2 = df.copy()

In [13]: df2[df2[1:4] > 0] = 3

In [14]: df2
Out[14]:
<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-1.101581</td>
<td>1.187831</td>
<td>0.630693</td>
</tr>
<tr>
<td>1</td>
<td>3.000000</td>
<td>3.000000</td>
<td>-0.870464</td>
</tr>
<tr>
<td>2</td>
<td>3.000000</td>
<td>-0.224382</td>
<td>0.642489</td>
</tr>
<tr>
<td>3</td>
<td>3.000000</td>
<td>-1.848369</td>
<td>3.000000</td>
</tr>
<tr>
<td>4</td>
<td>1.235390</td>
<td>1.615529</td>
<td>-0.303272</td>
</tr>
</tbody>
</table>
[5 rows x 3 columns]
```

*DataFrame.mask* is the inverse boolean operation of *where*.

```python
In [15]: df.mask(df<=0)
```
(continues on next page)
pandas: powerful Python data analysis toolkit, Release 0.23.2

(continued from previous page)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NaN</td>
<td>NaN</td>
<td>0.630693</td>
</tr>
<tr>
<td>1</td>
<td>2.369983</td>
<td>0.333769</td>
<td>NaN</td>
</tr>
<tr>
<td>2</td>
<td>1.118760</td>
<td>NaN</td>
<td>0.642489</td>
</tr>
<tr>
<td>3</td>
<td>0.961751</td>
<td>NaN</td>
<td>0.440883</td>
</tr>
<tr>
<td>4</td>
<td>1.235390</td>
<td>1.615529</td>
<td>NaN</td>
</tr>
</tbody>
</table>

[5 rows x 3 columns]

- Enable referencing of Excel columns by their column names (GH1936)

```
In [16]: xl = ExcelFile('data/test.xls')
```

```
In [17]: xl.parse('Sheet1', index_col=0, parse_dates=True, ....:   parse_cols='A:D')
```

```
Out[17]:
<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-03</td>
<td>0.980269</td>
<td>3.685731</td>
<td>-0.364217</td>
<td>-1.159738</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>1.047916</td>
<td>-0.041232</td>
<td>-0.161812</td>
<td>0.212549</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>0.498581</td>
<td>0.731168</td>
<td>-0.537677</td>
<td>1.346270</td>
</tr>
<tr>
<td>2000-01-06</td>
<td>1.120202</td>
<td>1.567621</td>
<td>0.003641</td>
<td>0.675253</td>
</tr>
<tr>
<td>2000-01-07</td>
<td>-0.487094</td>
<td>0.571455</td>
<td>-1.611639</td>
<td>0.103469</td>
</tr>
<tr>
<td>2000-01-10</td>
<td>0.836649</td>
<td>0.246462</td>
<td>0.588543</td>
<td>1.062782</td>
</tr>
<tr>
<td>2000-01-11</td>
<td>-0.157161</td>
<td>1.340307</td>
<td>1.195778</td>
<td>-1.097007</td>
</tr>
</tbody>
</table>
```

[7 rows x 4 columns]

- Added option to disable pandas-style tick locators and formatters using `series.plot(x_compat=True)` or `pandas.plot_params['x_compat'] = True` (GH2205)
- Existing TimeSeries methods `at_time` and `between_time` were added to DataFrame (GH2149)
- DataFrame.dot can now accept ndarrays (GH2042)
- DataFrame.drop now supports non-unique indexes (GH2101)
- Panel.shift now supports negative periods (GH2164)
- DataFrame now support unary ~ operator (GH2110)

### 1.31.2 API changes

- Upsampling data with a PeriodIndex will result in a higher frequency TimeSeries that spans the original time window

```
In [1]: prng = period_range('2012Q1', periods=2, freq='Q')
```

```
In [2]: s = Series(np.random.randn(len(prng)), prng)
```

```
In [4]: s.resample('M')
```

```
Out[4]:
2012-01 -1.471992
2012-02 NaN
2012-03 NaN
2012-04 NaN
```

(continues on next page)
2012-05 NaN
2012-06 NaN
Freq: M, dtype: float64

- Period.end_time now returns the last nanosecond in the time interval (GH2124, GH2125, GH1764)

```python
In [18]: p = Period('2012')
In [19]: p.end_time
Out[19]: Timestamp('2012-12-31 23:59:59.999999999')
```

- File parsers no longer coerce to float or bool for columns that have custom converters specified (GH2184)

```python
In [20]: data = 'A,B,C

00001,001,5
00002,002,6'

In [21]: read_csv(StringIO(data), converters={'A': lambda x: x.strip()})
Out[21]:
   A  B  C
0  00001 1  5
1  00002 2  6
```

See the full release notes or issue tracker on GitHub for a complete list.

### 1.32 v0.9.0 (October 7, 2012)

This is a major release from 0.8.1 and includes several new features and enhancements along with a large number of bug fixes. New features include vectorized unicode encoding/decoding for `Series.str`, `to_latex` method to DataFrame, more flexible parsing of boolean values, and enabling the download of options data from Yahoo! Finance.

#### 1.32.1 New features

- Add `encode` and `decode` for unicode handling to vectorized string processing methods in `Series.str` (GH1706)
- Add `DataFrame.to_latex` method (GH1735)
- Add convenient expanding window equivalents of all rolling_* ops (GH1785)
- Add Options class to pandas.io.data for fetching options data from Yahoo! Finance (GH1748, GH1739)
- More flexible parsing of boolean values (Yes, No, TRUE, FALSE, etc) (GH1691, GH1295)
- Add `level` parameter to `Series.reset_index`
- `TimeSeries.between_time` can now select times across midnight (GH1871)
- Series constructor can now handle generator as input (GH1679)
- `DataFrame.dropna` can now take multiple axes (tuple/list) as input (GH924)
- Enable `skip_footer` parameter in `ExcelFile.parse` (GH1843)
1.32.2 API changes

- The default column names when header=None and no columns names passed to functions like read_csv has changed to be more Pythonic and amenable to attribute access:

```
In [1]: data = '0,0,1
   
1,1,0
   
0,1,0'

In [2]: df = read_csv(StringIO(data), header=None)

In [3]: df
Out[3]:
   0 1 2
0 0 0 1
1 1 1 0
2 0 1 0
[3 rows x 3 columns]
```

- Creating a Series from another Series, passing an index, will cause reindexing to happen inside rather than treating the Series like an ndarray. Technically improper usages like Series(df[col1], index=df[col2]) that worked before “by accident” (this was never intended) will lead to all NA Series in some cases. To be perfectly clear:

```
In [4]: s1 = Series([1, 2, 3])

In [5]: s1
Out[5]:
0 1
1 2
2 3
Length: 3, dtype: int64

In [6]: s2 = Series(s1, index=['foo', 'bar', 'baz'])

In [7]: s2
Out[7]:
foo  NaN
bar  NaN
baz  NaN
Length: 3, dtype: float64
```

- Deprecated day_of_year API removed from PeriodIndex, use dayofyear (GH1723)
- Don’t modify NumPy suppress printoption to True at import time
- The internal HDF5 data arrangement for DataFrames has been transposed. Legacy files will still be readable by HDFStore (GH1834, GH1824)
- Legacy cruft removed: pandas.stats.misc.quantileTS
- Use ISO8601 format for Period repr: monthly, daily, and on down (GH1776)
- Empty DataFrame columns are now created as object dtype. This will prevent a class of TypeErrors that was occurring in code where the dtype of a column would depend on the presence of data or not (e.g. a SQL query having results) (GH1783)
- Setting parts of DataFrame/Panel using ix now aligns input Series/DataFrame (GH1630)
- first and last methods in GroupBy no longer drop non-numeric columns (GH1809)
• Resolved inconsistencies in specifying custom NA values in text parser. `na_values` of type `dict` no longer override default NAs unless `keep_default_na` is set to `false` explicitly (GH1657)
• `DataFrame.dot` will not do data alignment, and also work with Series (GH1915)

See the full release notes or issue tracker on GitHub for a complete list.

1.33 v0.8.1 (July 22, 2012)

This release includes a few new features, performance enhancements, and over 30 bug fixes from 0.8.0. New features include notably NA friendly string processing functionality and a series of new plot types and options.

1.33.1 New features

• Add vectorized string processing methods accessible via `Series.str` (GH620)
• Add option to disable adjustment in EWMA (GH1584)
• Radviz plot (GH1566)
• Parallel coordinates plot
• Bootstrap plot
• Per column styles and secondary y-axis plotting (GH1559)
• New datetime converters millisecond plotting (GH1599)
• Add option to disable "sparse" display of hierarchical indexes (GH1538)
• Series/DataFrame’s `set_index` method can `append levels` to an existing `Index/MultiIndex` (GH1569, GH1577)

1.33.2 Performance improvements

• Improved implementation of rolling min and max (thanks to Bottleneck !)
• Add accelerated 'median' GroupBy option (GH1358)
• Significantly improve the performance of parsing ISO8601-format date strings with `DatetimeIndex` or `to_datetime` (GH1571)
• Improve the performance of GroupBy on single-key aggregations and use with Categorical types
• Significant datetime parsing performance improvements

1.34 v0.8.0 (June 29, 2012)

This is a major release from 0.7.3 and includes extensive work on the time series handling and processing infrastructure as well as a great deal of new functionality throughout the library. It includes over 700 commits from more than 20 distinct authors. Most pandas 0.7.3 and earlier users should not experience any issues upgrading, but due to the migration to the NumPy datetime64 dtype, there may be a number of bugs and incompatibilities lurking. Lingering incompatibilities will be fixed ASAP in a 0.8.1 release if necessary. See the full release notes or issue tracker on GitHub for a complete list.
1.34.1 Support for non-unique indexes

All objects can now work with non-unique indexes. Data alignment / join operations work according to SQL join semantics (including, if application, index duplication in many-to-many joins)

1.34.2 NumPy datetime64 dtype and 1.6 dependency

Time series data are now represented using NumPy’s datetime64 dtype; thus, pandas 0.8.0 now requires at least NumPy 1.6. It has been tested and verified to work with the development version (1.7+) of NumPy as well which includes some significant user-facing API changes. NumPy 1.6 also has a number of bugs having to do with nanosecond resolution data, so I recommend that you steer clear of NumPy 1.6’s datetime64 API functions (though limited as they are) and only interact with this data using the interface that pandas provides.

See the end of the 0.8.0 section for a “porting” guide listing potential issues for users migrating legacy codebases from pandas 0.7 or earlier to 0.8.0.

Bug fixes to the 0.7.x series for legacy NumPy < 1.6 users will be provided as they arise. There will be no more further development in 0.7.x beyond bug fixes.

1.34.3 Time series changes and improvements

Note: With this release, legacy scikits.timeseries users should be able to port their code to use pandas.

Note: See documentation for overview of pandas timeseries API.

- New datetime64 representation speeds up join operations and data alignment, reduces memory usage, and improve serialization / deserialization performance significantly over datetime.datetime
- High performance and flexible resample method for converting from high-to-low and low-to-high frequency. Supports interpolation, user-defined aggregation functions, and control over how the intervals and result labeling are defined. A suite of high performance Cython/C-based resampling functions (including Open-High-Low-Close) have also been implemented.
- Revamp of frequency aliases and support for frequency shortcuts like ‘15min’, or ‘1h30min’
- New DatetimeIndex class supports both fixed frequency and irregular time series. Replaces now deprecated DateRange class
- New PeriodIndex and Period classes for representing time spans and performing calendar logic, including the 12 fiscal quarterly frequencies <timeseries.quarterly>. This is a partial port of, and a substantial enhancement to, elements of the scikits.timeseries codebase. Support for conversion between PeriodIndex and DatetimeIndex
- New Timestamp data type subclasses datetime.datetime, providing the same interface while enabling working with nanosecond-resolution data. Also provides easy time zone conversions.
- Enhanced support for time zones. Add tz_convert and tz_localize methods to TimeSeries and DataFrame. All timestamps are stored as UTC; Timestamps from DatetimeIndex objects with time zone set will be localized to localtime. Time zone conversions are therefore essentially free. User needs to know very little about pytz library now; only time zone names as as strings are required. Time zone-aware timestamps are equal if and only if their UTC timestamps match. Operations between time zone-aware time series with different time zones will result in a UTC-indexed time series.
- Time series string indexing conveniences / shortcuts: slice years, year and month, and index values with strings
• Enhanced time series plotting: adaptation of scikits.timeseries matplotlib-based plotting code
• New date_range, bdate_range, and period_range factory functions
• Robust frequency inference function infer_freq and inferred_freq property of DatetimeIndex, with option to infer frequency on construction of DatetimeIndex
• to_datetime function efficiently parses array of strings to DatetimeIndex. DatetimeIndex will parse array or list of strings to datetime64
• Optimized support for datetime64-dtype data in Series and DataFrame columns
• New NaT (Not-a-Time) type to represent NA in timestamp arrays
• Optimize Series.asof for looking up “as of” values for arrays of timestamps
• Milli, Micro, Nano date offset objects
• Can index time series with datetime.time objects to select all data at particular time of day (TimeSeries. at_time) or between two times (TimeSeries.between_time)
• Add tshift method for leading/lagging using the frequency (if any) of the index, as opposed to a naive lead/lag using shift

1.34.4 Other new features

• New cut and qcut functions (like R’s cut function) for computing a categorical variable from a continuous variable by binning values either into value-based (cut) or quantile-based (qcut) bins
• Rename Factor to Categorical and add a number of usability features
• Add limit argument to fillna/reindex
• More flexible multiple function application in GroupBy, and can pass list (name, function) tuples to get result in particular order with given names
• Add flexible replace method for efficiently substituting values
• Enhanced read_csv/read_table for reading time series data and converting multiple columns to dates
• Add comments option to parser functions: read_csv, etc.
• Add dayfirst option to parser functions for parsing international DD/MM/YYYY dates
• Allow the user to specify the CSV reader dialect to control quoting etc.
• Handling thousands separators in read_csv to improve integer parsing.
• Enable unstacking of multiple levels in one shot. Alleviate pivot_table bugs (empty columns being introduced)
• Move to klib-based hash tables for indexing; better performance and less memory usage than Python’s dict
• Add first, last, min, max, and prod optimized GroupBy functions
• New ordered_merge function
• Add flexible comparison instance methods eq, ne, lt, gt, etc. to DataFrame, Series
• Improve scatter_matrix plotting function and add histogram or kernel density estimates to diagonal
• Add ‘kde’ plot option for density plots
• Support for converting DataFrame to R data.frame through rpy2
• Improved support for complex numbers in Series and DataFrame
• Add `pct_change` method to all data structures
• Add `max_colwidth` configuration option for DataFrame console output
• `Interpolate` Series values using index values
• Can select multiple columns from GroupBy
• Add `update` methods to Series/DataFrame for updating values in place
• Add `any` and `all` method to DataFrame

### 1.34.5 New plotting methods

`Series.plot` now supports a `secondary_y` option:

```python
In [1]: plt.figure()
Out[1]: <Figure size 640x480 with 0 Axes>

In [2]: fx['FR'].plot(style='g')
   
Out[2]: <matplotlib.axes._subplots.AxesSubplot at 0x1c376acfd0>

In [3]: fx['IT'].plot(style='k--', secondary_y=True)
   
Out[3]: <matplotlib.axes._subplots.AxesSubplot at 0x1c3781cb38>
```

Vytautas Jancauskas, the 2012 GSOC participant, has added many new plot types. For example, `kde` is a new option:

```python
In [4]: s = Series(np.concatenate((np.random.randn(1000),
                          ...
                          np.random.randn(1000) * 0.5 + 3)))

In [5]: plt.figure()
Out[5]: <Figure size 640x480 with 0 Axes>

In [6]: s.hist(normed=True, alpha=0.2)
Out[6]: <matplotlib.axes._subplots.AxesSubplot at 0x1c37c3a588>

In [7]: s.plot(kind='kde')
Out[7]: <matplotlib.axes._subplots.AxesSubplot at 0x1c37c3a588>
```

See the `plotting page` for much more.

### 1.34.6 Other API changes

• Deprecation of `offset`, `time_rule`, and `timeRule` arguments names in time series functions. Warnings will be printed until pandas 0.9 or 1.0.

### 1.34.7 Potential porting issues for pandas <= 0.7.3 users

The major change that may affect you in pandas 0.8.0 is that time series indexes use NumPy’s `datetime64` data type instead of `dtype=object` arrays of Python’s built-in `datetime.datetime` objects. `DateRange` has been
replaced by `DatetimeIndex` but otherwise behaved identically. But, if you have code that converts `DateRange` or `Index` objects that used to contain `datetime.datetime` values to plain NumPy arrays, you may have bugs lurking with code using scalar values because you are handing control over to NumPy:

```python
In [8]: import datetime

In [9]: rng = date_range('1/1/2000', periods=10)

In [10]: rng[5]
Out[10]: Timestamp('2000-01-06 00:00:00', freq='D')

In [11]: isinstance(rng[5], datetime.datetime)
Out[11]: True

In [12]: rng_asarray = np.asarray(rng)

In [13]: scalar_val = rng_asarray[5]

In [14]: type(scalar_val)
Out[14]: numpy.datetime64
```

Pandas’s `Timestamp` object is a subclass of `datetime.datetime` that has nanosecond support (the nanosecond field store the nanosecond value between 0 and 999). It should substitute directly into any code that used `datetime.datetime` values before. Thus, I recommend not casting `DatetimeIndex` to regular NumPy arrays.

If you have code that requires an array of `datetime.datetime` objects, you have a couple of options. First, the `astype(object)` method of `DatetimeIndex` produces an array of `Timestamp` objects:

```python
In [15]: stamp_array = rng.astype(object)

In [16]: stamp_array
Out[16]:
Index(['2000-01-01 00:00:00', '2000-01-02 00:00:00', '2000-01-03 00:00:00',
'2000-01-04 00:00:00', '2000-01-05 00:00:00', '2000-01-06 00:00:00',
'2000-01-07 00:00:00', '2000-01-08 00:00:00', '2000-01-09 00:00:00',
'2000-01-10 00:00:00'],
dtype='object')

In [17]: stamp_array[5]

→ Timestamp('2000-01-06 00:00:00', freq='D')
```

To get an array of proper `datetime.datetime` objects, use the `to_pydatetime` method:

```python
In [18]: dt_array = rng.to_pydatetime()

In [19]: dt_array
Out[19]:
array([datetime.datetime(2000, 1, 1, 0, 0),
       datetime.datetime(2000, 1, 2, 0, 0),
       datetime.datetime(2000, 1, 3, 0, 0),
       datetime.datetime(2000, 1, 4, 0, 0),
       datetime.datetime(2000, 1, 5, 0, 0),
       datetime.datetime(2000, 1, 6, 0, 0),
       datetime.datetime(2000, 1, 7, 0, 0),
       datetime.datetime(2000, 1, 8, 0, 0),
       datetime.datetime(2000, 1, 9, 0, 0),
       (continues on next page)
```
datetime.datetime(2000, 1, 10, 0, 0)], dtype=object)

In [20]: dt_array[5]
Out[20]:

matplotlib knows how to handle `datetime.datetime` but not `Timestamp` objects. While I recommend that you plot time series using `TimeSeries.plot`, you can either use `to_pydatetime` or register a converter for the `Timestamp` type. See matplotlib documentation for more on this.

```
In [21]: rng = date_range('1/1/2000', periods=10)
In [22]: rng
Out[22]:
```

```
In [23]: np.asarray(rng)
Out[23]:
```

```
In [24]: converted = np.asarray(rng, dtype=object)
In [25]: converted[5]
Out[25]:
```

**Warning:** There are bugs in the user-facing API with the nanosecond `datetime64` unit in NumPy 1.6. In particular, the string version of the array shows garbage values, and conversion to `dtype=object` is similarly broken.

```
In [21]: rng = date_range('1/1/2000', periods=10)
In [22]: rng
Out[22]:
```

```
In [23]: np.asarray(rng)
Out[23]:
```

```
In [24]: converted = np.asarray(rng, dtype=object)
In [25]: converted[5]
```

**Trust me: don’t panic.** If you are using NumPy 1.6 and restrict your interaction with `datetime64` values to pandas’s API you will be just fine. There is nothing wrong with the data-type (a 64-bit integer internally); all of the important data processing happens in pandas and is heavily tested. I strongly recommend that you do not work directly with `datetime64` arrays in NumPy 1.6 and only use the pandas API.

Support for non-unique indexes: In the latter case, you may have code inside a `try:... catch:` block that failed due to the index not being unique. In many cases it will no longer fail (some method like `append` still check for uniqueness unless disabled). However, all is not lost: you can inspect `index.is_unique` and raise an exception explicitly if it is `False` or go to a different code branch.

1.35 v.0.7.3 (April 12, 2012)

This is a minor release from 0.7.2 and fixes many minor bugs and adds a number of nice new features. There are also a couple of API changes to note; these should not affect very many users, and we are inclined to call them “bug fixes” even though they do constitute a change in behavior. See the full release notes or issue tracker on GitHub for a complete list.
1.35.1 New features

- New *fixed width file reader*, `read_fwf`
- New `scatter_matrix` function for making a scatter plot matrix

```python
from pandas.tools.plotting import scatter_matrix
scatter_matrix(df, alpha=0.2)
```

```
import matplotlib.pyplot as plt
plt.show()
```

- Add `stacked` argument to Series and DataFrame's `plot` method for *stacked bar plots*.

```python
df.plot(kind='bar', stacked=True)
```
Add log x and y scaling options to DataFrame.plot and Series.plot

Add kurt methods to Series and DataFrame for computing kurtosis

1.35.2 NA Boolean Comparison API Change

Reverted some changes to how NA values (represented typically as NaN or None) are handled in non-numeric Series:

In [1]: series = Series(['Steve', np.nan, 'Joe'])

In [2]: series == 'Steve'
Out[2]:
0    True
1   False
In comparisons, NA / NaN will always come through as False except with != which is True. Be very careful with boolean arithmetic, especially negation, in the presence of NA data. You may wish to add an explicit NA filter into boolean array operations if you are worried about this:

```python
In [4]: mask = series == 'Steve'
In [5]: series[mask & series.notnull()]
Out[5]:
    0  Steve
Length: 1, dtype: object
```

While propagating NA in comparisons may seem like the right behavior to some users (and you could argue on purely technical grounds that this is the right thing to do), the evaluation was made that propagating NA everywhere, including in numerical arrays, would cause a large amount of problems for users. Thus, a “practicality beats purity” approach was taken. This issue may be revisited at some point in the future.

### 1.35.3 Other API Changes

When calling apply on a grouped Series, the return value will also be a Series, to be more consistent with the groupby behavior with DataFrame:

```python
In [6]: df = DataFrame({'A' : ['foo', 'bar', 'foo', 'bar',
                          'foo', 'bar', 'foo', 'foo'],
                     'B' : ['one', 'one', 'two', 'three',
                             'two', 'two', 'one', 'three'],
                     'C' : np.random.randn(8), 'D' : np.random.randn(8))
In [7]: df
Out[7]:
   A  B         C         D
0  foo  one -0.841015  0.459840
1   bar  one  0.114219 -0.253040
2  foo  two -0.405617 -0.261128
3   bar  three  1.240678  0.406604
4  foo  two -1.022256  0.406604
5   bar  two  1.525196 -0.882785
6  foo  one  0.520047  1.793331
7  foo  three  0.163834 -0.429688
8 rows x 4 columns
```

```python
In [8]: grouped = df.groupby('A')['C']
In [9]: grouped.describe()
```
**1.36 v.0.7.2 (March 16, 2012)**

This release targets bugs in 0.7.1, and adds a few minor features.

**1.36.1 New features**

- Add additional tie-breaking methods in DataFrame.rank (GH874)
- Add ascending parameter to rank in Series, DataFrame (GH875)
- Add coerce_float option to DataFrame.from_records (GH893)
- Add sort_columns parameter to allow unsorted plots (GH918)
- Enable column access via attributes on GroupBy (GH882)
- Can pass dict of values to DataFrame.fillna (GH661)
- Can select multiple hierarchical groups by passing list of values in .ix (GH134)
- Add axis option to DataFrame.fillna (GH174)
- Add level keyword to drop for dropping values from a level (GH159)

**1.36.2 Performance improvements**

- Use khash for Series.value_counts, add raw function to algorithms.py (GH861)
- Intercept __builtin__.sum in groupby (GH885)

**1.37 v.0.7.1 (February 29, 2012)**

This release includes a few new features and addresses over a dozen bugs in 0.7.0.
1.37.1 New features

- Add `to_clipboard` function to pandas namespace for writing objects to the system clipboard (GH774)
- Add `itertuples` method to DataFrame for iterating through the rows of a dataframe as tuples (GH818)
- Add ability to pass `fill_value` and method to DataFrame and Series align method (GH806, GH807)
- Add `fill_value` option to `reindex`, `align` methods (GH784)
- Enable `concat` to produce DataFrame from Series (GH787)
- Add `between` method to Series (GH802)
- Add HTML representation hook to DataFrame for the IPython HTML notebook (GH773)
- Support for reading Excel 2007 XML documents using openpyxl

1.37.2 Performance improvements

- Improve performance and memory usage of `fillna` on DataFrame
- Can concatenate a list of Series along axis=1 to obtain a DataFrame (GH787)

1.38 v.0.7.0 (February 9, 2012)

1.38.1 New features

- New unified merge function for efficiently performing full gamut of database / relational-algebra operations. Refactored existing join methods to use the new infrastructure, resulting in substantial performance gains (GH220, GH249, GH267)
- New unified concatenation function for concatenating Series, DataFrame or Panel objects along an axis. Can form union or intersection of the other axes. Improves performance of `Series.append` and `DataFrame.append` (GH468, GH479, GH273)
- Can pass multiple DataFrames to `DataFrame.append` to concatenate (stack) and multiple Series to `Series.append` too
- Can pass list of dicts (e.g., a list of JSON objects) to DataFrame constructor (GH526)
- You can now set multiple columns in a DataFrame via `__getitem__`, useful for transformation (GH342)
- Handle differently-indexed output values in `DataFrame.apply` (GH498)

```
In [1]: df = DataFrame(randn(10, 4))
In [2]: df.apply(lambda x: x.describe())
Out[2]:
   0       1       2       3
count 10.000000 10.000000 10.000000 10.000000
mean  0.424980  0.115056  0.452000 -0.103829
std   0.898046  0.712034  0.867316  0.830197
min  -1.337024 -0.779344 -1.206466 -1.022360
25%  -0.000996 -0.344789 -0.120217 -0.744313
50%   0.860419  0.098422  0.540168 -0.387554
75%   1.094236  0.375137  1.076331  0.674952
max   1.207725  1.601703  1.663859  1.096187
```

(continues on next page)
1.38.2 API Changes to integer indexing

One of the potentially riskiest API changes in 0.7.0, but also one of the most important, was a complete review of how integer indexes are handled with regard to label-based indexing. Here is an example:
In [3]: s = Series(randn(10), index=range(0, 20, 2))

In [4]: s
Out[4]:
   0    0.446246
   2   -0.500268
   4     0.814725
   6    -0.312744
   8    1.098892
  10    1.306330
  12   -0.312744
  14   -0.030890
  16    1.608095
  18   -0.023287
Length: 10, dtype: float64

In [5]: s[0]
Out[5]:
   0.44624598505731339

In [6]: s[2]
Out[6]:
   -0.500268093241102

In [7]: s[4]
Out[7]:
   0.8147247587659604

This is all exactly identical to the behavior before. However, if you ask for a key not contained in the Series, in versions 0.6.1 and prior, Series would fall back on a location-based lookup. This now raises a KeyError:

In [2]: s[1]
KeyError: 1

This change also has the same impact on DataFrame:

In [3]: df = DataFrame(randn(8, 4), index=range(0, 16, 2))

In [4]: df
Out[4]:
   0  1  2  3
  0  0.88427  0.3363 -0.1787  0.03162
  2  0.14451 -0.1415  0.2504  0.58374
  4 -1.44779  -0.9186 -1.4996  0.27163
  6 -0.26598  -2.4184 -0.2658  0.11503
  8  0.58776   0.3144  -0.8566  0.61941
 10  0.10940  -0.7175 -1.0108  0.47990
 12 -1.16919  -0.3087  -0.6049 -0.43544
 14 -0.07337   0.3410  0.0424 -0.16037

In [5]: df.ix[3]
KeyError: 3

In order to support purely integer-based indexing, the following methods have been added:
### Method Description

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series.iget_value(i)</td>
<td>Retrieve value stored at location i</td>
</tr>
<tr>
<td>Series.iget(i)</td>
<td>Alias for iget_value</td>
</tr>
<tr>
<td>DataFrame.irow(i)</td>
<td>Retrieve the i-th row</td>
</tr>
<tr>
<td>DataFrame.icol(j)</td>
<td>Retrieve the j-th column</td>
</tr>
<tr>
<td>DataFrame.iget_value(i, j)</td>
<td>Retrieve the value at row i and column j</td>
</tr>
</tbody>
</table>

#### 1.38.3 API tweaks regarding label-based slicing

Label-based slicing using `ix` now requires that the index be sorted (monotonic) unless both the start and endpoint are contained in the index:

```python
In [1]: s = Series(randn(6), index=list('gmkaec'))
In [2]: s
Out[2]:
g -1.182230
m -0.276183
k -0.243550
a  1.628992
e  0.073308
c -0.539890
dtype: float64
```

Then this is OK:

```python
In [3]: s.ix['k':'e']
Out[3]:
k -0.243550
a  1.628992
e  0.073308
dtype: float64
```

But this is not:

```python
In [12]: s.ix['b':'h']
KeyError 'b'
```

If the index had been sorted, the “range selection” would have been possible:

```python
In [4]: s2 = s.sort_index()
In [5]: s2
Out[5]:
a  1.628992
c -0.539890
e  0.073308
g -1.182230
k -0.243550
m -0.276183
dtype: float64
```

```python
In [6]: s2.ix['b':'h']
Out[6]:
c -0.539890
```

(continues on next page)
1.38.4 Changes to Series [ ] operator

As as notational convenience, you can pass a sequence of labels or a label slice to a Series when getting and setting values via [ ] (i.e. the __getitem__ and __setitem__ methods). The behavior will be the same as passing similar input to ix except in the case of integer indexing:

```python
In [8]: s = Series(randn(6), index=list('acegkm'))

In [9]: s
Out[9]:
a   -0.800734
b   -0.229737
c   -0.781940
d   0.756053
e   -0.159310
f   2.613373
Length: 6, dtype: float64

In [10]: s[['m', 'a', 'c', 'e']]
→
m   -0.159310
a   -0.800734
c   -0.229737
e   -0.781940
Length: 4, dtype: float64

In [11]: s['b':'l']
→
c   -0.229737
e   -0.781940
g   0.756053
k   2.613373
Length: 4, dtype: float64

In [12]: s['c':'k']
→
c   -0.229737
e   -0.781940
g   0.756053
k   2.613373
Length: 4, dtype: float64
```

In the case of integer indexes, the behavior will be exactly as before (shadowing ndarray):

```python
In [13]: s = Series(randn(6), index=range(0, 12, 2))

In [14]: s[[4, 0, 2]]
Out[14]:
a   -0.800734
c   -0.229737
e   -0.781940
g   0.756053
k   2.613373
Length: 4, dtype: float64
```
4  0.022862
0  -0.321246
2  -0.707337
Length: 3, dtype: float64

In [15]: s[1:5]
Out[15]:
   2    -0.707337
   4     0.022862
   6     0.306713
   8   -0.162222
Length: 4, dtype: float64

If you wish to do indexing with sequences and slicing on an integer index with label semantics, use `ix`.

### 1.38.5 Other API Changes

- The deprecated `LongPanel` class has been completely removed
- If `Series.sort` is called on a column of a DataFrame, an exception will now be raised. Before it was possible to accidentally mutate a DataFrame’s column by doing `df[col].sort()` instead of the side-effect free method `df[col].order()` (GH316)
- Miscellaneous renames and deprecations which will (harmlessly) raise `FutureWarning`
- `drop` added as an optional parameter to `DataFrame.reset_index` (GH699)

### 1.38.6 Performance improvements

- **Cythonized GroupBy aggregations** no longer presort the data, thus achieving a significant speedup (GH93). GroupBy aggregations with Python functions significantly sped up by clever manipulation of the ndarray data type in Cython (GH496).
- Better error message in DataFrame constructor when passed column labels don’t match data (GH497)
- Substantially improve performance of multi-GroupBy aggregation when a Python function is passed, reuse ndarray object in Cython (GH496)
- Can store objects indexed by tuples and floats in HDFStore (GH492)
- Don’t print length by default in `Series.to_string`, add `length` option (GH489)
- Improve Cython code for multi-groupby to aggregate without having to sort the data (GH93)
- Improve MultiIndex reindexing speed by storing tuples in the MultiIndex, test for backwards unpickling compatibility
- Improve column reindexing performance by using specialized Cython take function
- Further performance tweaking of `Series._getitem__` for standard use cases
- Avoid Index dict creation in some cases (i.e. when getting slices, etc.), regression from prior versions
- Friendlier error message in setup.py if NumPy not installed
- Use common set of NA-handling operations (sum, mean, etc.) in Panel class also (GH536)
- Default name assignment when calling `reset_index` on DataFrame with a regular (non-hierarchical) index (GH476)
• Use Cythonized groupers when possible in Series/DataFrame stat ops with level parameter passed (GH545)
• Ported skiplist data structure to C to speed up rolling_median by about 5-10x in most typical use cases (GH374)

1.39 v.0.6.1 (December 13, 2011)

1.39.1 New features

• Can append single rows (as Series) to a DataFrame
• Add Spearman and Kendall rank correlation options to Series.corr and DataFrame.corr (GH428)
• Added get_value and set_value methods to Series, DataFrame, and Panel for very low-overhead access (>2x faster in many cases) to scalar elements (GH437, GH438). set_value is capable of producing an enlarged object.
• Add PyQt table widget to sandbox (GH435)
• DataFrame.align can accept Series arguments and an axis option (GH461)
• Implement new SparseArray and SparseList data structures. SparseSeries now derives from SparseArray (GH463)
• Better console printing options (GH453)
• Implement fast data ranking for Series and DataFrame, fast versions of scipy.stats.rankdata (GH428)
• Implement DataFrame.from_items alternate constructor (GH444)
• DataFrame.convert_objects method for inferring better dtypes for object columns (GH302)
• Add rolling_corr_pairwise function for computing Panel of correlation matrices (GH189)
• Add margins option to pivot_table for computing subgroup aggregates (GH114)
• Add Series.from_csv function (GH482)
• Can pass DataFrame/DataFrame and DataFrame/Series to rolling_corr/rolling_cov (GH #462)
• MultiIndex.get_level_values can accept the level name

1.39.2 Performance improvements

• Improve memory usage of DataFrame.describe (do not copy data unnecessarily) (PR #425)
• Optimize scalar value lookups in the general case by 25% or more in Series and DataFrame
• Fix performance regression in cross-sectional count in DataFrame, affecting DataFrame.dropna speed
• Column deletion in DataFrame copies no data (computes views on blocks) (GH #158)

1.40 v.0.6.0 (November 25, 2011)

1.40.1 New Features

• Added melt function to pandas.core.reshape
• Added level parameter to group by level in Series and DataFrame descriptive statistics (GH313)
• Added head and tail methods to Series, analogous to to DataFrame (GH296)
• Added Series.isin function which checks if each value is contained in a passed sequence (GH289)
• Added float_format option to Series.to_string
• Added skip_footer (GH291) and converters (GH343) options to read_csv and read_table
• Added drop_duplicates and duplicated functions for removing duplicate DataFrame rows and checking for duplicate rows, respectively (GH319)
• Implemented operators ‘&’, ‘|’, ‘^’, ‘~’ on DataFrame (GH347)
• Added Series.mad, mean absolute deviation
• Added QuarterEnd DateOffset (GH321)
• Added dot to DataFrame (GH65)
• Added orient option to Panel.from_dict (GH359, GH301)
• Added orient option to DataFrame.from_dict
• Added passing list of tuples or list of lists to DataFrame.from_records (GH357)
• Added multiple levels to groupby (GH103)
• Allow multiple columns in by argument of DataFrame.sort_index (GH92, GH362)
• Added fast get_value and put_value methods to DataFrame (GH360)
• Added cov instance methods to Series and DataFrame (GH194, GH362)
• Added kind='bar' option to DataFrame.plot (GH348)
• Added idxmin and idxmax to Series and DataFrame (GH286)
• Added read_clipboard function to parse DataFrame from clipboard (GH300)
• Added nunique function to Series for counting unique elements (GH297)
• Made DataFrame constructor use Series name if no columns passed (GH373)
• Support regular expressions in read_table/read_csv (GH364)
• Added DataFrame.to_html for writing DataFrame to HTML (GH387)
• Added support for MaskedArray data in DataFrame, masked values converted to NaN (GH396)
• Added DataFrame.boxplot function (GH368)
• Can pass extra args, kwds to DataFrame.apply (GH376)
• Implement DataFrame.join with vector on argument (GH312)
• Added legend boolean flag to DataFrame.plot (GH324)
• Can pass multiple levels to stack and unstack (GH370)
• Can pass multiple values columns to pivot_table (GH381)
• Use Series name in GroupBy for result index (GH363)
• Added raw option to DataFrame.apply for performance if only need ndarray (GH309)
• Added proper, tested weighted least squares to standard and panel OLS (GH303)
1.40.2 Performance Enhancements

- **VBENCH** Cythonized `cache_readonly`, resulting in substantial micro-performance enhancements throughout the codebase (GH361)
- **VBENCH** Special Cython matrix iterator for applying arbitrary reduction operations with 3-5x better performance than `np.apply_along_axis` (GH309)
- **VBENCH** Improved performance of `MultiIndex.from_tuples`
- **VBENCH** Special Cython matrix iterator for applying arbitrary reduction operations
- **VBENCH + DOCUMENT** Add `raw` option to DataFrame.apply for getting better performance when
- **VBENCH** Faster cythonized count by level in Series and DataFrame (GH341)
- **VBENCH**? Significant GroupBy performance enhancement with multiple keys with many “empty” combinations
- **VBENCH** New Cython vectorized function `map_infer` speeds up Series.apply and Series.map significantly when passed elementwise Python function, motivated by (GH355)
- **VBENCH** Significantly improved performance of Series.order, which also makes np.unique called on a Series faster (GH327)
- **VBENCH** Vastly improved performance of GroupBy on axes with a MultiIndex (GH299)

1.41 v.0.5.0 (October 24, 2011)

1.41.1 New Features

- **Added** DataFrame.align method with standard join options
- **Added** `parse_dates` option to read_csv and read_table methods to optionally try to parse dates in the index columns
- **Added** `nrows`, `chunksize`, and `iterator` arguments to read_csv and read_table. The last two return a new TextParser class capable of lazily iterating through chunks of a flat file (GH242)
- **Added** ability to join on multiple columns in DataFrame.join (GH214)
- **Added** private `_get_duplicates` function to Index for identifying duplicate values more easily (ENH5c)
- **Added** column attribute access to DataFrame.
- **Added** Python tab completion hook for DataFrame columns. (GH233, GH230)
- **Implemented** Series.describe for Series containing objects (GH241)
- **Added** inner join option to DataFrame.join when joining on key(s) (GH248)
- **Implemented** selecting DataFrame columns by passing a list to `__getitem__` (GH253)
- **Implemented** `&` and `|` to intersect / union Index objects, respectively (GH261)
- **Added** pivot_table convenience function to pandas namespace (GH234)
- **Implemented** Panel.rename_axis function (GH243)
- **Implemented** DataFrame will show index level names in console output (GH334)
- **Implemented** Panel.take
- **Added** `set_eng_float_format` for alternate DataFrame floating point string formatting (ENH61)
• *Added* convenience *set_index* function for creating a DataFrame index from its existing columns
• *Implemented* *groupby* hierarchical index level name (GH223)
• *Added* support for different delimiters in *DataFrame.to_csv* (GH244)
• TODO: DOCS ABOUT TAKE METHODS

### 1.41.2 Performance Enhancements

• **VBENCH** Major performance improvements in file parsing functions *read_csv* and *read_table*
• **VBENCH** Added Cython function for converting tuples to ndarray very fast. Speeds up many MultiIndex-related operations
• **VBENCH** Refactored merging / joining code into a tidy class and disabled unnecessary computations in the float/object case, thus getting about 10% better performance (GH211)
• **VBENCH** Improved speed of *DataFrame.xs* on mixed-type DataFrame objects by about 5x, regression from 0.3.0 (GH215)
• **VBENCH** With new *DataFrame.align* method, speeding up binary operations between differently-indexed DataFrame objects by 10-25%.
• **VBENCH** Significantly sped up conversion of nested dict into DataFrame (GH212)
• **VBENCH** Significantly speed up *DataFrame.__repr__* and *count* on large mixed-type DataFrame objects

### 1.42 v.0.4.3 through v0.4.1 (September 25 - October 9, 2011)

#### 1.42.1 New Features

• *Added* Python 3 support using 2to3 (GH200)
• *Added* *name* attribute to *Series*, now prints as part of *Series.__repr__*
• *Added* instance methods *isnull* and *notnull* to *Series* (GH209, GH203)
• *Added* *Series.align* method for aligning two series with choice of join method (ENH56)
• *Added* method *get_level_values* to *MultiIndex* (GH188)
• Set values in mixed-type DataFrame objects via *.ix* indexing attribute (GH135)
• *Added* new *DataFrame methods* *get_dtype_counts* and property *dtypes* (ENHdc)
• *Added* *ignore_index* option to *DataFrame.append* to stack DataFrames (ENH1b)
• *read_csv* tries to *sniff* delimiters using *csv.Sniffer* (GH146)
• *read_csv* can *read* multiple columns into a MultiIndex; *DataFrame‘s to_csv* method writes out a corresponding MultiIndex (GH151)
• *DataFrame.rename* has a new *copy* parameter to *rename* a DataFrame in place (ENHed)
• *Enable* unstacking by name (GH142)
• *Enable* *sortlevel* to work by level (GH141)
1.42.2 Performance Enhancements

- Altered binary operations on differently-indexed SparseSeries objects to use the integer-based (dense) alignment logic which is faster with a larger number of blocks (GH205)
- Wrote faster Cython data alignment / merging routines resulting in substantial speed increases
- Improved performance of `isnull` and `notnull`, a regression from v0.3.0 (GH187)
- Refactored code related to `DataFrame.join` so that intermediate aligned copies of the data in each `DataFrame` argument do not need to be created. Substantial performance increases result (GH176)
- Substantially improved performance of generic `Index.intersection` and `Index.union`
- Implemented `BlockManager.take` resulting in significantly faster `take` performance on mixed-type `DataFrame` objects (GH104)
- Improved performance of `Series.sort_index`
- Significant groupby performance enhancement: removed unnecessary integrity checks in `DataFrame` internals that were slowing down slicing operations to retrieve groups
- Optimized `_ensure_index` function resulting in performance savings in type-checking `Index` objects
- Wrote fast time series merging / joining methods in Cython. Will be integrated later into `DataFrame.join` and related functions
The easiest way to install pandas is to install it as part of the Anaconda distribution, a cross platform distribution for data analysis and scientific computing. This is the recommended installation method for most users. Instructions for installing from source, PyPI, ActivePython, various Linux distributions, or a development version are also provided.

2.1 Plan for dropping Python 2.7

The Python core team plans to stop supporting Python 2.7 on January 1st, 2020. In line with NumPy’s plans, all pandas releases through December 31, 2018 will support Python 2.

The final release before December 31, 2018 will be the last release to support Python 2. The released package will continue to be available on PyPI and through conda.

Starting January 1, 2019, all releases will be Python 3 only.

If there are people interested in continued support for Python 2.7 past December 31, 2018 (either backporting bugfixes or funding) please reach out to the maintainers on the issue tracker.

For more information, see the Python 3 statement and the Porting to Python 3 guide.

2.2 Python version support

Officially Python 2.7, 3.5, 3.6, and 3.7.

2.3 Installing pandas

2.3.1 Installing with Anaconda

Installing pandas and the rest of the NumPy and SciPy stack can be a little difficult for inexperienced users.

The simplest way to install not only pandas, but Python and the most popular packages that make up the SciPy stack (IPython, NumPy, Matplotlib, ...) is with Anaconda, a cross-platform (Linux, Mac OS X, Windows) Python distribution for data analytics and scientific computing.

After running the installer, the user will have access to pandas and the rest of the SciPy stack without needing to install anything else, and without needing to wait for any software to be compiled.

Installation instructions for Anaconda can be found here.
A full list of the packages available as part of the Anaconda distribution can be found here.

Another advantage to installing Anaconda is that you don’t need admin rights to install it. Anaconda can install in the user’s home directory, which makes it trivial to delete Anaconda if you decide (just delete that folder).

### 2.3.2 Installing with Miniconda

The previous section outlined how to get pandas installed as part of the Anaconda distribution. However this approach means you will install well over one hundred packages and involves downloading the installer which is a few hundred megabytes in size.

If you want to have more control on which packages, or have a limited internet bandwidth, then installing pandas with Miniconda may be a better solution.

Conda is the package manager that the Anaconda distribution is built upon. It is a package manager that is both cross-platform and language agnostic (it can play a similar role to a pip and virtualenv combination).

Miniconda allows you to create a minimal self contained Python installation, and then use the Conda command to install additional packages.

First you will need Conda to be installed and downloading and running the Miniconda will do this for you. The installer can be found here

The next step is to create a new conda environment. A conda environment is like a virtualenv that allows you to specify a specific version of Python and set of libraries. Run the following commands from a terminal window:

```bash
conda create -n name_of_my_env python
```

This will create a minimal environment with only Python installed in it. To put your self inside this environment run:

```bash
source activate name_of_my_env
```

On Windows the command is:

```bash
activate name_of_my_env
```

The final step required is to install pandas. This can be done with the following command:

```bash
conda install pandas
```

To install a specific pandas version:

```bash
conda install pandas=0.20.3
```

To install other packages, IPython for example:

```bash
conda install ipython
```

To install the full Anaconda distribution:

```bash
conda install anaconda
```

If you need packages that are available to pip but not conda, then install pip, and then use pip to install those packages:

```bash
conda install pip
pip install django
```
2.3.3 Installing from PyPI

pandas can be installed via pip from PyPI.

```bash
pip install pandas
```

2.3.4 Installing with ActivePython

Installation instructions for ActivePython can be found here. Versions 2.7 and 3.5 include pandas.

2.3.5 Installing using your Linux distribution's package manager.

The commands in this table will install pandas for Python 3 from your distribution. To install pandas for Python 2, you may need to use the `python-pandas` package.

```none
<table>
<thead>
<tr>
<th>Distribution</th>
<th>Status</th>
<th>Download / Repository Link</th>
<th>Install method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debian</td>
<td>stable</td>
<td>official Debian repository</td>
<td><code>sudo apt-get install python3-pandas</code></td>
</tr>
<tr>
<td>Debian &amp; Ubuntu</td>
<td>unstable (latest packages)</td>
<td>NeuroDebian</td>
<td><code>sudo apt-get install python3-pandas</code></td>
</tr>
<tr>
<td>Ubuntu</td>
<td>stable</td>
<td>official Ubuntu repository</td>
<td><code>sudo apt-get install python3-pandas</code></td>
</tr>
<tr>
<td>OpenSuse</td>
<td>stable</td>
<td>OpenSuse Repository</td>
<td><code>zypper in python3-pandas</code></td>
</tr>
<tr>
<td>Fedora</td>
<td>stable</td>
<td>official Fedora repository</td>
<td><code>dnf install python3-pandas</code></td>
</tr>
<tr>
<td>Centos/RHEL</td>
<td>stable</td>
<td>EPEL repository</td>
<td><code>yum install python3-pandas</code></td>
</tr>
</tbody>
</table>
```

However, the packages in the linux package managers are often a few versions behind, so to get the newest version of pandas, it’s recommended to install using the `pip` or `conda` methods described above.

2.3.6 Installing from source

See the contributing documentation for complete instructions on building from the git source tree. Further, see creating a development environment if you wish to create a pandas development environment.

2.4 Running the test suite

pandas is equipped with an exhaustive set of unit tests, covering about 97% of the codebase as of this writing. To run it on your machine to verify that everything is working (and that you have all of the dependencies, soft and hard, installed), make sure you have `pytest` and run:

```bash
>>> import pandas as pd
>>> pd.test()
running: pytest --skip-slow --skip-network C:\Users\TF\Anaconda3\envs\py36\lib\site-packages\pandas
================================== test session starts ==================================
(continues on next page)
2.5 Dependencies

- setuptools: 24.2.0 or higher
- NumPy: 1.9.0 or higher
- python-dateutil: 2.5.0 or higher
- pytz

2.5.1 Recommended Dependencies

- numexpr: for accelerating certain numerical operations. numexpr uses multiple cores as well as smart chunking and caching to achieve large speedups. If installed, must be Version 2.4.6 or higher.
- bottleneck: for accelerating certain types of nan evaluations. bottleneck uses specialized cython routines to achieve large speedups. If installed, must be Version 1.0.0 or higher.

Note: You are highly encouraged to install these libraries, as they provide speed improvements, especially when working with large data sets.

2.5.2 Optional Dependencies

- Cython: Only necessary to build development version. Version 0.24 or higher.
- SciPy: miscellaneous statistical functions, Version 0.14.0 or higher
- xarray: pandas like handling for > 2 dims, needed for converting Panels to xarray objects. Version 0.7.0 or higher is recommended.
- PyTables: necessary for HDF5-based storage. Version 3.0.0 or higher required, Version 3.2.1 or higher highly recommended.
- Feather Format: necessary for feather-based storage, version 0.3.1 or higher.
- Apache Parquet, either pyarrow (>= 0.4.1) or fastparquet (>= 0.0.6) for parquet-based storage. The snappy and brotli are available for compression support.
- SQLAlchemy: for SQL database support. Version 0.8.1 or higher recommended. Besides SQLAlchemy, you also need a database specific driver. You can find an overview of supported drivers for each SQL dialect in the SQLAlchemy docs. Some common drivers are:
  - psycopg2: for PostgreSQL
• **pymysql**: for MySQL.
• **SQLite**: for SQLite, this is included in Python’s standard library by default.

**matplotlib**: for plotting, Version 1.4.3 or higher.

**For Excel I/O:**

• **xlrd/xlwt**: Excel reading (xlrd) and writing (xlwt)
• **openpyxl**: openpyxl version 2.4.0 for writing .xlsx files (xlrd >= 0.9.0)
• **XlsxWriter**: Alternative Excel writer

**Jinja2**: Template engine for conditional HTML formatting.

**s3fs**: necessary for Amazon S3 access (s3fs >= 0.0.7).

**blosc**: for msgpack compression using blosc

• One of **qtpy** (requires PyQt or PySide), **PyQt5**, **PyQt4**, **pygtk**, **xsel**, or **xclip**: necessary to use `read_clipboard()`. Most package managers on Linux distributions will have `xclip` and/or `xsel` immediately available for installation.

**pandas-gbq**: for Google BigQuery I/O.

**Backports.lzma**: Only for Python 2, for writing to and/or reading from an xz compressed DataFrame in CSV; Python 3 support is built into the standard library.

• One of the following combinations of libraries is needed to use the top-level `read_html()` function:

  Changed in version 0.23.0.

**Note**: If using BeautifulSoup4 a minimum version of 4.2.1 is required

• **BeautifulSoup4** and **html5lib** (Any recent version of html5lib is okay.)
• **BeautifulSoup4** and **lxml**
• **BeautifulSoup4** and **html5lib** and **lxml**
• **Only lxml**, although see *HTML Table Parsing* for reasons as to why you should probably **not** take this approach.

**Warning:**

• if you install **BeautifulSoup4** you must install either **lxml** or **html5lib** or both. **read_html()** will **not** work with only **BeautifulSoup4** installed.

• You are highly encouraged to read *HTML Table Parsing gotchas*. It explains issues surrounding the installation and usage of the above three libraries.

**Note:**

• if you’re on a system with **apt-get** you can do

```bash
sudo apt-get build-dep python-lxml
```

to get the necessary dependencies for installation of **lxml**. This will prevent further headaches down the line.
Note: Without the optional dependencies, many useful features will not work. Hence, it is highly recommended that you install these. A packaged distribution like Anaconda, ActivePython (version 2.7 or 3.5), or Enthought Canopy may be worth considering.
CHAPTER THREE

CONTRIBUTING TO PANDAS

Table of contents:

• Where to start?
• Bug reports and enhancement requests
• Working with the code
  – Version control, Git, and GitHub
  – Getting started with Git
  – Forking
  – Creating a development environment
    * Installing a C Compiler
    * Creating a Python Environment
    * Creating a Python Environment (pip)
  – Creating a branch
• Contributing to the documentation
  – About the pandas documentation
  – How to build the pandas documentation
    * Requirements
    * Building the documentation
    * Building master branch documentation
• Contributing to the code base
  – Code standards
    * C (cpplint)
    * Python (PEP8)
    * Backwards Compatibility
  – Testing With Continuous Integration
  – Test-driven development/code writing
    * Writing tests
3.1 Where to start?

All contributions, bug reports, bug fixes, documentation improvements, enhancements, and ideas are welcome.

If you are brand new to pandas or open-source development, we recommend going through the GitHub “issues” tab to find issues that interest you. There are a number of issues listed under Docs and good first issue where you could start out. Once you’ve found an interesting issue, you can return here to get your development environment setup.

Feel free to ask questions on the mailing list or on Gitter.

3.2 Bug reports and enhancement requests

Bug reports are an important part of making pandas more stable. Having a complete bug report will allow others to reproduce the bug and provide insight into fixing. See this stackoverflow article and this blogpost for tips on writing a good bug report.

Trying the bug-producing code out on the master branch is often a worthwhile exercise to confirm the bug still exists. It is also worth searching existing bug reports and pull requests to see if the issue has already been reported and/or fixed.

Bug reports must:

1. Include a short, self-contained Python snippet reproducing the problem. You can format the code nicely by using GitHub Flavored Markdown:

```
```python
>>> from pandas import DataFrame
>>> df = DataFrame(...)
...
```

2. Include the full version string of pandas and its dependencies. You can use the built in function:
3. Explain why the current behavior is wrong/not desired and what you expect instead.

The issue will then show up to the pandas community and be open to comments/ideas from others.

### 3.3 Working with the code

Now that you have an issue you want to fix, enhancement to add, or documentation to improve, you need to learn how to work with GitHub and the pandas code base.

#### 3.3.1 Version control, Git, and GitHub

To the new user, working with Git is one of the more daunting aspects of contributing to pandas. It can very quickly become overwhelming, but sticking to the guidelines below will help keep the process straightforward and mostly trouble free. As always, if you are having difficulties please feel free to ask for help.

The code is hosted on GitHub. To contribute you will need to sign up for a free GitHub account. We use Git for version control to allow many people to work together on the project.

Some great resources for learning Git:

- the GitHub help pages.
- the NumPy’s documentation.
- Matthew Brett’s Pydagogue.

#### 3.3.2 Getting started with Git

GitHub has instructions for installing git, setting up your SSH key, and configuring git. All these steps need to be completed before you can work seamlessly between your local repository and GitHub.

#### 3.3.3 Forking

You will need your own fork to work on the code. Go to the pandas project page and hit the Fork button. You will want to clone your fork to your machine:

```bash
$ git clone https://github.com/your-user-name/pandas.git pandas-yourname
$ cd pandas-yourname
$ git remote add upstream https://github.com/pandas-dev/pandas.git
```

This creates the directory pandas-yourname and connects your repository to the upstream (main project) pandas repository.

#### 3.3.4 Creating a development environment

To test out code changes, you’ll need to build pandas from source, which requires a C compiler and Python environment. If you’re making documentation changes, you can skip to Contributing to the documentation but you won’t be able to build the documentation locally before pushing your changes.
3.3.4.1 Installing a C Compiler

Pandas uses C extensions (mostly written using Cython) to speed up certain operations. To install pandas from source, you need to compile these C extensions, which means you need a C compiler. This process depends on which platform you’re using. Follow the CPython contributing guidelines for getting a compiler installed. You don’t need to do any of the ./configure or make steps; you only need to install the compiler.

For Windows developers, the following links may be helpful.

- https://cowboyprogrammer.org/building-python-wheels-for-windows/
- https://blog.ionelmc.ro/2014/12/21/compiling-python-extensions-on-windows/

Let us know if you have any difficulties by opening an issue or reaching out on Gitter.

3.3.4.2 Creating a Python Environment

Now that you have a C compiler, create an isolated pandas development environment:

- Install either Anaconda or miniconda
- Make sure your conda is up to date (conda update conda)
- Make sure that you have cloned the repository
- cd to the pandas source directory

We’ll now kick off a three-step process:

1. Install the build dependencies
2. Build and install pandas
3. Install the optional dependencies

```bash
# Create and activate the build environment
conda env create -f ci/environment-dev.yaml
conda activate pandas-dev

# or with older versions of Anaconda:
source activate pandas-dev

# Build and install pandas
python setup.py build_ext --inplace -j 4
python -m pip install -e .

# Install the rest of the optional dependencies
conda install -c defaults -c conda-forge --file=ci/requirements-optional-conda.txt
```

At this point you should be able to import pandas from your locally built version:

```bash
$ python  # start an interpreter
>>> import pandas
>>> print(pandas.__version__)
0.22.0.dev0+29.g4ad6d4d74
```
This will create the new environment, and not touch any of your existing environments, nor any existing Python installation.

To view your environments:

```bash
conda info -e
```

To return to your root environment:

```bash
conda deactivate
```

See the full conda docs [here](#).

### 3.3.4.3 Creating a Python Environment (pip)

If you aren’t using conda for you development environment, follow these instructions. You’ll need to have at least python3.5 installed on your system.

```bash
# Create a virtual environment
# Use an ENV_DIR of your choice. We'll use ~/virtualenvs/pandas-dev
# Any parent directories should already exist
python3 -m venv ~/virtualenvs/pandas-dev
# Activate the virtualenv
. ~/virtualenvs/pandas-dev/bin/activate

# Install the build dependencies
python -m pip install -r ci/requirements_dev.txt
# Build and install pandas
python setup.py build_ext --inplace -j 4
python -m pip install -e .

# Install additional dependencies
python -m pip install -r ci/requirements-optional-pip.txt
```

### 3.3.5 Creating a branch

You want your master branch to reflect only production-ready code, so create a feature branch for making your changes. For example:

```bash
git branch shiny-new-feature
git checkout shiny-new-feature
```

The above can be simplified to:

```bash
git checkout -b shiny-new-feature
```

This changes your working directory to the shiny-new-feature branch. Keep any changes in this branch specific to one bug or feature so it is clear what the branch brings to pandas. You can have many shiny-new-features and switch in between them using the git checkout command.

When creating this branch, make sure your master branch is up to date with the latest upstream master version. To update your local master branch, you can do:

```bash
git checkout master
git pull upstream master --ff-only
```
When you want to update the feature branch with changes in master after you created the branch, check the section on updating a PR.

### 3.4 Contributing to the documentation

Contributing to the documentation benefits everyone who uses pandas. We encourage you to help us improve the documentation, and you don’t have to be an expert on pandas to do so! In fact, there are sections of the docs that are worse off after being written by experts. If something in the docs doesn’t make sense to you, updating the relevant section after you figure it out is a great way to ensure it will help the next person.

**Documentation:**

- *About the pandas documentation*
- *How to build the pandas documentation*
  - Requirements
  - Building the documentation
  - Building master branch documentation

#### 3.4.1 About the pandas documentation

The documentation is written in reStructuredText, which is almost like writing in plain English, and built using Sphinx. The Sphinx Documentation has an excellent introduction to reST. Review the Sphinx docs to perform more complex changes to the documentation as well.

Some other important things to know about the docs:

- The pandas documentation consists of two parts: the docstrings in the code itself and the docs in this folder pandas/doc/.
  
The docstrings provide a clear explanation of the usage of the individual functions, while the documentation in this folder consists of tutorial-like overviews per topic together with some other information (what’s new, installation, etc).

- The docstrings follow a pandas convention, based on the Numpy Docstring Standard. Follow the pandas docstring guide for detailed instructions on how to write a correct docstring.

#### 3.4.1.1 pandas docstring guide

**Note:** Video tutorial: Pandas docstring guide by Frank Akogun.

**About docstrings and standards**

A Python docstring is a string used to document a Python module, class, function or method, so programmers can understand what it does without having to read the details of the implementation.

Also, it is a common practice to generate online (html) documentation automatically from docstrings. Sphinx serves this purpose.
Next example gives an idea on how a docstring looks like:

```python
def add(num1, num2):
    """
    Add up two integer numbers.
    
    This function simply wraps the `+` operator, and does not
    do anything interesting, except for illustrating what is
    the docstring of a very simple function.
    
    Parameters
    ----------
    num1 : int
        First number to add
    num2 : int
        Second number to add
    
    Returns
    -------
    int
        The sum of `num1` and `num2`
    
    See Also
    --------
    subtract : Subtract one integer from another
    
    Examples
    --------
    >>> add(2, 2)
    4
    >>> add(25, 0)
    25
    >>> add(10, -10)
    0
    """
    return num1 + num2
```

Some standards exist about docstrings, so they are easier to read, and they can be exported to other formats such as html or pdf.

The first conventions every Python docstring should follow are defined in PEP-257.

As PEP-257 is quite open, and some other standards exist on top of it. In the case of pandas, the numpy docstring convention is followed. The conventions is explained in this document:

- numpydoc docstring guide (which is based in the original Guide to NumPy/SciPy documentation)

numpydoc is a Sphinx extension to support the numpy docstring convention.

The standard uses reStructuredText (reST). reStructuredText is a markup language that allows encoding styles in plain text files. Documentation about reStructuredText can be found in:

- Sphinx reStructuredText primer
- Quick reStructuredText reference
- Full reStructuredText specification

Pandas has some helpers for sharing docstrings between related classes, see Sharing Docstrings.

The rest of this document will summarize all the above guides, and will provide additional convention specific to the pandas project.
Writing a docstring

General rules

Docstrings must be defined with three double-quotes. No blank lines should be left before or after the docstring. The text starts in the next line after the opening quotes. The closing quotes have their own line (meaning that they are not at the end of the last sentence).

In rare occasions reST styles like bold text or italics will be used in docstrings, but it is common to have inline code, which is presented between backticks. It is considered inline code:

- The name of a parameter
- Python code, a module, function, built-in, type, literal... (e.g. os, list, numpy.abs, datetime.date, True)
- A pandas class (in the form :class:`pandas.Series`)
- A pandas method (in the form :meth:`pandas.Series.sum`)
- A pandas function (in the form :func:`pandas.to_datetime`)

**Note:** To display only the last component of the linked class, method or function, prefix it with ~. For example, :class:`~pandas.Series` will link to pandas.Series but only display the last part, Series as the link text. See Sphinx cross-referencing syntax for details.

**Good:**

```python
def add_values(arr):
    
    Add the values in `arr`.
    This is equivalent to Python `sum` of :meth:`pandas.Series.sum`.
    Some sections are omitted here for simplicity.
    
    return sum(arr)
```

**Bad:**

```python
def func():

    """Some function.
    With several mistakes in the docstring.
    It has a blank like after the signature `def func():`.
    The text 'Some function' should go in the line after the opening quotes of the docstring, not in the same line.
    There is a blank line between the docstring and the first line of code `foo = 1`.
    The closing quotes should be in the next line, not in this one.""

    foo = 1
```

(continues on next page)
Section 1: Short summary

The short summary is a single sentence that expresses what the function does in a concise way.

The short summary must start with a capital letter, end with a dot, and fit in a single line. It needs to express what the object does without providing details. For functions and methods, the short summary must start with an infinitive verb.

**Good:**

```python
def astype(dtype):
    """
    Cast Series type.
    
    This section will provide further details.
    """
    pass
```

**Bad:**

```python
def astype(dtype):
    """
    Casts Series type.
    
    Verb in third-person of the present simple, should be infinitive.
    """
    pass

def astype(dtype):
    """
    Method to cast Series type.
    
    Does not start with verb.
    """
    pass

def astype(dtype):
    """
    Cast Series type
    
    Missing dot at the end.
    """
    pass

def astype(dtype):
    """
    Cast Series type from its current type to the new type defined in the parameter `dtype`.
    
    Summary is too verbose and doesn't fit in a single line.
    """
    pass
```
Section 2: Extended summary

The extended summary provides details on what the function does. It should not go into the details of the parameters, or discuss implementation notes, which go in other sections.

A blank line is left between the short summary and the extended summary. And every paragraph in the extended summary is finished by a dot.

The extended summary should provide details on why the function is useful and their use cases, if it is not too generic.

```python
def unstack():
    """
    Pivot a row index to columns.

    When using a multi-index, a level can be pivoted so each value in
    the index becomes a column. This is especially useful when a subindex
    is repeated for the main index, and data is easier to visualize as a
    pivot table.

    The index level will be automatically removed from the index when added
    as columns.
    """
    pass
```

Section 3: Parameters

The details of the parameters will be added in this section. This section has the title “Parameters”, followed by a line with a hyphen under each letter of the word “Parameters”. A blank line is left before the section title, but not after, and not between the line with the word “Parameters” and the one with the hyphens.

After the title, each parameter in the signature must be documented, including *args and **kwargs, but not self.

The parameters are defined by their name, followed by a space, a colon, another space, and the type (or types). Note that the space between the name and the colon is important. Types are not defined for *args and **kwargs, but must be defined for all other parameters. After the parameter definition, it is required to have a line with the parameter description, which is indented, and can have multiple lines. The description must start with a capital letter, and finish with a dot.

For keyword arguments with a default value, the default will be listed after a comma at the end of the type. The exact form of the type in this case will be “int, default 0”. In some cases it may be useful to explain what the default argument means, which can be added after a comma “int, default -1, meaning all cpus”.

In cases where the default value is None, meaning that the value will not be used. Instead of “str, default None”, it is preferred to write “str, optional”. When None is a value being used, we will keep the form “str, default None”. For example, in df.to_csv(compression=None), None is not a value being used, but means that compression is optional, and no compression is being used if not provided. In this case we will use str, optional. Only in cases like func(value=None) and None is being used in the same way as 0 or foo would be used, then we will specify “str, int or None, default None”.

Good:

```python
class Series:
    def plot(self, kind, color='blue', **kwargs):
        """
        Generate a plot.
        """
```
Render the data in the Series as a matplotlib plot of the specified kind.

Parameters

    kind : str
        Kind of matplotlib plot.
    color : str, default 'blue'
        Color name or rgb code.
    **kwargs
        These parameters will be passed to the matplotlib plotting function.

""
    pass

Bad:

```python
class Series:

    def plot(self, kind, **kwargs):
        ""
        Generate a plot.
        Render the data in the Series as a matplotlib plot of the specified kind.

        Note the blank line between the parameters title and the first parameter. Also, note that after the name of the parameter 'kind' and before the colon, a space is missing.

        Also, note that the parameter descriptions do not start with a capital letter, and do not finish with a dot.

        Finally, the `**kwargs` parameter is missing.

        Parameters

        kind: str
            kind of matplotlib plot
        ""
        pass
```

Parameter types

When specifying the parameter types, Python built-in data types can be used directly (the Python type is preferred to the more verbose string, integer, boolean, etc):

- int
- float
- str
- bool

For complex types, define the subtypes. For dict and tuple, as more than one type is present, we use the brackets to help read the type (curly brackets for dict and normal brackets for tuple):
– list of int
– dict of {str : int}
– tuple of (str, int, int)
– tuple of (str,)
– set of str

In case where there are just a set of values allowed, list them in curly brackets and separated by commas (followed by a space). If the values are ordinal and they have an order, list them in this order. Otherwise, list the default value first, if there is one:
– {0, 10, 25}
– {‘simple’, ‘advanced’}
– {‘low’, ‘medium’, ‘high’}
– {‘cat’, ‘dog’, ‘bird’}

If the type is defined in a Python module, the module must be specified:
– datetime.date
– datetime.datetime
– decimal.Decimal

If the type is in a package, the module must be also specified:
– numpy.ndarray
– scipy.sparse.coo_matrix

If the type is a pandas type, also specify pandas except for Series and DataFrame:
– Series
– DataFrame
– pandas.Index
– pandas.Categorical
– pandas.SparseArray

If the exact type is not relevant, but must be compatible with a numpy array, array-like can be specified. If Any type that can be iterated is accepted, iterable can be used:
– array-like
– iterable

If more than one type is accepted, separate them by commas, except the last two types, that need to be separated by the word ‘or’:
– int or float
– float, decimal.Decimal or None
– str or list of str

If None is one of the accepted values, it always needs to be the last in the list.

For axis, the convention is to use something like:
– axis : {0 or ‘index’, 1 or ‘columns’, None}, default None
Section 4: Returns or Yields

If the method returns a value, it will be documented in this section. Also if the method yields its output.

The title of the section will be defined in the same way as the “Parameters”. With the names “Returns” or “Yields” followed by a line with as many hyphens as the letters in the preceding word.

The documentation of the return is also similar to the parameters. But in this case, no name will be provided, unless the method returns or yields more than one value (a tuple of values).

The types for “Returns” and “Yields” are the same as the ones for the “Parameters”. Also, the description must finish with a dot.

For example, with a single value:

```python
def sample():
    """
    Generate and return a random number.
    The value is sampled from a continuous uniform distribution between 0 and 1.
    Returns
    -------
    float
    Random number generated.
    """
    return random.random()
```

With more than one value:

```python
def random_letters():
    """
    Generate and return a sequence of random letters.
    The length of the returned string is also random, and is also returned.
    Returns
    -------
    length : int
    Length of the returned string.
    letters : str
    String of random letters.
    """
    length = random.randint(1, 10)
    letters = ''.join(random.choice(string.ascii_lowercase) for i in range(length))
    return length, letters
```

If the method yields its value:

```python
def sample_values():
    """
    Generate an infinite sequence of random numbers.
    The values are sampled from a continuous uniform distribution between 0 and 1.
    """
    """
```
Section 5: See Also

This section is used to let users know about pandas functionality related to the one being documented. In rare cases, if no related methods or functions can be found at all, this section can be skipped.

An obvious example would be the `head()` and `tail()` methods. As `tail()` does the equivalent as `head()` but at the end of the `Series` or `DataFrame` instead of at the beginning, it is good to let the users know about it.

To give an intuition on what can be considered related, here there are some examples:

- `loc` and `iloc`, as they do the same, but in one case providing indices and in the other positions
- `max` and `min`, as they do the opposite
- `iterrows`, `itertuples` and `iteritems`, as it is easy that a user looking for the method to iterate over columns ends up in the method to iterate over rows, and vice-versa
- `fillna` and `dropna`, as both methods are used to handle missing values
- `read_csv` and `to_csv`, as they are complementary
- `merge` and `join`, as one is a generalization of the other
- `astype` and `pandas.to_datetime`, as users may be reading the documentation of `astype` to know how to cast as a date, and the way to do it is with `pandas.to_datetime`
- `where` is related to `numpy.where`, as its functionality is based on it

When deciding what is related, you should mainly use your common sense and think about what can be useful for the users reading the documentation, especially the less experienced ones.

When relating to other libraries (mainly `numpy`), use the name of the module first (not an alias like `np`). If the function is in a module which is not the main one, like `scipy.sparse`, list the full module (e.g. `scipy.sparse.coo_matrix`).

This section, as the previous, also has a header, “See Also” (note the capital S and A). Also followed by the line with hyphens, and preceded by a blank line.

After the header, we will add a line for each related method or function, followed by a space, a colon, another space, and a short description that illustrated what this method or function does, why is it relevant in this context, and what are the key differences between the documented function and the one referencing. The description must also finish with a dot.

Note that in “Returns” and “Yields”, the description is located in the following line than the type. But in this section it is located in the same line, with a colon in between. If the description does not fit in the same line, it can continue in the next ones, but it has to be indented in them.

For example:
class Series:
    def head(self):
        """
        Return the first 5 elements of the Series.
        This function is mainly useful to preview the values of the
        Series without displaying the whole of it.
        """
        return self.iloc[:5]

Section 6: Notes

This is an optional section used for notes about the implementation of the algorithm. Or to document technical aspects of the function behavior.

Feel free to skip it, unless you are familiar with the implementation of the algorithm, or you discover some counter-intuitive behavior while writing the examples for the function.

This section follows the same format as the extended summary section.

Section 7: Examples

This is one of the most important sections of a docstring, even if it is placed in the last position. As often, people understand concepts better with examples, than with accurate explanations.

Examples in docstrings, besides illustrating the usage of the function or method, must be valid Python code, that in a deterministic way returns the presented output, and that can be copied and run by users.

They are presented as a session in the Python terminal. >>> is used to present code. ... is used for code continuing from the previous line. Output is presented immediately after the last line of code generating the output (no blank lines in between). Comments describing the examples can be added with blank lines before and after them.

The way to present examples is as follows:

1. Import required libraries (except numpy and pandas)
2. Create the data required for the example
3. Show a very basic example that gives an idea of the most common use case
4. Add examples with explanations that illustrate how the parameters can be used for extended functionality

A simple example could be:
class Series:
    def head(self, n=5):
        
        """
        Return the first elements of the Series.
        This function is mainly useful to preview the values of the
        Series without displaying the whole of it.
        """
        Parameters
        ----------
        n : int
            Number of values to return.
        Return
        ------
        pandas.Series
            Subset of the original series with the n first values.
        See Also
        --------
        tail : Return the last n elements of the Series.
        Examples
        --------
        >>> s = pd.Series(['Ant', 'Bear', 'Cow', 'Dog', 'Falcon', ...'Lion', 'Monkey', 'Rabbit', 'Zebra'])
        >>> s.head()
        0    Ant
        1    Bear
        2    Cow
        3    Dog
        4    Falcon
        dtype: object
        With the `n` parameter, we can change the number of returned rows:
        >>> s.head(n=3)
        0    Ant
        1    Bear
        2    Cow
        dtype: object
        """
        return self.iloc[:n]

The examples should be as concise as possible. In cases where the complexity of the function requires long
examples, is recommended to use blocks with headers in bold. Use double star ** to make a text bold, like in
**this example**.

**Conventions for the examples**

Code in examples is assumed to always start with these two lines which are not shown:

```
import numpy as np
import pandas as pd
```

Any other module used in the examples must be explicitly imported, one per line (as recommended in PEP-8)
and avoiding aliases. Avoid excessive imports, but if needed, imports from the standard library go first, followed by third-party libraries (like matplotlib).

When illustrating examples with a single Series use the name `s`, and if illustrating with a single DataFrame use the name `df`. For indices, `idx` is the preferred name. If a set of homogeneous Series or DataFrame is used, name them `s1, s2, s3...` or `df1, df2, df3...` If the data is not homogeneous, and more than one structure is needed, name them with something meaningful, for example `df_main` and `df_to_join`.

Data used in the example should be as compact as possible. The number of rows is recommended to be around 4, but make it a number that makes sense for the specific example. For example in the `head` method, it requires to be higher than 5, to show the example with the default values. If doing the `mean`, we could use something like `[1, 2, 3]`, so it is easy to see that the value returned is the mean.

For more complex examples (grouping for example), avoid using data without interpretation, like a matrix of random numbers with columns A, B, C, D... And instead use a meaningful example, which makes it easier to understand the concept. Unless required by the example, use names of animals, to keep examples consistent. And numerical properties of them.

When calling the method, keywords arguments `head(n=3)` are preferred to positional arguments `head(3)`.

**Good:**

```python
class Series:
    def mean(self):
        """
        Compute the mean of the input.
        """
        Examples
        --------
        >>> s = pd.Series([1, 2, 3])
        >>> s.mean()
        2
        """
        pass

    def fillna(self, value):
        """
        Replace missing values by 'value'.
        """
        Examples
        --------
        >>> s = pd.Series([1, np.nan, 3])
        >>> s.fillna(0)
        [1, 0, 3]
        """
        pass

    def groupby_mean(self):
        """
        Group by index and return mean.
        """
        Examples
        --------
        >>> s = pd.Series([380., 370., 24., 26],
        ... name='max_speed',
        ... index=['falcon', 'falcon', 'parrot', 'parrot'])
        >>> s.groupby_mean()
```
contains(self, pattern, case_sensitive=True, na=numpy.nan):
    
    Return whether each value contains 'pattern'.

    In this case, we are illustrating how to use sections, even if the example is simple enough and does not require them.

    Examples
    -------------
    >>> s = pd.Series('Antelope', 'Lion', 'Zebra', numpy.nan)
    >>> s.contains(pattern='a')
    0    False
    1    False
    2     True
    3    NaN
    dtype: bool

    **Case sensitivity**

    With 'case_sensitive' set to 'False' we can match 'a' with both 'a' and 'A':

    >>> s.contains(pattern='a', case_sensitive=False)
    0     True
    1    False
    2     True
    3    NaN
    dtype: bool

    **Missing values**

    We can fill missing values in the output using the 'na' parameter:

    >>> s.contains(pattern='a', na=False)
    0    False
    1    False
    2     True
    3     False
    dtype: bool

    pass
to understand.

Try to avoid positional arguments like in `df.method(1)`. They can be all right if previously defined with a meaningful name, like in `present_value(interest_rate))`, but avoid them otherwise.

When presenting the behavior with different parameters, do not place all the calls one next to the other. Instead, add a short sentence explaining what the example shows.

Examples
--------
>>> import numpy as np
>>> import pandas as pd
>>> df = pd.DataFrame(numpy.random.randn(3, 3),
...                   columns=('a', 'b', 'c'))
>>> df.method(1)
21
>>> df.method(bar=14)
123
***
pass

Tips for getting your examples pass the doctests

Getting the examples pass the doctests in the validation script can sometimes be tricky. Here are some attention points:

- Import all needed libraries (except for pandas and numpy, those are already imported as import pandas as pd and import numpy as np) and define all variables you use in the example.

- Try to avoid using random data. However random data might be OK in some cases, like if the function you are documenting deals with probability distributions, or if the amount of data needed to make the function result meaningful is too much, such that creating it manually is very cumbersome. In those cases, always use a fixed random seed to make the generated examples predictable. Example:

```python
>>> np.random.seed(42)
>>> df = pd.DataFrame({'normal': np.random.normal(100, 5, 20)})
```

- If you have a code snippet that wraps multiple lines, you need to use `...` on the continued lines:

```python
>>> df = pd.DataFrame([[1, 2, 3], [4, 5, 6]], index=['a', 'b', 'c'], columns=['A', 'B'])
```

- If you want to show a case where an exception is raised, you can do:

```python
>>> pd.to_datetime(['712-01-01'])
Traceback (most recent call last):
OutOfBoundsDatet ime: Out of bounds nanosecond timestamp: 712-01-01 00:00:00
```

It is essential to include the “Traceback (most recent call last):”, but for the actual error only the error name is sufficient.

- If there is a small part of the result that can vary (e.g. a hash in an object representation), you can use `...` to represent this part.

3.4. Contributing to the documentation 477
If you want to show that \texttt{s.plot()} returns a matplotlib AxesSubplot object, this will fail the doctest

```python
>>> s.plot()
<matplotlib.axes._subplots.AxesSubplot at 0x7efd0c0b0690>
```

However, you can do (notice the comment that needs to be added)

```python
>>> s.plot()
<matplotlib.axes._subplots.AxesSubplot at ...>
```

## Plots in examples

There are some methods in pandas returning plots. To render the plots generated by the examples in the documentation, the `.. plot::` directive exists.

To use it, place the next code after the “Examples” header as shown below. The plot will be generated automatically when building the documentation.

```python
class Series:
    def plot(self):
        """
        Generate a plot with the `Series` data.
        
        Examples
        --------
        .. plot::
            :context: close-figs

            >>> s = pd.Series([1, 2, 3])
            >>> s.plot()
        """
        pass
```

## Sharing Docstrings

Pandas has a system for sharing docstrings, with slight variations, between classes. This helps us keep docstrings consistent, while keeping things clear for the user reading. It comes at the cost of some complexity when writing.

Each shared docstring will have a base template with variables, like `%(klass)s`. The variables filled in later on using the Substitution decorator. Finally, docstrings can be appended to with the Appender decorator.

In this example, we’ll create a parent docstring normally (this is like pandas.core.generic.NDFrame. Then we’ll have two children (like pandas.core.series.Series and pandas.core.frame.DataFrame). We’ll substitute the children’s class names in this docstring.

```python
class Parent:
    def my_function(self):
        """Apply my function to %(klass)s."""
        ...

class ChildA(Parent):
    @Substitution(klass="ChildA")
    @Appender(Parent.my_function.__doc__)
    def my_function(self):
```

(continues on next page)
The resulting docstrings are

```python
>>> print(Parent.my_function.__doc__)
Apply my function to %klass%s.
>>> print(ChildA.my_function.__doc__)
Apply my function to ChildA.
>>> print(ChildB.my_function.__doc__)
Apply my function to ChildB.
```

Notice two things:

1. We “append” the parent docstring to the children docstrings, which are initially empty.
2. Python decorators are applied inside out. So the order is Append then Substitution, even though Substitution comes first in the file.

Our files will often contain a module-level `_shared_doc_kwargs` with some common substitution values (things like `klass`, `axes`, etc).

You can substitute and append in one shot with something like

```python
@Appender(template % _shared_doc_kwargs)
def my_function(self):
    ...
```

where `template` may come from a module-level `_shared_docs` dictionary mapping function names to docstrings. Wherever possible, we prefer using `Appender` and `Substitution`, since the docstring-writing processes is slightly closer to normal.

See `pandas.core.generic.NDFramefillna` for an example template, and `pandas.core.series.Seriesfillna` and `pandas.core.generic.framefillna` for the filled versions.

- The tutorials make heavy use of the `ipython directive` sphinx extension. This directive lets you put code in the documentation which will be run during the doc build. For example:

```ipython:: python
    x = 2
    x**3
```

will be rendered as:

```
In [1]: x = 2
In [2]: x**3
Out[2]: 8
```

Almost all code examples in the docs are run (and the output saved) during the doc build. This approach means that code examples will always be up to date, but it does make the doc building a bit more complex.

3.4. Contributing to the documentation
• Our API documentation in doc/source/api.rst houses the auto-generated documentation from the docstrings. For classes, there are a few subtleties around controlling which methods and attributes have pages auto-generated.

We have two autosummary templates for classes.

1. _templates/autosummary/class.rst. Use this when you want to automatically generate a page for every public method and attribute on the class. The Attributes and Methods sections will be automatically added to the class’ rendered documentation by numpydoc. See DataFrame for an example.

2. _templates/autosummary/class_without_autosummary. Use this when you want to pick a subset of methods / attributes to auto-generate pages for. When using this template, you should include an Attributes and Methods section in the class docstring. See CategoricalIndex for an example.

Every method should be included in a toctree in api.rst, else Sphinx will emit a warning.

Note: The .rst files are used to automatically generate Markdown and HTML versions of the docs. For this reason, please do not edit CONTRIBUTING.md directly, but instead make any changes to doc/source/contributing.rst. Then, to generate CONTRIBUTING.md, use pandoc with the following command:

```
pandoc doc/source/contributing.rst -t markdown_github > CONTRIBUTING.md
```

The utility script scripts/validate_docstrings.py can be used to get a csv summary of the API documentation. And also validate common errors in the docstring of a specific class, function or method. The summary also compares the list of methods documented in doc/source/api.rst (which is used to generate the API Reference page) and the actual public methods. This will identify methods documented in doc/source/api.rst that are not actually class methods, and existing methods that are not documented in doc/source/api.rst.

### 3.4.2 How to build the pandas documentation

#### 3.4.2.1 Requirements

First, you need to have a development environment to be able to build pandas (see the docs on creating a development environment above).

#### 3.4.2.2 Building the documentation

So how do you build the docs? Navigate to your local pandas/doc/ directory in the console and run:

```
python make.py html
```

Then you can find the HTML output in the folder pandas/doc/build/html/.

The first time you build the docs, it will take quite a while because it has to run all the code examples and build all the generated docstring pages. In subsequent evocations, sphinx will try to only build the pages that have been modified.

If you want to do a full clean build, do:

```
python make.py clean
python make.py html
```

You can tell make.py to compile only a single section of the docs, greatly reducing the turn-around time for checking your changes.
For comparison, a full documentation build may take 15 minutes, but a single section may take 15 seconds. Subsequent builds, which only process portions you have changed, will be faster.

You can also specify to use multiple cores to speed up the documentation build:

```
python make.py html --num-jobs 4
```

Open the following file in a web browser to see the full documentation you just built:

```
pandas/docs/build/html/index.html
```

And you’ll have the satisfaction of seeing your new and improved documentation!

### 3.4.2.3 Building master branch documentation

When pull requests are merged into the pandas master branch, the main parts of the documentation are also built by Travis-CI. These docs are then hosted here, see also the Continuous Integration section.

### 3.5 Contributing to the code base

**Code Base:**

- Code standards
  - C (cpplint)
  - Python (PEP8)
  - Backwards Compatibility
- Testing With Continuous Integration
- Test-driven development/code writing
  - Writing tests
  - Transitioning to pytest
  - Using pytest
- Running the test suite
- Running the performance test suite
3.5.1 Code standards

Writing good code is not just about what you write. It is also about how you write it. During Continuous Integration testing, several tools will be run to check your code for stylistic errors. Generating any warnings will cause the test to fail. Thus, good style is a requirement for submitting code to pandas.

In addition, because a lot of people use our library, it is important that we do not make sudden changes to the code that could have the potential to break a lot of user code as a result, that is, we need it to be as backwards compatible as possible to avoid mass breakages.

Additional standards are outlined on the code style wiki page.

3.5.1.1 C (cpplint)

pandas uses the Google standard. Google provides an open source style checker called cpplint, but we use a fork of it that can be found here. Here are some of the more common cpplint issues:

- we restrict line-length to 80 characters to promote readability
- every header file must include a header guard to avoid name collisions if re-included

Continuous Integration will run the cpplint tool and report any stylistic errors in your code. Therefore, it is helpful before submitting code to run the check yourself:

```
cpplint --extensions=c,h --headers=h --filter=-readability/casting,-runtime/int,-
          --build/include_subdir modified-c-file
```

You can also run this command on an entire directory if necessary:

```
cpplint --extensions=c,h --headers=h --filter=-readability/casting,-runtime/int,-
          --build/include_subdir --recursive modified-c-directory
```

To make your commits compliant with this standard, you can install the ClangFormat tool, which can be downloaded here. To configure, in your home directory, run the following command:

```
clang-format style=google -dump-config > .clang-format
```

Then modify the file to ensure that any indentation width parameters are at least four. Once configured, you can run the tool as follows:

```
clang-format modified-c-file
```

This will output what your file will look like if the changes are made, and to apply them, run the following command:

```
clang-format -i modified-c-file
```

To run the tool on an entire directory, you can run the following analogous commands:

```
clang-format modified-c-directory/*.c modified-c-directory/*.h
clang-format -i modified-c-directory/*.c modified-c-directory/*.h
```

Do note that this tool is best-effort, meaning that it will try to correct as many errors as possible, but it may not correct all of them. Thus, it is recommended that you run cpplint to double check and make any other style fixes manually.

---

482 Chapter 3. Contributing to pandas
3.5.1.2 Python (PEP8)

*pandas* uses the PEP8 standard. There are several tools to ensure you abide by this standard. Here are some of the more common PEP8 issues:

- we restrict line-length to 79 characters to promote readability
- passing arguments should have spaces after commas, e.g. `foo(arg1, arg2, kw1='bar')`

*Continuous Integration* will run the *flake8* tool and report any stylistic errors in your code. Therefore, it is helpful before submitting code to run the check yourself on the diff:

```
% git diff master -u -- "*.py" | flake8 --diff
```

This command will catch any stylistic errors in your changes specifically, but be beware it may not catch all of them. For example, if you delete the only usage of an imported function, it is stylistically incorrect to import an unused function. However, style-checking the diff will not catch this because the actual import is not part of the diff. Thus, for completeness, you should run this command, though it will take longer:

```
% git diff master --name-only -- "*.py" | grep "pandas/" | xargs -r flake8
```

Note that on OSX, the `-r` flag is not available, so you have to omit it and run this slightly modified command:

```
% git diff master --name-only -- "*.py" | grep "pandas/" | xargs flake8
```

Note that on Windows, these commands are unfortunately not possible because commands like `grep` and `xargs` are not available natively. To imitate the behavior with the commands above, you should run:

```
% git diff master --name-only -- "*.py"
```

This will list all of the Python files that have been modified. The only ones that matter during linting are any whose directory filepath begins with “pandas.” For each filepath, copy and paste it after the *flake8* command as shown below:

```
flake8 <python-filepath>
```

Alternatively, you can install the *grep* and *xargs* commands via the MinGW toolchain, and it will allow you to run the commands above.

3.5.1.3 Backwards Compatibility

Please try to maintain backward compatibility. *pandas* has lots of users with lots of existing code, so don’t break it if at all possible. If you think breakage is required, clearly state why as part of the pull request. Also, be careful when changing method signatures and add deprecation warnings where needed. Also, add the deprecated sphinx directive to the deprecated functions or methods.

If a function with the same arguments as the one being deprecated exist, you can use the *pandas.util._decorators.deprecate*:

```
from pandas.util._decorators import deprecate
deprecate('old_func', 'new_func', '0.21.0')
```

Otherwise, you need to do it manually:
3.5.2 Testing With Continuous Integration

The pandas test suite will run automatically on Travis-CI, Appveyor, and Circle CI continuous integration services, once your pull request is submitted. However, if you wish to run the test suite on a branch prior to submitting the pull request, then the continuous integration services need to be hooked to your GitHub repository. Instructions are here for Travis-CI, Appveyor, and CircleCI.

A pull-request will be considered for merging when you have an all ‘green’ build. If any tests are failing, then you will get a red ‘X’, where you can click through to see the individual failed tests. This is an example of a green build.

Note: Each time you push to your fork, a new run of the tests will be triggered on the CI. Appveyor will auto-cancel any non-currently-running tests for that same pull-request. You can enable the auto-cancel feature for Travis-CI here and for CircleCI here.

3.5.3 Test-driven development/code writing

pandas is serious about testing and strongly encourages contributors to embrace test-driven development (TDD). This development process “relies on the repetition of a very short development cycle: first the developer writes an (initially failing) automated test case that defines a desired improvement or new function, then produces the minimum amount
of code to pass that test.” So, before actually writing any code, you should write your tests. Often the test can be taken from the original GitHub issue. However, it is always worth considering additional use cases and writing corresponding tests.

Adding tests is one of the most common requests after code is pushed to pandas. Therefore, it is worth getting in the habit of writing tests ahead of time so this is never an issue.

Like many packages, pandas uses pytest and the convenient extensions in numpy.testing.

**Note:** The earliest supported pytest version is 3.1.0.

### 3.5.3.1 Writing tests

All tests should go into the tests subdirectory of the specific package. This folder contains many current examples of tests, and we suggest looking to these for inspiration. If your test requires working with files or network connectivity, there is more information on the testing page of the wiki.

The pandas.util.testing module has many special assert functions that make it easier to make statements about whether Series or DataFrame objects are equivalent. The easiest way to verify that your code is correct is to explicitly construct the result you expect, then compare the actual result to the expected correct result:

```python
def test_pivot(self):
    data = {
        'index' : ['A', 'B', 'C', 'C', 'B', 'A'],
        'columns' : ['One', 'One', 'One', 'Two', 'Two', 'Two'],
        'values' : [1., 2., 3., 3., 2., 1.]
    }

    frame = DataFrame(data)
    pivoted = frame.pivot(index='index', columns='columns', values='values')

    expected = DataFrame({
        'One' : {'A' : 1., 'B' : 2., 'C' : 3.},
        'Two' : {'A' : 1., 'B' : 2., 'C' : 3.}
    })

    assert_frame_equal(pivoted, expected)
```

### 3.5.3.2 Transitioning to pytest

pandas existing test structure is mostly classed based, meaning that you will typically find tests wrapped in a class.

```python
class TestReallyCoolFeature(object):
    ....
```

Going forward, we are moving to a more functional style using the pytest framework, which offers a richer testing framework that will facilitate testing and developing. Thus, instead of writing test classes, we will write test functions like this:

```python
def test_really_cool_feature():
    ....
```
3.5.3.3 Using pytest

Here is an example of a self-contained set of tests that illustrate multiple features that we like to use.

- functional style: tests are like test_* and only take arguments that are either fixtures or parameters
- pytest.mark can be used to set metadata on test functions, e.g. skip or xfail.
- using parametrize: allow testing of multiple cases
- to set a mark on a parameter, pytest.param(...) syntax should be used
- fixture, code for object construction, on a per-test basis
- using bare assert for scalars and truth-testing
- tm.assert_series_equal (and its counter part tm.assert_frame_equal), for pandas object comparisons.
- the typical pattern of constructing an expected and comparing versus the result

We would name this file test_cool_feature.py and put in an appropriate place in the pandas/tests/ structure.

```python
import pytest
import numpy as np
import pandas as pd
from pandas.util import testing as tm

@pytest.mark.parametrize('dtype', ['int8', 'int16', 'int32', 'int64'])
def test_dtypes(dtype):
    assert str(np.dtype(dtype)) == dtype

@ pytest.mark.parametrize('dtype', ['float32',
    pytest.param('int16', marks=pytest.mark.skip),
    pytest.param('int32',
        marks=pytest.mark.xfail(reason='to show how it works')))]]

def test_mark(dtype):
    assert str(np.dtype(dtype)) == 'float32'

@ pytest.fixture
def series():
    return pd.Series([1, 2, 3])

@ pytest.fixture(params=['int8', 'int16', 'int32', 'int64'])
def dtype(request):
    return request.param

def test_series(series, dtype):
    result = series.astype(dtype)
    assert result.dtype == dtype
    expected = pd.Series([1, 2, 3], dtype=dtype)
    tm.assert_series_equal(result, expected)
```

A test run of this yields

```
(pandas) bash-3.2$ pytest test_cool_feature.py -v
=========================== test session starts ===========================
platform darwin -- Python 3.6.2, pytest-3.2.1, py-1.4.31, pluggy-0.4.0
collected 11 items

(continues on next page)
```
Tests that we have parametrized are now accessible via the test name, for example we could run these with \(-k\) \texttt{int8} to sub-select \textit{only} those tests which match \texttt{int8}.

```bash
((pandas) bash-3.2$ pytest test_cool_feature.py -v -k int8
=========================== test session starts ===========================
platform darwin -- Python 3.6.2, pytest-3.2.1, py-1.4.31, pluggy-0.4.0
collected 11 items
test_cool_feature.py::test_dtypes[int8] PASSED
```

### 3.5.4 Running the test suite

The tests can then be run directly inside your Git clone (without having to install \texttt{pandas}) by typing:

```
pytest pandas
```

The tests suite is exhaustive and takes around 20 minutes to run. Often it is worth running only a subset of tests first around your changes before running the entire suite.

The easiest way to do this is with:

```
pytest pandas/path/to/test.py -k regex_matching_test_name
```

Or with one of the following constructs:

```
pytest pandas/tests/[test-module].py
pytest pandas/tests/[test-module].py::[TestClass]
pytest pandas/tests/[test-module].py::[TestClass]::[test_method]
```

Using \texttt{pytest-xdist}, one can speed up local testing on multicore machines. To use this feature, you will need to install \texttt{pytest-xdist} via:

```
pip install pytest-xdist
```

Two scripts are provided to assist with this. These scripts distribute testing across 4 threads.

On Unix variants, one can type:

```
test_fast.sh
```

On Windows, one can type:
This can significantly reduce the time it takes to locally run tests before submitting a pull request.
For more, see the pytest documentation.

Furthermore one can run

```python
pd.test()
```

with an imported pandas to run tests similarly.

### 3.5.5 Running the performance test suite

Performance matters and it is worth considering whether your code has introduced performance regressions. pandas is in the process of migrating to asv benchmarks to enable easy monitoring of the performance of critical pandas operations. These benchmarks are all found in the pandas/asv_bench directory. asv supports both python2 and python3.

To use all features of asv, you will need either conda or virtualenv. For more details please check the asv installation webpage.

To install asv:

```bash
pip install git+https://github.com/spacetelescope/asv
```

If you need to run a benchmark, change your directory to `asv_bench/` and run:

```bash
asv continuous -f 1.1 upstream/master HEAD
```

You can replace `HEAD` with the name of the branch you are working on, and report benchmarks that changed by more than 10%. The command uses conda by default for creating the benchmark environments. If you want to use virtualenv instead, write:

```bash
asv continuous -f 1.1 -E virtualenv upstream/master HEAD
```

The `-E virtualenv` option should be added to all asv commands that run benchmarks. The default value is defined in `asv.conf.json`.

Running the full test suite can take up to one hour and use up to 3GB of RAM. Usually it is sufficient to paste only a subset of the results into the pull request to show that the committed changes do not cause unexpected performance regressions. You can run specific benchmarks using the `-b` flag, which takes a regular expression. For example, this will only run tests from a `pandas/asv_bench/benchmarks/groupby.py` file:

```bash
asv continuous -f 1.1 upstream/master HEAD -b ^groupby
```

If you want to only run a specific group of tests from a file, you can do it using \ as a separator. For example:

```bash
asv continuous -f 1.1 upstream/master HEAD -b groupby.GroupByMethods
```

will only run the `GroupByMethods` benchmark defined in `groupby.py`.

You can also run the benchmark suite using the version of pandas already installed in your current Python environment. This can be useful if you do not have virtualenv or conda, or are using the `setup.py develop` approach discussed above; for the in-place build you need to set `PYTHONPATH`, e.g. `PYTHONPATH="$PWD/..` asv [remaining arguments]. You can run benchmarks using an existing Python environment by:
or, to use a specific Python interpreter:

```
asv run -e -E existing:python3.5
```

This will display stderr from the benchmarks, and use your local python that comes from your $PATH.

Information on how to write a benchmark and how to use asv can be found in the asv documentation.

### 3.5.6 Documenting your code

Changes should be reflected in the release notes located in `doc/source/whatsnew/vx.y.z.txt`. This file contains an ongoing change log for each release. Add an entry to this file to document your fix, enhancement or (unavoidable) breaking change. Make sure to include the GitHub issue number when adding your entry (using `:issue:`1234` where 1234 is the issue/pull request number).

If your code is an enhancement, it is most likely necessary to add usage examples to the existing documentation. This can be done following the section regardong documentation above. Further, to let users know when this feature was added, the `versionadded` directive is used. The sphinx syntax for that is:

```
.. versionadded:: 0.21.0
```

This will put the text *New in version 0.21.0* wherever you put the sphinx directive. This should also be put in the docstring when adding a new function or method (example) or a new keyword argument (example).

### 3.6 Contributing your changes to pandas

#### 3.6.1 Committing your code

Keep style fixes to a separate commit to make your pull request more readable.

Once you’ve made changes, you can see them by typing:

```
git status
```

If you have created a new file, it is not being tracked by git. Add it by typing:

```
git add path/to/file-to-be-added.py
```

Doing 'git status' again should give something like:

```
# On branch shiny-new-feature
#
#     modified: /relative/path/to/file-you-added.py
#```

Finally, commit your changes to your local repository with an explanatory message. *Pandas* uses a convention for commit message prefixes and layout. Here are some common prefixes along with general guidelines for when to use them:

- **ENH**: Enhancement, new functionality
- **BUG**: Bug fix
The following defines how a commit message should be structured. Please reference the relevant GitHub issues in your commit message using GH1234 or #1234. Either style is fine, but the former is generally preferred:

- a subject line with < 80 chars.
- One blank line.
- Optionally, a commit message body.

Now you can commit your changes in your local repository:

```sh
git commit -m
```

### 3.6.2 Pushing your changes

When you want your changes to appear publicly on your GitHub page, push your forked feature branch’s commits:

```sh
git push origin shiny-new-feature
```

Here `origin` is the default name given to your remote repository on GitHub. You can see the remote repositories:

```sh
git remote -v
```

If you added the upstream repository as described above you will see something like:

```
origin git@github.com:yourname/pandas.git (fetch)
origin git@github.com:yourname/pandas.git (push)
upstream git://github.com/pandas-dev/pandas.git (fetch)
upstream git://github.com/pandas-dev/pandas.git (push)
```

Now your code is on GitHub, but it is not yet a part of the pandas project. For that to happen, a pull request needs to be submitted on GitHub.

### 3.6.3 Review your code

When you’re ready to ask for a code review, file a pull request. Before you do, once again make sure that you have followed all the guidelines outlined in this document regarding code style, tests, performance tests, and documentation. You should also double check your branch changes against the branch it was based on:

1. Navigate to your repository on GitHub – [https://github.com/your-user-name/pandas](https://github.com/your-user-name/pandas)
2. Click on Branches
3. Click on the Compare button for your feature branch
4. Select the base and compare branches, if necessary. This will be master and shiny-new-feature, respectively.
3.6.4 Finally, make the pull request

If everything looks good, you are ready to make a pull request. A pull request is how code from a local repository becomes available to the GitHub community and can be looked at and eventually merged into the master version. This pull request and its associated changes will eventually be committed to the master branch and available in the next release. To submit a pull request:

1. Navigate to your repository on GitHub
2. Click on the Pull Request button
3. You can then click on Commits and Files Changed to make sure everything looks okay one last time
4. Write a description of your changes in the Preview Discussion tab
5. Click Send Pull Request.

This request then goes to the repository maintainers, and they will review the code.

3.6.5 Updating your pull request

Based on the review you get on your pull request, you will probably need to make some changes to the code. In that case, you can make them in your branch, add a new commit to that branch, push it to GitHub, and the pull request will be automatically updated. Pushing them to GitHub again is done by:

```
git push origin shiny-new-feature
```

This will automatically update your pull request with the latest code and restart the Continuous Integration tests.

Another reason you might need to update your pull request is to solve conflicts with changes that have been merged into the master branch since you opened your pull request.

To do this, you need to “merge upstream master” in your branch:

```
git checkout shiny-new-feature
git fetch upstream
git merge upstream/master
```

If there are no conflicts (or they could be fixed automatically), a file with a default commit message will open, and you can simply save and quit this file.

If there are merge conflicts, you need to solve those conflicts. See for example at https://help.github.com/articles/resolving-a-merge-conflict-using-the-command-line/ for an explanation on how to do this. Once the conflicts are merged and the files where the conflicts were solved are added, you can run `git commit` to save those fixes.

If you have uncommitted changes at the moment you want to update the branch with master, you will need to `stash` them prior to updating (see the `stash` docs). This will effectively store your changes and they can be reapplied after updating.

After the feature branch has been update locally, you can now update your pull request by pushing to the branch on GitHub:

```
git push origin shiny-new-feature
```

3.6.6 Delete your merged branch (optional)

Once your feature branch is accepted into upstream, you’ll probably want to get rid of the branch. First, merge upstream master into your branch so git knows it is safe to delete your branch:

```
git checkout shiny-new-feature
git merge upstream/master
git branch -d shiny-new-feature
```

3.6. Contributing your changes to pandas
Then you can do:

```
git branch -d shiny-new-feature
```

Make sure you use a lower-case `-d`, or else git won’t warn you if your feature branch has not actually been merged. The branch will still exist on GitHub, so to delete it there do:

```
git push origin --delete shiny-new-feature
```
CHAPTER
FOUR

PACKAGE OVERVIEW

*pandas* is an open source, BSD-licensed library providing high-performance, easy-to-use data structures and data analysis tools for the Python programming language.

*pandas* consists of the following elements:

- A set of labeled array data structures, the primary of which are Series and DataFrame.
- Index objects enabling both simple axis indexing and multi-level / hierarchical axis indexing.
- An integrated group by engine for aggregating and transforming data sets.
- Date range generation (date_range) and custom date offsets enabling the implementation of customized frequencies.
- Input/Output tools: loading tabular data from flat files (CSV, delimited, Excel 2003), and saving and loading pandas objects from the fast and efficient PyTables/HDF5 format.
- Memory-efficient “sparse” versions of the standard data structures for storing data that is mostly missing or mostly constant (some fixed value).
- Moving window statistics (rolling mean, rolling standard deviation, etc.).

### 4.1 Data Structures

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Series</td>
<td>1D labeled homogeneously-typed array</td>
</tr>
<tr>
<td>2</td>
<td>DataFrame</td>
<td>General 2D labeled, size-mutable tabular structure with potentially heterogeneously-typed column</td>
</tr>
</tbody>
</table>

#### 4.1.1 Why more than one data structure?

The best way to think about the pandas data structures is as flexible containers for lower dimensional data. For example, DataFrame is a container for Series, and Series is a container for scalars. We would like to be able to insert and remove objects from these containers in a dictionary-like fashion.

Also, we would like sensible default behaviors for the common API functions which take into account the typical orientation of time series and cross-sectional data sets. When using ndarrays to store 2- and 3-dimensional data, a burden is placed on the user to consider the orientation of the data set when writing functions; axes are considered more or less equivalent (except when C- or Fortran-contiguousness matters for performance). In pandas, the axes are intended to lend more semantic meaning to the data; i.e., for a particular data set there is likely to be a “right” way to orient the data. The goal, then, is to reduce the amount of mental effort required to code up data transformations in downstream functions.
For example, with tabular data (DataFrame) it is more semantically helpful to think of the index (the rows) and the columns rather than axis 0 and axis 1. Iterating through the columns of the DataFrame thus results in more readable code:

```python
for col in df.columns:
    series = df[col]
    # do something with series
```

### 4.2 Mutability and copying of data

All pandas data structures are value-mutable (the values they contain can be altered) but not always size-mutable. The length of a Series cannot be changed, but, for example, columns can be inserted into a DataFrame. However, the vast majority of methods produce new objects and leave the input data untouched. In general we like to favor immutability where sensible.

### 4.3 Getting Support

The first stop for pandas issues and ideas is the Github Issue Tracker. If you have a general question, pandas community experts can answer through Stack Overflow.

### 4.4 Community

pandas is actively supported today by a community of like-minded individuals around the world who contribute their valuable time and energy to help make open source pandas possible. Thanks to all of our contributors.

If you’re interested in contributing, please visit Contributing to pandas webpage.

pandas is a NumFOCUS sponsored project. This will help ensure the success of development of pandas as a world-class open-source project, and makes it possible to donate to the project.

### 4.5 Project Governance

The governance process that pandas project has used informally since its inception in 2008 is formalized in Project Governance documents. The documents clarify how decisions are made and how the various elements of our community interact, including the relationship between open source collaborative development and work that may be funded by for-profit or non-profit entities.

Wes McKinney is the Benevolent Dictator for Life (BDFL).

### 4.6 Development Team

The list of the Core Team members and more detailed information can be found on the people’s page of the governance repo.
4.7 Institutional Partners

The information about current institutional partners can be found on pandas website page.

4.8 License

**BSD 3-Clause License**

Copyright (c) 2008-2012, AQR Capital Management, LLC, Lambda Foundry, Inc. and PyData Development Team

All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

- Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
- Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
- Neither the name of the copyright holder nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.
This is a short introduction to pandas, geared mainly for new users. You can see more complex recipes in the *Cookbook*. Customarily, we import as follows:

```
In [1]: import pandas as pd
In [2]: import numpy as np
In [3]: import matplotlib.pyplot as plt
```

### 5.1 Object Creation

See the *Data Structure Intro section.*

Creating a *Series* by passing a list of values, letting pandas create a default integer index:

```
In [4]: s = pd.Series([1,3,5,np.nan,6,8])
In [5]: s
Out[5]:
    0  1.0
    1  3.0
    2  5.0
    3  NaN
    4  6.0
    5  8.0
dtype: float64
```

Creating a *DataFrame* by passing a NumPy array, with a datetime index and labeled columns:

```
In [6]: dates = pd.date_range('20130101', periods=6)
In [7]: dates
Out[7]:
DatetimeIndex(['2013-01-01', '2013-01-02', '2013-01-03', '2013-01-04',
              '2013-01-05', '2013-01-06'],
              dtype='datetime64[ns]', freq='D')
In [8]: df = pd.DataFrame(np.random.randn(6,4), index=dates, columns=list('ABCD'))
In [9]: df
Out[9]:
```

(continues on next page)
Creating a DataFrame by passing a dict of objects that can be converted to series-like.

```python
In [10]: df2 = pd.DataFrame({
    'A' : 1.,
    'B' : pd.Timestamp('20130102'),
    'C' : pd.Series(1,index=list(range(4)),dtype='float32'),
    'D' : np.array([3]*4,dtype='int32'),
    'E' : pd.Categorical(['test','train','test','train'])),
    'F' : 'foo'})
In [11]: df2
Out[11]:
   A     B          C         D        E          F
0  1.0 2013-01-02  1.0 3.0  test  foo
1  1.0 2013-01-02  1.0 3.0  train foo
2  1.0 2013-01-02  1.0 3.0  test  foo
3  1.0 2013-01-02  1.0 3.0  train foo
```

The columns of the resulting DataFrame have different dtypes.

```python
In [12]: df2.dtypes
Out[12]:
A    float64
B  datetime64[ns]
C    float32
D     int32
E  category
F     object
dtype: object
```

If you’re using IPython, tab completion for column names (as well as public attributes) is automatically enabled. Here’s a subset of the attributes that will be completed:

```python
In [13]: df2.<TAB>
df2.A            df2 bool
df2.abs          df2.boxplot
df2.add          df2 C
df2.add_prefix   df2 clip
df2.add_suffix   df2.clip_lower
df2.align        df2.clip_upper
df2.all          df2 columns
df2.any          df2 combine
df2.append       df2 combine_first
df2.apply        df2 compound
df2.applymap     df2 consolidate
df2.D
```

As you can see, the columns A, B, C, and D are automatically tab completed. E is there as well; the rest of the attributes have been truncated for brevity.
5.2 Viewing Data

See the Basics section.

Here is how to view the top and bottom rows of the frame:

```
In [14]: df.head()
Out[14]:
          A         B         C         D
2013-01-01  0.469112 -0.282863 -1.509059 -1.135632
2013-01-02  1.212112 -0.173215  0.119209 -0.044236
2013-01-03  0.861849 -2.104569 -0.494929  1.071804
2013-01-04  0.721555 -0.706771 -1.039575  0.271860
2013-01-05  0.424972  0.567020  0.276232 -0.087401
```

```
In [15]: df.tail(3)
Out[15]:
          A         B         C         D
2013-01-04  0.721555 -0.706771 -1.039575  0.271860
2013-01-05  0.424972  0.567020  0.276232 -0.087401
2013-01-06 -0.673690  0.113648 -1.478427  0.524988
```

Display the index, columns, and the underlying NumPy data:

```
In [16]: df.index
Out[16]:
DatetimeIndex(['2013-01-01', '2013-01-02', '2013-01-03', '2013-01-04',
               '2013-01-05', '2013-01-06'],
               dtype='datetime64[ns]', freq='D')

In [17]: df.columns
Out[17]:
Index(['A', 'B', 'C', 'D'], dtype='object')

In [18]: df.values
Out[18]:
array([[ 0.4691, -0.2829, -1.5091, -1.1356],
       [ 1.2121, -0.1732,  0.1192, -0.0442],
       [ 0.8618, -2.1046, -0.4949,  1.0718],
       [ 0.7216, -0.7068, -1.0396,  0.2719],
       [ 0.425 ,  0.567 ,  0.2762, -1.0874],
       [-0.6737,  0.1136, -1.4784,  0.525 ]])
```

describe() shows a quick statistic summary of your data:

```
In [19]: df.describe()
Out[19]:
          A         B         C         D
count   6.000000  6.000000  6.000000  6.000000
mean   0.073711 -0.431125 -0.687758 -0.233103
std    0.843157  0.922818  0.779887  0.973118
min  -0.861849 -2.104569 -1.509059 -1.135632
25%  -0.611510 -0.600794 -1.368714 -1.076610
50%   0.022070 -0.228039 -0.767252 -0.386188
75%   0.658444  0.041933  0.276232  0.461706
max   1.212112  0.567020  0.276232  1.071804
```
Transposing your data:

```
In [20]: df.T
Out[20]:
A      0.469112  1.212112  -0.861849  0.721555  -0.424972  -0.673690
B     -0.282863  -0.173215  -2.104569  -0.706771   0.567020   0.113648
C    -1.509059   0.119209  -0.494929  -1.039575   0.276232  -1.478427
D    -1.135632  -1.044236  1.071804   0.271860  -1.087401   0.524988
```

Sorting by an axis:

```
In [21]: df.sort_index(axis=1, ascending=False)
Out[21]:
     D     C     B     A
2013-01-01 -1.135632 -1.509059 -0.282863  0.469112
2013-01-02 -1.044236  0.119209 -0.173215  1.212112
2013-01-03  1.071804  -0.494929 -2.104569  -0.861849
2013-01-04  0.271860  -1.039575  -0.706771   0.567020
2013-01-05  1.087401   0.276232  0.567020  -0.424972
2013-01-06  0.524988  -1.478427  0.113648  -0.673690
```

Sorting by values:

```
In [22]: df.sort_values(by='B')
Out[22]:
      A     B     C     D
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804
2013-01-04  0.721555  -0.706771  -1.039575   0.271860
2013-01-01  0.469112  -0.282863  -1.509059  -1.135632
2013-01-02  1.212112  -0.173215  0.119209  -1.044236
2013-01-06 -0.673690   0.113648  -1.478427   0.524988
2013-01-05  0.424972   0.567020   0.276232  -1.087401
```

5.3 Selection

**Note:** While standard Python / Numpy expressions for selecting and setting are intuitive and come in handy for interactive work, for production code, we recommend the optimized pandas data access methods, `.at`, `.iat`, `.loc` and `.iloc`.

See the indexing documentation *Indexing and Selecting Data* and *MultiIndex / Advanced Indexing*.

5.3.1 Getting

Selecting a single column, which yields a `Series`, equivalent to `df.A`:

```
In [23]: df['A']
Out[23]:
2013-01-01    0.469112
2013-01-02    1.212112
2013-01-03   -0.861849
2013-01-04    0.721555
```

(continues on next page)
Selecting via [], which slices the rows.

```
In [24]: df[0:3]
Out[24]:
   A     B     C     D
2013-01-01  0.469112 -0.282863 -1.509059 -1.135632
2013-01-02  1.212112 -0.173215  0.119209 -1.044236
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804
```

```
In [25]: df['20130102':'20130104']
Out[25]:
   A     B     C     D
2013-01-02  1.212112 -0.173215  0.119209 -1.044236
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804
2013-01-04  0.721555 -0.706771 -1.039575  0.271860
```

### 5.3.2 Selection by Label

See more in *Selection by Label*.

For getting a cross section using a label:

```
In [26]: df.loc[dates[0]]
Out[26]:
     A     B     C     D
2013-01-01  0.469112 -0.282863 -1.509059 -1.135632
```

Selecting on a multi-axis by label:

```
In [27]: df.loc[:,['A','B']]
Out[27]:
      A     B
2013-01-01  0.469112 -0.282863
2013-01-02  1.212112 -0.173215
2013-01-03 -0.861849 -2.104569
2013-01-04  0.721555 -0.706771
2013-01-05 -0.424972  0.567020
2013-01-06 -0.673690  0.113648
```

Showing label slicing, both endpoints are included:

```
In [28]: df.loc['20130102':'20130104',['A','B']]
Out[28]:
      A     B
2013-01-02  1.212112 -0.173215
2013-01-03 -0.861849 -2.104569
2013-01-04  0.721555 -0.706771
```
Reduction in the dimensions of the returned object:

In [29]:  df.loc['20130102', ['A', 'B']]
Out[29]:
   A    B
Name: 2013-01-02 00:00:00, dtype: float64

For getting a scalar value:

In [30]:  df.loc[dates[0], 'A']
Out[30]:
0.46911229990718628

For getting fast access to a scalar (equivalent to the prior method):

In [31]:  df.at[dates[0], 'A']
Out[31]:
0.46911229990718628

5.3.3 Selection by Position

See more in Selection by Position.

Select via the position of the passed integers:

In [32]:  df.iloc[3]
Out[32]:
   A    B    C    D
2013-01-04  0.721555 -0.706771  0.271860

By integer slices, acting similar to numpy/python:

In [33]:  df.iloc[3:5,0:2]
Out[33]:
   A       B
2013-01-04  0.721555 -0.706771
2013-01-05  0.424972  0.567020

By lists of integer position locations, similar to the numpy/python style:

In [34]:  df.iloc[[1,2,4], [0,2]]
Out[34]:
   A   C
2013-01-02  1.212112  0.119209
2013-01-03 -0.861849 -0.494929
2013-01-05 -0.424972  0.276232

For slicing rows explicitly:

In [35]:  df.iloc[1:3,:]
Out[35]:
   A    B    C    D
2013-01-02  1.212112 -0.173215  0.119209 -1.044236
2013-01-03 -0.861849 -2.104569 -0.494929  1.071804
For slicing columns explicitly:

```
In [36]: df.iloc[:,1:3]
Out[36]:
          B     C
2013-01-01 -0.282863 -1.509059
2013-01-02 -0.173215  0.119209
2013-01-03 -2.104569 -0.494929
2013-01-04 -0.706771 -1.039575
2013-01-05  0.567020  0.276232
2013-01-06  0.113648 -1.478427
```

For getting a value explicitly:

```
In [37]: df.iloc[1,1]
Out[37]:
-0.17321464905330858
```

For getting fast access to a scalar (equivalent to the prior method):

```
In [38]: df.iat[1,1]
Out[38]:
-0.17321464905330858
```

### 5.3.4 Boolean Indexing

Using a single column’s values to select data.

```
In [39]: df[df.A > 0]
Out[39]:
          A     B     C     D
2013-01-01 0.469112 -0.282863 -1.509059 -1.135632
2013-01-02 1.212112 -0.173215  0.119209 -1.044236
2013-01-03 0.721555 -0.706771 -1.039575  0.271860
```

Selecting values from a DataFrame where a boolean condition is met.

```
In [40]: df[df > 0]
Out[40]:
          A     B     C     D
2013-01-01 0.469112 NaN   NaN   NaN
2013-01-02 1.212112 NaN   0.119209 NaN
2013-01-03 NaN   NaN   NaN   1.071804
2013-01-04 0.721555 NaN   NaN   0.271860
2013-01-05 NaN   0.567020  0.276232 NaN
2013-01-06 NaN   0.113648 NaN   0.524988
```

Using the `isin()` method for filtering:

```
In [41]: df2 = df.copy()

In [42]: df2['E'] = ['one', 'one', 'two', 'three', 'four', 'three']

In [43]: df2
Out[43]:
          A     B     C     D     E
2013-01-01 0.469112 -0.282863 -1.509059 -1.135632 one
2013-01-02 1.212112 -0.173215  0.119209 -1.044236 one
```

(continues on next page)
5.3.5 Setting

Setting a new column automatically aligns the data by the indexes.

```
In [45]: s1 = pd.Series([1,2,3,4,5,6], index=pd.date_range('20130102', periods=6))
```

```
3.5. Setting

Setting values by label:
```
In [48]: df.at[dates[0],'A'] = 0
```

Setting values by position:
```
In [49]: df.iat[0,1] = 0
```

Setting by assigning with a NumPy array:
```
In [50]: df.loc[:,'D'] = np.array([5] * len(df))
```

The result of the prior setting operations.
```
In [51]: df
```
```
<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>2013-01-01 0.000000 0.000000 -1.509059 5</td>
<td>NaN</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-01-02 1.212112 -0.173215 0.119209 5</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-01-03 -0.861849 -2.104569 -0.494929 5</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-01-04 0.721555 -0.706771 -1.039575 5</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-01-05 -0.424972 0.567020 0.276232 5</td>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-01-06 -0.673690 0.113648 -1.478427 5</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

A where operation with setting.
In [52]: df2 = df.copy()

In [53]: df2[df2 > 0] = -df2

In [54]: df2

Out[54]:
   A    B     C     D    F
0 0.000000 0.000000 -1.509059 -5  NaN
1 -1.212112 -0.173215 -0.119209 -5  -1.0
2 -0.861849 -2.104569 -0.494929 -5  -2.0
3 -0.721555 -0.706771 -1.039575 -5  -3.0
4 -0.424972 -0.567020 -0.276232 -5  -4.0
5 -0.673690 -0.113648 -1.478427 -5  -5.0

5.4 Missing Data

pandas primarily uses the value \texttt{np.nan} to represent missing data. It is by default not included in computations. See the Missing Data section.

Reindexing allows you to change/add/delete the index on a specified axis. This returns a copy of the data.

In [55]: df1 = df.reindex(index=dates[0:4], columns=list(df.columns) + ['E'])

In [56]: df1.loc[dates[0]:dates[1],'E'] = 1

In [57]: df1

Out[57]:
   A       B   C       D    F  E
0 0.000000 0.000000 -1.509059 5  NaN 1.0
1 1.212112 -0.173215 0.119209 5  1.0 1.0
2 -0.861849 -2.104569 -0.494929 5  2.0  NaN
3 0.721555 -0.706771 -1.039575 5  3.0  NaN

To drop any rows that have missing data.

In [58]: df1.dropna(how='any')

Out[58]:
   A       B   C       D    F  E
0 1.212112 -0.173215 0.119209 5  1.0 1.0

Filling missing data.

In [59]: df1.fillna(value=5)

Out[59]:
   A       B   C       D    F  E
0 0.000000 0.000000 -1.509059 5  5.0 1.0
1 1.212112 -0.173215 0.119209 5  1.0 1.0
2 -0.861849 -2.104569 -0.494929 5  2.0  5.0
3 0.721555 -0.706771 -1.039575 5  3.0  5.0

To get the boolean mask where values are \texttt{nan}.

In [60]: pd.isna(df1)

Out[60]:
   A       B   C       D    F  E
0       False False  False  False  False False
1       False False  False  False  False False
2       False False  False  False  False False
3       False False  False  False  False False
4       False False  False  False  False False

(continues on next page)
5.5 Operations

See the Basic section on Binary Ops.

5.5.1 Stats

Operations in general exclude missing data.

Performing a descriptive statistic:

```
In [61]: df.mean()
Out[61]:
   A  -0.004474
   B  -0.383981
   C  -0.687758
   D   5.000000
   F   3.000000
dtype: float64
```

Same operation on the other axis:

```
In [62]: df.mean(1)
Out[62]:
2013-01-01  0.872735
2013-01-02  1.431621
2013-01-03  0.707731
2013-01-04  1.395042
2013-01-05  1.883656
2013-01-06  1.592306
Freq: D, dtype: float64
```

Operating with objects that have different dimensionality and need alignment. In addition, pandas automatically broadcasts along the specified dimension.

```
In [63]: s = pd.Series([1,3,5,np.nan,6,8], index=dates).shift(2)
In [64]: s
Out[64]:
2013-01-01    NaN
2013-01-02    NaN
2013-01-03    1.0
2013-01-04    3.0
2013-01-05    5.0
2013-01-06    NaN
Freq: D, dtype: float64
```

```
In [65]: df.sub(s, axis='index')
```

(continues on next page)
5.5.2 Apply

Applying functions to the data:

```
In [66]: df.apply(np.cumsum)
Out[66]:
          A         B         C         D         F
2013-01-01 0.000000 0.000000 -1.509059  5.000000 NaN
2013-01-02 1.212112 -0.173215 -1.389850 10.000000  1.000000
2013-01-03 0.350263 -2.277784 -1.884779 15.000000  3.000000
2013-01-04 1.071818 -2.984555 -2.924354 20.000000  6.000000
2013-01-05 0.646846 -2.417535 -2.648122 25.000000 10.000000
2013-01-06 -0.026844 -2.303886 -4.126549 30.000000 15.000000
```

```
In [67]: df.apply(lambda x: x.max() - x.min())
    ...:
    ...
    ...
         A  2.073961
         B  2.671590
         C  1.785291
         D  0.000000
         F  4.000000
dtype: float64
```

5.5.3 Histogramming

See more at Histogramming and Discretization.

```
In [68]: s = pd.Series(np.random.randint(0, 7, size=10))
In [69]: s
Out[69]:
0  4
1  2
2  1
3  2
4  6
5  4
6  4
7  6
8  4
9  4
dtype: int64
In [70]: s.value_counts()
```

(continues on next page)
5.5.4 String Methods

Series is equipped with a set of string processing methods in the `str` attribute that make it easy to operate on each element of the array, as in the code snippet below. Note that pattern-matching in `str` generally uses regular expressions by default (and in some cases always uses them). See more at Vectorized String Methods.

```python
In [71]: s = pd.Series(['A', 'B', 'C', 'Aaba', 'Baca', np.nan, 'CABA', 'dog', 'cat'])
In [72]: s.str.lower()
Out[72]:
   0   a
   1   b
   2   c
   3  aaba
   4   baca
   5   NaN
   6   caba
   7    dog
   8     cat
   dtype: object
```

5.6 Merge

5.6.1 Concat

pandas provides various facilities for easily combining together Series, DataFrame, and Panel objects with various kinds of set logic for the indexes and relational algebra functionality in the case of join / merge-type operations.

See the Merging section.

Concatenating pandas objects together with `concat()`:

```python
In [73]: df = pd.DataFrame(np.random.randn(10, 4))
In [74]: df
Out[74]:
   0   1   2   3
0 -0.548702 1.467327 -1.015962 -0.483075
1  1.637550 -1.217659 -0.291519 -1.745505
2 -0.263952  0.991460 -0.919069  0.266046
3 -0.709661  1.669052  1.037882 -1.705775
4 -0.919854 -0.042379  1.247642 -0.009920
5  0.290213  0.495767  0.362949  1.548106
6 -1.131345 -0.089329  0.337863 -0.945867
```
7    -0.932132    1.956030    0.017587   -0.016692
8    -0.575247    0.254161  -1.143704    0.215897
9    1.193555   -0.077118  -0.408530   -0.862495

# break it into pieces
In [75]: pieces = [df[:3], df[3:7], df[7:]]

In [76]: pd.concat(pieces)
Out[76]:
      0     1     2     3
0 -0.548702  1.467327 -1.015962 -0.483075
1  1.637550 -1.217659 -0.291519 -1.745505
2 -0.263952  0.991460 -0.919069  0.266046
3  0.709661  1.669052  1.037882 -1.705775
4 -0.919854 -0.042379  1.247642 -0.009920
5  0.290213  0.495767  0.362949  1.548106
6 -1.131345 -0.089329  0.337863 -0.945867
7 -0.930231  1.956030  0.017587 -0.016692
8  0.254161 -1.143704  0.215897
9  1.193555 -0.077118 -0.408530 -0.862495

5.6.2 Join

SQL style merges. See the Database style joining section.

In [77]: left = pd.DataFrame({'key': ['foo', 'foo'], 'lval': [1, 2]})

In [78]: right = pd.DataFrame({'key': ['foo', 'foo'], 'rval': [4, 5]})

In [79]: left
Out[79]:
   key lval
0  foo   1
1  foo   2

In [80]: right
   key rval
0  foo     4
1  foo     5

In [81]: pd.merge(left, right, on='key')
   key lval  rval
0  foo   1     4
1  foo   1     5
2  foo   2     4
3  foo   2     5

Another example that can be given is:

In [82]: left = pd.DataFrame({'key': ['foo', 'bar'], 'lval': [1, 2]})

In [83]: right = pd.DataFrame({'key': ['foo', 'bar'], 'rval': [4, 5]})

(continues on next page)
5.6.3 Append

Append rows to a dataframe. See the `Appending` section.

In [87]: df = pd.DataFrame(np.random.randn(8, 4), columns=['A','B','C','D'])

In [88]: df
Out[88]:
   A         B         C         D
0  1.346061  1.511763  1.627081 -0.990582
1 -0.441652  1.211526  0.268520  0.024580
2 -1.577585  0.396823 -0.105381 -0.532532
3  1.453749  1.208843 -0.080952 -0.264610
4 -0.727965 -0.589346  0.339969 -0.693205
5 -0.339355  0.593616  0.884345  1.591431
6  0.141809  0.220390  0.435589  0.192451
7 -0.096701  0.803351  1.715071 -0.708758

In [89]: s = df.iloc[3]

In [90]: df.append(s, ignore_index=True)
Out[90]:
   A         B         C         D
0  1.346061  1.511763  1.627081 -0.990582
1 -0.441652  1.211526  0.268520  0.024580
2 -1.577585  0.396823 -0.105381 -0.532532
3  1.453749  1.208843 -0.080952 -0.264610
4 -0.727965 -0.589346  0.339969 -0.693205
5 -0.339355  0.593616  0.884345  1.591431
6  0.141809  0.220390  0.435589  0.192451
7 -0.096701  0.803351  1.715071 -0.708758
8  1.453749  1.208843 -0.080952 -0.264610
5.7 Grouping

By “group by” we are referring to a process involving one or more of the following steps:

- **Splitting** the data into groups based on some criteria
- **Applying** a function to each group independently
- **Combining** the results into a data structure

See the *Grouping section*.

```python
In [91]: df = pd.DataFrame({'A' : ['foo', 'bar', 'foo', 'bar', 'foo', 'bar', 'foo', 'foo'],
                      ....:                     'B' : ['one', 'one', 'two', 'three', 'two', 'two', 'one', 'three'],
                      ....:                     'C' : np.random.randn(8),
                      ....:                     'D' : np.random.randn(8))

In [92]: df
Out[92]:
      A  B      C         D
0  foo  one -1.202872 -0.055224
1  bar  one -1.814470  2.395985
2  foo  two  1.018601  1.552825
3  bar  three -0.595447  0.166599
4  foo  two  1.395433  0.047609
5  bar  two -0.392670 -0.136473
6  foo  one  0.007207 -0.561757
7  foo  three  1.928123 -1.623033

Grouping and then applying the `sum()` function to the resulting groups.

```python
In [93]: df.groupby('A').sum()
Out[93]:
     C         D
A
  bar -2.802588  2.426110
  foo  3.146492 -0.639581

Grouping by multiple columns forms a hierarchical index, and again we can apply the `sum` function.

```python
In [94]: df.groupby(['A', 'B']).sum()
Out[94]:
          C         D
A B
bar one -1.814470  2.395985
   three -0.595447  0.166599
   two -0.392670 -0.136473
foo one -1.195665 -0.616981
   three  1.928123 -1.623033
   two  2.414034  1.600434

5.8 Reshaping

See the sections on *Hierarchical Indexing* and *Reshaping*.
5.8.1 Stack

```python
In [95]: tuples = list(zip(*[['bar', 'bar', 'baz', 'baz',
                          'foo', 'foo', 'qux', 'qux'],
                          ['one', 'two', 'one', 'two',
                          'one', 'two', 'one', 'two']]))

In [96]: index = pd.MultiIndex.from_tuples(tuples, names=['first', 'second'])

In [97]: df = pd.DataFrame(np.random.randn(8, 2), index=index, columns=['A', 'B'])

In [98]: df2 = df[:4]

In [99]: df2
Out[99]:
         A       B
first second
bar     one  0.029399 -0.542108
        two  0.282696 -0.087302
baz     one -1.575170  1.771208
        two  0.816482  1.100230

The `stack()` method “compresses” a level in the DataFrame’s columns.

```python
In [100]: stacked = df2.stack()

In [101]: stacked
Out[101]:
         A       B
first second
bar     one    A  0.029399
        B -0.542108
        two   A  0.282696
               B -0.087302
baz     one    A -1.575170
        B  1.771208
        two   A  0.816482
               B  1.100230
dtype: float64

With a “stacked” DataFrame or Series (having a MultiIndex as the index), the inverse operation of `stack()` is `unstack()`, which by default unstacks the last level:

```python
In [102]: stacked.unstack()
Out[102]:
         A       B
first second
bar     one  0.029399 -0.542108
        two  0.282696 -0.087302
baz     one -1.575170  1.771208
        two  0.816482  1.100230

In [103]: stacked.unstack(1)

(continues on next page)
5.8.2 Pivot Tables

See the section on **Pivot Tables**.

```python
In [105]: df = pd.DataFrame({'A': ['one', 'one', 'two', 'three'] * 3,
                        'B': ['A', 'B', 'C'] * 4,
                        'C': ['foo', 'foo', 'foo', 'bar', 'bar', 'bar'] * 2,
                        'D': np.random.randn(12),
                        'E': np.random.randn(12)})
```

```python
In [106]: df
Out[106]:
A   B   C   D   E
0   one A   foo 1.418757 -0.179666
1   one B   foo -1.879024 1.291836
2   two C   foo 0.536826 -0.009614
3   three A  bar 1.006160 0.392149
4    one B  bar  -0.029716 0.264599
5    one C  bar  -1.146178 0.057409
6   two A   foo  0.100900 -1.425638
7   three B   foo  1.035018 1.024098
8    one C   foo  0.314665 -0.106062
9    one A  bar  -0.773723 1.824375
10  two B  bar  -1.170653 0.595974
11  three C  bar  0.648740 1.167115
```

We can produce pivot tables from this data very easily:

```python
In [107]: pd.pivot_table(df, values='D', index=['A', 'B'], columns=['C'])
```

```python
Out[107]:
C    bar   foo
  A  B
one  A  -0.773723  1.418757
     B  -0.029716 -1.879024
     C  -1.146178  0.314665
three A  1.006160   NaN
          B  NaN  -1.035018
          C  0.648740  NaN
two   A  NaN  0.100900
```

5.8. Reshaping
5.9 Time Series

pandas has simple, powerful, and efficient functionality for performing resampling operations during frequency conversion (e.g., converting secondly data into 5-minutely data). This is extremely common in, but not limited to, financial applications. See the Time Series section.

In [108]: rng = pd.date_range('1/1/2012', periods=100, freq='S')
In [109]: ts = pd.Series(np.random.randint(0, 500, len(rng)), index=rng)
In [110]: ts.resample('5Min').sum()
Out[110]:
2012-01-01  25083
Freq: 5T, dtype: int64

Time zone representation:

In [111]: rng = pd.date_range('3/6/2012 00:00', periods=5, freq='D')
In [112]: ts = pd.Series(np.random.randn(len(rng)), rng)
In [113]: ts
Out[113]:
2012-03-06  0.464000
2012-03-07  0.227371
2012-03-08  -0.496922
2012-03-09  0.306389
2012-03-10  -2.290613
Freq: D, dtype: float64
In [114]: ts_utc = ts.tz_localize('UTC')
In [115]: ts_utc
Out[115]:
2012-03-05 19:00:00+00:00  0.464000
2012-03-06 19:00:00+00:00  0.227371
2012-03-08 19:00:00+00:00  -0.496922
2012-03-09 19:00:00+00:00  0.306389
2012-03-10 19:00:00+00:00  -2.290613
Freq: D, dtype: float64

Converting to another time zone:

In [116]: ts_utc.tz_convert('US/Eastern')
Out[116]:
2012-03-05 19:00:00-05:00  0.464000
2012-03-06 19:00:00-05:00  0.227371
2012-03-08 19:00:00-05:00  -0.496922
2012-03-09 19:00:00-05:00  0.306389
2012-03-10 19:00:00-05:00  -2.290613
Freq: D, dtype: float64
Converting between time span representations:

```python
In [117]: rng = pd.date_range('1/1/2012', periods=5, freq='M')
In [118]: ts = pd.Series(np.random.randn(len(rng)), index=rng)
In [119]: ts
Out[119]:
2012-01-31  -1.134623
2012-02-29  -1.561819
2012-03-31  -0.260838
2012-04-30   0.281957
2012-05-31   1.523962
Freq: M, dtype: float64
In [120]: ps = ts.to_period()
In [121]: ps
Out[121]:
2012-01    -1.134623
2012-02    -1.561819
2012-03    -0.260838
2012-04     0.281957
2012-05    1.523962
Freq: M, dtype: float64
In [122]: ps.to_timestamp()
Out[122]:
2012-01-01 -1.134623
2012-02-01 -1.561819
2012-03-01 -0.260838
2012-04-01  0.281957
2012-05-01  1.523962
Freq: MS, dtype: float64
```

Converting between period and timestamp enables some convenient arithmetic functions to be used. In the following example, we convert a quarterly frequency with year ending in November to 9am of the end of the month following the quarter end:

```python
In [123]: prng = pd.period_range('1990Q1', '2000Q4', freq='Q-NOV')
In [124]: ts = pd.Series(np.random.randn(len(prng)), prng)
In [125]: ts.index = (prng.asfreq('M', 'e') + 1).asfreq('H', 's') + 9
In [126]: ts.head()
Out[126]:
1990-03-01 09:00  -0.902937
1990-06-01 09:00   0.068159
1990-09-01 09:00  -0.057873
1990-12-01 09:00  -0.368204
1991-03-01 09:00  -1.144073
Freq: H, dtype: float64
```

5.9. Time Series
5.10 Categoricals

pandas can include categorical data in a DataFrame. For full docs, see the categorical introduction and the API documentation.

```
In [127]: df = pd.DataFrame({"id":[1,2,3,4,5,6], "raw_grade":["a", 'b', 'b', 'a', 'a', 'e']})
```

Convert the raw grades to a categorical data type.

```
In [128]: df["grade"] = df["raw_grade"].astype("category")
In [129]: df["grade"]
Out[129]:
0  a
1  b
2  b
3  a
4  a
5  e
Name: grade, dtype: category
Categories (3, object): [a, b, e]
```

Rename the categories to more meaningful names (assigning to Series.cat.categories is inplace!).

```
In [130]: df["grade"].cat.categories = ["very good", "good", "very bad"]
```

Reorder the categories and simultaneously add the missing categories (methods under Series.cat return a new Series by default).

```
In [131]: df["grade"] = df["grade"].cat.set_categories(["very bad", "bad", "medium", "good", "very good"])
In [132]: df["grade"]
Out[132]:
0  very good
1  good
2  good
3  very good
4  very good
5  very bad
Name: grade, dtype: category
Categories (5, object): [very bad, bad, medium, good, very good]
```

Sorting is per order in the categories, not lexical order.

```
In [133]: df.sort_values(by="grade")
Out[133]:
     id  raw_grade  grade
    5      6      e  very bad
    1      2      b   good
    2      3      b   good
    0      1      a  very good
    3      4      a  very good
    4      5      a  very good
```

Grouping by a categorical column also shows empty categories.
5.11 Plotting

See the Plotting docs.

On a DataFrame, the `plot()` method is a convenience to plot all of the columns with labels:
5.12 Getting Data In/Out

5.12.1 CSV

Writing to a csv file.

In [141]: df.to_csv('foo.csv')

Reading from a csv file.

In [142]: pd.read_csv('foo.csv')

Out[142]:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>4</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

(continues on next page)
0 2000-01-01 0.266457 -0.399641 -0.219582 1.186860
1 2000-01-02 -1.170732 -0.345873 1.653061 -0.282953
2 2000-01-03 -1.734933 0.530468 2.060811 -0.515536
3 2000-01-04 -1.555121 1.452620 0.239859 -1.156896
4 2000-01-05 0.578117 0.511371 0.103552 -2.428202
5 2000-01-06 0.478344 0.449933 -0.741620 -1.962409
6 2000-01-07 1.235339 -0.091757 -1.543861 -1.084753
... ... ... ... ... ...
994 2002-09-21 -10.390377 -8.727491 -6.399645 30.914107
998 2002-09-25 -10.216020 -9.480682 -3.933802 29.758560
999 2002-09-26 -11.856774 -10.671012 -3.216025 29.369368

[1000 rows x 5 columns]

5.12.2 HDF5

Reading and writing to HDFStores.

Writing to a HDF5 Store.

```
In [143]: df.to_hdf('foo.h5','df')
```

Reading from a HDF5 Store.

```
In [144]: pd.read_hdf('foo.h5','df')
Out [144]:
   A     B     C     D
0 0.266457 -0.399641 -0.219582 1.186860
1 -1.170732 -0.345873 1.653061 -0.282953
2 -1.734933  0.530468  2.060811 -0.515536
3 -1.555121  1.452620  0.239859 -1.156896
4  0.578117  0.511371  0.103552 -2.428202
5  0.478344  0.449933 -0.741620 -1.962409
6  1.235339 -0.091757 -1.543861 -1.084753
... ... ... ... ...
993 -10.628548 -9.153563 -7.883146 28.313940
994 -10.390377 -8.727491 -6.399645 30.914107
995 -8.985362 -8.485624 -4.669462 31.367740
996 -9.558560 -8.781216 -4.499815 30.518439
998 -10.216020 -9.480682 -3.933802 29.758560
999 -11.856774 -10.671012 -3.216025 29.369368

[1000 rows x 4 columns]
```

5.12.3 Excel

Reading and writing to MS Excel.

Writing to an excel file.

5.12. Getting Data In/Out
Reading from an excel file.

```python
In [146]: pd.read_excel('foo.xlsx', 'Sheet1', index_col=None, na_values=['NA'])
Out[146]:
      A         B         C         D
2000-01-01  0.266457  -0.399641  -0.219582  1.186860
2000-01-02  1.170732  -0.345873   1.653061  -0.282953
2000-01-03  1.734933   0.530468   2.060811  -0.515536
2000-01-04  1.555121   1.452620   0.239859  -1.156896
2000-01-05  0.578117   0.511371   0.103552  -2.428202
2000-01-06  0.478344   0.499933  -0.741620  -1.962409
2000-01-07  1.235339  -0.091757  -1.543861  -1.084753
         ...         ...         ...         ...
2002-09-21 -10.390377  -8.727491  -6.399645  30.914107
2002-09-26 -11.856774  -10.671012  -3.216025  29.369368
[1000 rows x 4 columns]
```

### 5.13 Gotchas

If you are attempting to perform an operation you might see an exception like:

```python
>>> if pd.Series([False, True, False]):
    print("I was true")
Traceback
  ...
ValueError: The truth value of an array is ambiguous. Use a.empty, a.any() or a.all().
```

See *Comparisons* for an explanation and what to do.

See *Gotchas* as well.
CHAPTER SIX

TUTORIALS

This is a guide to many pandas tutorials, geared mainly for new users.

6.1 Internal Guides

pandas’ own 10 Minutes to pandas.
More complex recipes are in the Cookbook.
A handy pandas cheat sheet.

6.2 pandas Cookbook

The goal of this 2015 cookbook (by Julia Evans) is to give you some concrete examples for getting started with pandas. These are examples with real-world data, and all the bugs and weirdness that entails.

Here are links to the v0.2 release. For an up-to-date table of contents, see the pandas-cookbook GitHub repository. To run the examples in this tutorial, you’ll need to clone the GitHub repository and get IPython Notebook running. See How to use this cookbook.

• A quick tour of the IPython Notebook: Shows off IPython’s awesome tab completion and magic functions.
• Chapter 1: Reading your data into pandas is pretty much the easiest thing. Even when the encoding is wrong!
• Chapter 2: It’s not totally obvious how to select data from a pandas dataframe. Here we explain the basics (how to take slices and get columns)
• Chapter 3: Here we get into serious slicing and dicing and learn how to filter dataframes in complicated ways, really fast.
• Chapter 4: Groupby/aggregate is seriously my favorite thing about pandas and I use it all the time. You should probably read this.
• Chapter 5: Here you get to find out if it’s cold in Montreal in the winter (spoiler: yes). Web scraping with pandas is fun! Here we combine dataframes.
• Chapter 6: Strings with pandas are great. It has all these vectorized string operations and they’re the best. We will turn a bunch of strings containing “Snow” into vectors of numbers in a trice.
• Chapter 7: Cleaning up messy data is never a joy, but with pandas it’s easier.
• Chapter 8: Parsing Unix timestamps is confusing at first but it turns out to be really easy.
• Chapter 9: Reading data from SQL databases.
6.3 Lessons for new pandas users

For more resources, please visit the main repository.

• 01 - Lesson: - Importing libraries - Creating data sets - Creating data frames - Reading from CSV - Exporting to CSV - Finding maximums - Plotting data
• 02 - Lesson: - Reading from TXT - Exporting to TXT - Selecting top/bottom records - Descriptive statistics - Grouping/sorting data
• 03 - Lesson: - Creating functions - Reading from EXCEL - Exporting to EXCEL - Outliers - Lambda functions - Slice and dice data
• 04 - Lesson: - Adding/deleting columns - Index operations
• 05 - Lesson: - Stack/Unstack/Transpose functions
• 06 - Lesson: - GroupBy function
• 07 - Lesson: - Ways to calculate outliers
• 08 - Lesson: - Read from Microsoft SQL databases
• 09 - Lesson: - Export to CSV/EXCEL/TXT
• 10 - Lesson: - Converting between different kinds of formats
• 11 - Lesson: - Combining data from various sources

6.4 Practical data analysis with Python

This guide is a comprehensive introduction to the data analysis process using the Python data ecosystem and an interesting open dataset. There are four sections covering selected topics as follows:

• Munging Data
• Aggregating Data
• Visualizing Data
• Time Series

6.5 Exercises for new users

Practice your skills with real data sets and exercises. For more resources, please visit the main repository.

• 01 - Getting & Knowing Your Data
• 02 - Filtering & Sorting
• 03 - Grouping
• 04 - Apply
• 05 - Merge
• 06 - Stats
• 07 - Visualization
• 08 - Creating Series and DataFrames
6.6 Modern pandas

Tutorial series written in 2016 by Tom Augspurger. The source may be found in the GitHub repository TomAugspurger/effective-pandas.

- Modern Pandas
- Method Chaining
- Indexes
- Performance
- Tidy Data
- Visualization
- Timeseries

6.7 Excel charts with pandas, vincent and xlsxwriter

- Using Pandas and XlsxWriter to create Excel charts

6.8 Video Tutorials

- Pandas: .head() to .tail() (2016) (1:26) GitHub repo

6.9 Various Tutorials

- Wes McKinney’s (pandas BDFL) blog
- Statistical analysis made easy in Python with SciPy and pandas DataFrames, by Randal Olson
- Statistical Data Analysis in Python, tutorial videos, by Christopher Fonnesbeck from SciPy 2013
- Financial analysis in Python, by Thomas Wiecki
- Intro to pandas data structures, by Greg Reda
- Pandas and Python: Top 10, by Manish Amde
- Pandas Tutorial, by Mikhail Semeniuk
- Pandas DataFrames Tutorial, by Karlijn Willems
- A concise tutorial with real life examples
This is a repository for short and sweet examples and links for useful pandas recipes. We encourage users to add to this documentation.

Adding interesting links and/or inline examples to this section is a great First Pull Request.

Simplified, condensed, new-user friendly, in-line examples have been inserted where possible to augment the Stack-Overflow and GitHub links. Many of the links contain expanded information, above what the in-line examples offer.

Pandas (pd) and Numpy (np) are the only two abbreviated imported modules. The rest are kept explicitly imported for newer users.

These examples are written for Python 3. Minor tweaks might be necessary for earlier python versions.

### 7.1 Idioms

These are some neat pandas idioms

if-then/if-then-else on one column, and assignment to another one or more columns:

```python
In [1]: df = pd.DataFrame(
    ...:   {'AAA' : [4,5,6,7], 'BBB' : [10,20,30,40], 'CCC' : [100,50,-30,-50]});
Out[1]:
     AAA  BBB  CCC
0    4    10   100
1    5    20    50
2    6    30   -30
3    7    40   -50
```

#### 7.1.1 if-then...

An if-then on one column

```python
In [2]: df.loc[df.AAA >= 5,'BBB'] = -1; df
Out[2]:
     AAA  BBB  CCC
0    4    10   100
1    5   -1    50
2    6   -1   -30
3    7   -1   -50
```

An if-then with assignment to 2 columns:
In [3]: df.loc[df.AAA >= 5,['BBB','CCC']] = 555; df
Out[3]:
   AAA  BBB  CCC
0  4    10  100
1  5   555  555
2  6   555  555
3  7   555  555

Add another line with different logic, to do the -else
In [4]: df.loc[df.AAA < 5,['BBB','CCC']] = 2000; df
Out[4]:
   AAA  BBB  CCC
0  4   2000  2000
1  5   555  555
2  6   555  555
3  7   555  555

Or use pandas where after you’ve set up a mask
In [6]: df.where(df_mask,-1000)
Out[6]:
   AAA  BBB  CCC
0  4   -1000  2000
1  5    -1000 -1000
2  6   -1000   555
3  7    -1000 -1000

if-then-else using numpy’s where()
In [7]: df = pd.DataFrame(
      ...:     {'AAA' : [4,5,6,7], 'BBB' : [10,20,30,40],'CCC' : [100,50,-30,-50]}); df
      ...
Out[7]:
   AAA  BBB  CCC
0  4   10   100
1  5   20    50
2  6   30    -30
3  7   40    -50
In [8]: df['logic'] = np.where(df['AAA'] > 5,'high','low'); df

   AAA  BBB  CCC   logic
0  4   10    100  low
1  5   20     50  low
2  6   30    -30  high
3  7   40    -50  high

7.1.2 Splitting

Split a frame with a boolean criterion

526  Chapter 7. Cookbook
In [9]: df = pd.DataFrame(
    ...:
     ('AAA' : [4, 5, 6, 7], 'BBB' : [10, 20, 30, 40], 'CCC' : [100, 50, -30, -50])); df
    ...:
Out[9]:
    AAA  BBB  CCC
   0  4    10   100
   1  5     20    50
   2  6     30   -30
   3  7     40   -50

In [10]: dflow = df[df.AAA <= 5]; dflow

    AAA  BBB  CCC
    0  4    10   100
    1  5     20    50

In [11]: dfhigh = df[df.AAA > 5]; dfhigh

    AAA  BBB  CCC
    2  6     30   -30
    3  7     40   -50

### 7.1.3 Building Criteria

Select with multi-column criteria

In [12]: df = pd.DataFrame(
    ...:
     ('AAA' : [4, 5, 6, 7], 'BBB' : [10, 20, 30, 40], 'CCC' : [100, 50, -30, -50])); df
    ...:
Out[12]:
    AAA  BBB  CCC
   0  4    10   100
   1  5     20    50
   2  6     30   -30
   3  7     40   -50

... and (without assignment returns a Series)

In [13]: newseries = df.loc[(df['BBB'] < 25) & (df['CCC'] >= -40), 'AAA']; newseries
Out[13]:
    0  4
    1  5
Name: AAA, dtype: int64

... or (without assignment returns a Series)

In [14]: newseries = df.loc[(df['BBB'] > 25) | (df['CCC'] >= 75), 'AAA']; newseries;

... or (with assignment modifies the DataFrame.)

In [15]: df.loc[(df['BBB'] > 25) | (df['CCC'] >= 75), 'AAA'] = 0.1; df
Out[15]:
    AAA  BBB  CCC
    0  0.1    10   100

### 7.1. Idioms 527
Select rows with data closest to certain value using argsort

```
In [16]: df = pd.DataFrame(  
.....:    {'AAA' : [4,5,6,7], 'BBB' : [10,20,30,40], 'CCC' : [100,50,-30,-50]}); df  
.....:
Out[16]:  
AAA  BBB  CCC
0  4    10  100  
1  5    20   50  
2  6    30  -30  
3  7    40  -50  

In [17]: aValue = 43.0

In [18]: df.loc[(df.CCC-aValue).abs().argsort()]
Out[18]:  
AAA  BBB  CCC
1  5    20   50  
0  4    10  100  
2  6    30  -30  
3  7    40  -50  
```

Dynamically reduce a list of criteria using a binary operators

```
In [19]: df = pd.DataFrame(  
.....:    {'AAA' : [4,5,6,7], 'BBB' : [10,20,30,40], 'CCC' : [100,50,-30,-50]}); df  
.....:
Out[19]:  
AAA  BBB  CCC
0  4    10  100  
1  5    20   50  
2  6    30  -30  
3  7    40  -50  

In [20]: Crit1 = df.AAA <= 5.5

In [21]: Crit2 = df.BBB == 10.0

In [22]: Crit3 = df.CCC > -40.0

One could hard code:

```
In [23]: AllCrit = Crit1 & Crit2 & Crit3

... Or it can be done with a list of dynamically built criteria

```

```
In [24]: CritList = [Crit1,Crit2,Crit3]

In [25]: AllCrit = functools.reduce(lambda x,y: x & y, CritList)

In [26]: df[AllCrit]
Out[26]:  
```
### 7.2 Selection

#### 7.2.1 DataFrames

The *indexing* docs.

Using both row labels and value conditionals

```python
In [27]: df = pd.DataFrame(
    ....:     {'AAA': [4, 5, 6, 7], 'BBB': [10, 20, 30, 40], 'CCC': [100, 50, -30, -50]}); df
   ....:
Out[27]:
    AAA  BBB  CCC
   0   4    10  100
   1   5    20   50
   2   6    30  -30
   3   7    40  -50
```

```python
In [28]: df[(df.AAA <= 6) & (df.index.isin([0, 2, 4]))]
```

```
AAA  BBB  CCC
0    4    10  100
2    6    30  -30
```

Use `loc` for label-oriented slicing and `iloc` positional slicing

```python
In [29]: data = {'AAA': [4, 5, 6, 7], 'BBB': [10, 20, 30, 40], 'CCC': [100, 50, -30, -50]}
In [30]: df = pd.DataFrame(data=data, index=['foo', 'bar', 'boo', 'kar']); df
Out[30]:
    AAA  BBB  CCC
  foo    4    10  100
  bar    5    20   50
  boo    6    30  -30
  kar    7    40  -50
```

There are 2 explicit slicing methods, with a third general case

1. Positional-oriented (Python slicing style: exclusive of end)
2. Label-oriented (Non-Python slicing style: inclusive of end)
3. General (Either slicing style: depends on if the slice contains labels or positions)

```python
In [31]: df.loc['bar':'kar']  # Label
Out[31]:
    AAA  BBB  CCC
  bar    5    20   50
  boo    6    30  -30
  kar    7    40  -50
```

(continues on next page)
# Generic

In [32]: df.iloc[0:3]

\n\n→
\nAAA BBB CCC
foo  4  10  100
bar  5  20  50
boo  6  30 -30

In [33]: df.loc['bar':'kar']

\n\n→
\nAAA BBB CCC
bar  5  20  50
boo  6  30 -30
kar  7  40 -50

Ambiguity arises when an index consists of integers with a non-zero start or non-unit increment.

In [34]: df2 = pd.DataFrame(data=data,index=[1,2,3,4]); # Note index starts at 1.

In [35]: df2.iloc[1:3] # Position-oriented

Out[35]:
\n\nAAA BBB CCC
2   5  20  50
3   6  30 -30

In [36]: df2.loc['1:3'] # Label-oriented

\n\nAAA BBB CCC
1   4  10  100
2   5  20  50
3   6  30 -30

Using inverse operator (~) to take the complement of a mask

In [37]: df = pd.DataFrame(
.....:     ('AAA' : [4,5,6,7], 'BBB' : [10,20,30,40], 'CCC' : [100,50,-30,-50]));
~df

Out[37]:
\n\nAAA BBB CCC
0   4  10  100
1   5  20  50
2   6  30 -30
3   7  40 -50

In [38]: df[~((df.AAA <= 6) & (df.index.isin([0,2,4])))]

\n\nAAA BBB CCC
1   5  20  50
3   7  40 -50
7.2.2 Panels

Extend a panel frame by transposing, adding a new dimension, and transposing back to the original dimensions

```python
In [39]: rng = pd.date_range('1/1/2013', periods=100, freq='D')
In [40]: data = np.random.randn(100, 4)
In [41]: cols = ['A', 'B', 'C', 'D']
In [42]: df1, df2, df3 = pd.DataFrame(data, rng, cols), pd.DataFrame(data, rng, cols),
   → pd.DataFrame(data, rng, cols)
In [43]: pf = pd.Panel({'df1':df1,'df2':df2,'df3':df3});pf
Out[43]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 100 (major_axis) x 4 (minor_axis)
Items axis: df1 to df3
Major_axis axis: 2013-01-01 00:00:00 to 2013-04-10 00:00:00
Minor_axis axis: A to D
In [44]: pf.loc[:,:,'F'] = pd.DataFrame(data, rng, cols);pf

Out[44]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 100 (major_axis) x 5 (minor_axis)
Items axis: df1 to df3
Major_axis axis: 2013-01-01 00:00:00 to 2013-04-10 00:00:00
Minor_axis axis: A to F
```

Mask a panel by using np.where and then reconstructing the panel with the new masked values

7.2.3 New Columns

Efficiently and dynamically creating new columns using applymap

```python
In [45]: df = pd.DataFrame({
   ....:     'AAA' : [1,2,1,3],
   ....:     'BBB' : [1,1,2,2],
   ....:     'CCC' : [2,1,3,1]
   ....: }); df
Out[45]:
      AAA  BBB  CCC
0    1    1   2
1    2    1   1
2    1    2   3
3    3    2   1
In [46]: source_cols = df.columns  # or some subset would work too.
In [47]: new_cols = [str(x) + '_cat' for x in source_cols]
In [48]: categories = {1 : 'Alpha', 2 : 'Beta', 3 : 'Charlie'}
In [49]: df[new_cols] = df[source_cols].applymap(categories.get);df
Out[49]:
      AAA  BBB  CCC   AAA_cat  BBB_cat  CCC_cat
0    1    1   2    Alpha      Alpha  Beta
```

(continues on next page)
Keep other columns when using min() with groupby

```python
In [50]: df = pd.DataFrame(
    ....:     {'AAA' : [1,1,1,2,2,2,3,3], 'BBB' : [2,1,3,4,5,1,2,3]}); df
Out[50]:
    AAA  BBB
  0  1    2
  1  1    1
  2  1    3
  3  2    4
  4  2    5
  5  2    1
  6  3    2
  7  3    3
```

Method 1: idxmin() to get the index of the mins

```python
In [51]: df.loc[df.groupby("AAA")["BBB"].idxmin()]
Out[51]:
    AAA  BBB
  1  1    1
  5  2    1
  6  3    2
```

Method 2: sort then take first of each

```python
In [52]: df.sort_values(by="BBB").groupby("AAA", as_index=False).first()
Out[52]:
    AAA  BBB
  0  1    1
  1  2    1
  2  3    2
```

Notice the same results, with the exception of the index.

### 7.3 MultIndexing

The **multindexing** docs.

Creating a multi-index from a labeled frame

```python
In [53]: df = pd.DataFrame({'row' : [0,1,2],
    ....:     'One_X' : [1.1,1.1,1.1],
    ....:     'One_Y' : [1.2,1.2,1.2],
    ....:     'Two_X' : [1.11,1.11,1.11],
    ....:     'Two_Y' : [1.22,1.22,1.22]}); df
Out[53]:
   row  One_X  One_Y  Two_X  Two_Y
0    0   1.1    1.2  1.11  1.22
```

(continues on next page)
# As Labelled Index

```python
In [54]: df = df.set_index('row');df

Out[54]:

<table>
<thead>
<tr>
<th></th>
<th>One_X</th>
<th>One_Y</th>
<th>Two_X</th>
<th>Two_Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>row</td>
<td>1.1</td>
<td>1.2</td>
<td>1.11</td>
<td>1.22</td>
</tr>
<tr>
<td>0</td>
<td>1.1</td>
<td>1.2</td>
<td>1.11</td>
<td>1.22</td>
</tr>
<tr>
<td>1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.11</td>
<td>1.22</td>
</tr>
<tr>
<td>2</td>
<td>1.1</td>
<td>1.2</td>
<td>1.11</td>
<td>1.22</td>
</tr>
</tbody>
</table>
```

# With Hierarchical Columns

```python
In [55]: df.columns = pd.MultiIndex.from_tuples((tuple(c.split('_')) for c in df.columns));df

Out[55]:

<table>
<thead>
<tr>
<th></th>
<th>One</th>
<th>Two</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>Y</td>
</tr>
<tr>
<td>row</td>
<td>0</td>
<td>1.1</td>
</tr>
<tr>
<td>0</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>1</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>2</td>
<td>1.1</td>
<td>1.2</td>
</tr>
</tbody>
</table>
```

# Now stack & Reset

```python
In [56]: df = df.stack(0).reset_index(1);df

Out[56]:

<table>
<thead>
<tr>
<th></th>
<th>level_1</th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>row</td>
<td>One</td>
<td>1.10</td>
<td>1.20</td>
</tr>
<tr>
<td>0</td>
<td>Two</td>
<td>1.11</td>
<td>1.22</td>
</tr>
<tr>
<td>1</td>
<td>One</td>
<td>1.10</td>
<td>1.20</td>
</tr>
<tr>
<td>1</td>
<td>Two</td>
<td>1.11</td>
<td>1.22</td>
</tr>
<tr>
<td>2</td>
<td>One</td>
<td>1.10</td>
<td>1.20</td>
</tr>
<tr>
<td>2</td>
<td>Two</td>
<td>1.11</td>
<td>1.22</td>
</tr>
</tbody>
</table>
```

# And fix the labels (Notice the label 'level_1' got added automatically)

```python
In [57]: df.columns = ['Sample','All_X','All_Y'];df

Out[57]:

<table>
<thead>
<tr>
<th></th>
<th>Sample</th>
<th>All_X</th>
<th>All_Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>row</td>
<td>0</td>
<td>One</td>
<td>1.10</td>
</tr>
<tr>
<td>0</td>
<td>Two</td>
<td>1.11</td>
<td>1.22</td>
</tr>
<tr>
<td>1</td>
<td>One</td>
<td>1.10</td>
<td>1.20</td>
</tr>
<tr>
<td>1</td>
<td>Two</td>
<td>1.11</td>
<td>1.22</td>
</tr>
<tr>
<td>2</td>
<td>One</td>
<td>1.10</td>
<td>1.20</td>
</tr>
<tr>
<td>2</td>
<td>Two</td>
<td>1.11</td>
<td>1.22</td>
</tr>
</tbody>
</table>
```

### 7.3.1 Arithmetic

Performing arithmetic with a multi-index that needs broadcasting
In [58]: cols = pd.MultiIndex.from_tuples([(x,y) for x in ['A','B','C'] for y in ['O', 'I']])

In [59]: df = pd.DataFrame(np.random.randn(2,6),index=['n','m'],columns=cols); df
Out[59]:
    A  B  C
  nO  1.920906 -0.388231 -2.314394 0.665508 0.402562 0.399555
  mO -1.765956  0.850423  0.388054 0.992312 0.744086 -0.739776

In [60]: df = df.div(df['C'],level=1); df
   A  B  C
  nO I  O I  O I
  mO I  O I  O I

7.3.2 Slicing

Slicing a multi-index with xs

In [61]: coords = [('AA','one'), ('AA','six'), ('BB','one'), ('BB','two'), ('BB','six')]

In [62]: index = pd.MultiIndex.from_tuples(coords)

In [63]: df = pd.DataFrame([11,22,33,44,55],index,['MyData']); df
Out[63]:
     MyData
    AA one  11
    six  22
    BB one  33
two  44
    six  55

To take the cross section of the 1st level and 1st axis the index:

In [64]: df.xs('BB',level=0,axis=0)  #Note : level and axis are optional, and default to zero
Out[64]:
     MyData
   one  33
two  44
    six  55

...and now the 2nd level of the 1st axis.

In [65]: df.xs('six',level=1,axis=0)
Out[65]:
     MyData
AA   22
BB   55

Slicing a multi-index with xs, method #2
In [66]: index = list(itertools.product(['Ada','Quinn','Violet'],['Comp','Math','Sci']))

In [67]: headr = list(itertools.product(['Exams','Labs'],['I','II']))

In [68]: indx = pd.MultiIndex.from_tuples(index,names=['Student','Course'])

In [69]: cols = pd.MultiIndex.from_tuples(headr) #Notice these are un-named

In [70]: data = [(70+x+y+(x*y)%3 for x in range(4)) for y in range(9)]

In [71]: df = pd.DataFrame(data,indx,cols); df

Out[71]:

<table>
<thead>
<tr>
<th>Exams</th>
<th>Labs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Student</td>
<td>Course</td>
</tr>
<tr>
<td>Ada</td>
<td>Comp</td>
</tr>
<tr>
<td></td>
<td>Math</td>
</tr>
<tr>
<td></td>
<td>Sci</td>
</tr>
<tr>
<td>Quinn</td>
<td>Comp</td>
</tr>
<tr>
<td></td>
<td>Math</td>
</tr>
<tr>
<td></td>
<td>Sci</td>
</tr>
<tr>
<td>Violet</td>
<td>Comp</td>
</tr>
<tr>
<td></td>
<td>Math</td>
</tr>
<tr>
<td></td>
<td>Sci</td>
</tr>
</tbody>
</table>

In [72]: All = slice(None)

In [73]: df.loc['Violet']

Out[73]:

<table>
<thead>
<tr>
<th>Exams</th>
<th>Labs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Course</td>
<td></td>
</tr>
<tr>
<td>Comp</td>
<td>76</td>
</tr>
<tr>
<td>Math</td>
<td>77</td>
</tr>
<tr>
<td>Sci</td>
<td>78</td>
</tr>
</tbody>
</table>

In [74]: df.loc[(All,'Math'),All]

In [75]: df.loc[(slice('Ada','Quinn'),'Math'),All]

In [76]: df.loc[(All,'Math'),('Exams')]

(continues on next page)
### 7.3.3 Sorting

Sort by specific column or an ordered list of columns, with a multi-index

```
In [78]: df.sort_values(by=('Labs', 'II'), ascending=False)
```

```
Out[78]:

<table>
<thead>
<tr>
<th>Student</th>
<th>Course</th>
<th>Exams</th>
<th>Labs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Violet</td>
<td>Sci</td>
<td>78</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>Math</td>
<td>77</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Comp</td>
<td>76</td>
<td>79</td>
</tr>
<tr>
<td>Quinn</td>
<td>Sci</td>
<td>75</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>Math</td>
<td>74</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>Comp</td>
<td>73</td>
<td>76</td>
</tr>
<tr>
<td>Ada</td>
<td>Sci</td>
<td>72</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Math</td>
<td>71</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Comp</td>
<td>70</td>
<td>73</td>
</tr>
</tbody>
</table>
```

Partial Selection, the need for sortedness;

### 7.3.4 Levels

Prepending a level to a multiindex

Flatten Hierarchical columns

### 7.4 Missing Data

The *missing data* docs.

Fill forward a reversed timeseries
pandas: powerful Python data analysis toolkit, Release 0.23.2

In [79]: df = pd.DataFrame(np.random.randn(6,1), index=pd.date_range('2013-08-01',
                           periods=6, freq='B'), columns=list('A'))

In [80]: df.loc[df.index[3], 'A'] = np.nan

In [81]: df
Out[81]:
          A
2013-08-01 -1.054874
2013-08-02 -0.179642
2013-08-05  0.639589
2013-08-06   NaN
2013-08-07  1.906684
2013-08-08  0.104050

In [82]: df.reindex(df.index[::-1]).ffill()

A
2013-08-08  0.104050
2013-08-07  1.906684
2013-08-06  1.906684
2013-08-05  0.639589
2013-08-02 -0.179642
2013-08-01 -1.054874

cumsum reset at NaN values

7.4.1 Replace

Using replace with backrefs

7.5 Grouping

The grouping docs.

Basic grouping with apply

Unlike agg, apply’s callable is passed a sub-DataFrame which gives you access to all the columns

In [83]: df = pd.DataFrame({'animal': 'cat dog cat fish dog cat cat'.split(),
                        ....:                      'size': list('SSMMMLL'),
                        ....:                      'weight': [8, 10, 11, 1, 20, 12, 12],
                        ....:                      'adult': [False] * 5 + [True] * 2}); df

Out[83]:
          animal size  weight  adult
0       cat    S      8   False
1       dog    S     10   False
2       cat    M     11   False
3       fish    M      1   False
4       dog    M     20   False
5       cat    L     12    True
6       cat    L     12    True

(continues on next page)
List the size of the animals with the highest weight.
In [84]: df.groupby('animal').apply(lambda subf: subf['size'][subf['weight'].idxmax()])

animal
cat   L
dog   M
fish  M
dtype: object

Using `get_group`

In [85]: gb = df.groupby(['animal'])
In [86]: gb.get_group('cat')
Out[86]:
animal size weight adult
0  cat   S   8  False
2  cat   M  11  False
5  cat   L  12   True
6  cat   L  12   True

Apply to different items in a group

In [87]: def GrowUp(x):
   .....:    avg_weight = sum(x[x['size'] == 'S'].weight * 1.5)
   .....:    avg_weight += sum(x[x['size'] == 'M'].weight * 1.25)
   .....:    avg_weight += sum(x[x['size'] == 'L'].weight)
   .....:    avg_weight /= len(x)
   .....:    return pd.Series(['L', avg_weight, True], index=['size', 'weight', 'adult'])
   .....:
In [88]: expected_df = gb.apply(GrowUp)
In [89]: expected_df
Out[89]:
size  weight  adult
animal
  cat   L  12.4375  True
  dog   L  20.0000  True
  fish  L  1.2500   True

Expanding Apply

In [90]: S = pd.Series([i / 100.0 for i in range(1,11)])
In [91]: def CumRet(x,y):
   .....:    return x * (1 + y)
   .....:
In [92]: def Red(x):
   .....:    return functools.reduce(CumRet,x,1.0)
   .....:
In [93]: S.expanding().apply(Red, raw=True)
Out[93]: (continues on next page)
Replacing some values with mean of the rest of a group

```
In [94]: df = pd.DataFrame({'A' : [1, 1, 2, 2], 'B' : [1, -1, 1, 2]})
In [95]: gb = df.groupby('A')
In [96]: def replace(g):
   ....:     mask = g < 0
   ....:     g.loc[mask] = g[~mask].mean()
   ....:     return g
   ....:
In [97]: gb.transform(replace)
Out[97]:
    B
0  1.0
1  1.0
2  1.0
3  2.0
```

Sort groups by aggregated data

```
In [98]: df = pd.DataFrame({'code': ['foo', 'bar', 'baz'] * 2,
   ....:                     'data': [0.16, -0.21, 0.33, 0.45, -0.59, 0.62],
   ....:                     'flag': [False, True] * 3})
In [99]: code_groups = df.groupby('code')
In [100]: agg_n_sort_order = code_groups[['data']].transform(sum).sort_values(by='data')
In [101]: sorted_df = df.loc[agg_n_sort_order.index]
In [102]: sorted_df
Out[102]:
      code   data  flag
    0    foo  0.16  False
    1    bar -0.21   True
    2    baz  0.33  False
    3    foo  0.45   True
    4    bar -0.59   False
    5    baz  0.62   True
```

Create multiple aggregated columns

### 7.5. Grouping
In [103]: rng = pd.date_range(start="2014-10-07", periods=10, freq='2min')

In [104]: ts = pd.Series(data = list(range(10)), index = rng)

In [105]: def MyCust(x):
   ....:     if len(x) > 2:
   ....:         return x[1] * 1.234
   ....:     return pd.NaT
   ....:

In [106]: mhc = {'Mean': np.mean, 'Max': np.max, 'Custom': MyCust}

In [107]: ts.resample("5min").apply(mhc)

Out[107]:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Custom</td>
<td>2014-10-07 00:00:00</td>
<td>1.234</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2014-10-07 00:05:00</td>
<td>NaT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2014-10-07 00:10:00</td>
<td>7.404</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2014-10-07 00:15:00</td>
<td>NaT</td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>2014-10-07 00:00:00</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2014-10-07 00:05:00</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2014-10-07 00:10:00</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2014-10-07 00:15:00</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2014-10-07 00:00:00</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2014-10-07 00:05:00</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2014-10-07 00:10:00</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2014-10-07 00:15:00</td>
<td>8.5</td>
<td></td>
</tr>
</tbody>
</table>

In [108]: ts

In [109]: df = pd.DataFrame({'Color': 'Red Red Red Blue'.split(),
   ....:     'Value': [100, 150, 50, 50]})

In [110]: df['Counts'] = df.groupby(['Color']).transform(len)

Create a value counts column and reassign back to the DataFrame
Shift groups of the values in a column based on the index

```
In [112]: df = pd.DataFrame(
    ....:   {u'line_race': [10, 10, 8, 10, 10, 8],
    ....:    u'beyer': [99, 102, 103, 103, 88, 100],
    ....:    index=[u'Last Gunfighter', u'Last Gunfighter', u'Last Gunfighter',
    ....:    u'Paynter', u'Paynter', u'Paynter']}); df
```

```
Out[112]:
     line_race  beyer
Last Gunfighter    10   99
Last Gunfighter    10  102
Last Gunfighter     8  103
   Paynter        10  103
   Paynter        10   88
   Paynter         8  100
```

```
In [113]: df['beyer_shifted'] = df.groupby(level=0)['beyer'].shift(1)
```

```
In [114]: df
Out[114]:
     line_race  beyer  beyer_shifted
    Last Gunfighter   10     99          NaN
    Last Gunfighter   10  102      99.0
    Last Gunfighter     8  103    102.0
       Paynter      10  103         NaN
       Paynter      10   88    103.0
       Paynter       8  100     88.0
```

Select row with maximum value from each group

```
In [115]: df = pd.DataFrame({'host':['other','other','that','this','this'],
    ....:   'service':['mail','web','mail','mail','web'],
    ....:   'no':[1, 2, 1, 2, 1]}).set_index(['host', 'service'])
```

```
In [116]: mask = df.groupby(level=0).agg('idxmax')
```

```
In [117]: df_count = df.loc[mask['no']].reset_index()
```

```
In [118]: df_count
Out[118]:
     host  service  no
0  other    web    2
1   that   mail    1
2  this    mail    2
```

Grouping like Python’s itertools.groupby
7.5.1 Expanding Data

Alignment and to-date

Rolling Computation window based on values instead of counts

Rolling Mean by Time Interval

7.5.2 Splitting

Splitting a frame

Create a list of dataframes, split using a delineation based on logic included in rows.
7.5.3 Pivot

The Pivot docs.

Partial sums and subtotals

```
In [127]: df = pd.DataFrame(data={'Province': ['ON','QC','BC','AL','AL','MN','ON'],
                               'City': ['Toronto','Montreal','Vancouver','Calgary','Edmonton','Winnipeg','Windsor'],
                               'Sales': [13,6,16,8,4,3,1]})

In [128]: table = pd.pivot_table(df,values=['Sales'],index=['Province'],columns=['City'],aggfunc=np.sum,margins=True)

In [129]: table.stack('City')
```

```
Out[129]:
           Sales
    Province City
    AL     All     12.0
           Calgary   8.0
           Edmonton   4.0
    BC     All     16.0
           Vancouver  16.0
    MN     All      3.0
           Winnipeg   3.0
   ...  ...  ...  ...
    All  Calgary   8.0
           Edmonton   4.0
           Montreal   6.0
           Toronto   13.0
           Vancouver  16.0
           Windsor   1.0
           Winnipeg   3.0

[20 rows x 1 columns]
```

Frequency table like plyr in R

```
In [130]: grades = [48,99,75,80,42,80,72,68,36,78]
```

(continues on next page)
In [131]: df = pd.DataFrame( {'ID': ["x%d" % r for r in range(10)],  
......:             'Gender' : ['F', 'M', 'F', 'M', 'F', 'M', 'M', 'F', 'M', 'M'],  
......:             '2009', '2009', '2009', '2009'],  
......:             'Class' : ['algebra', 'stats', 'bio', 'algebra', 'algebra',  
......:             'stats', 'stats', 'algebra', 'bio', 'bio'],  
......:             'Participated': ['yes', 'yes', 'yes', 'yes', 'no', 'yes', 'yes',  
......:             'yes', 'yes', 'yes'],  
......:             'Passed' : ['yes' if x > 50 else 'no' for x in grades],  
......:             'Employed' : [True, True, True, False, False, False, False,  
......:             True, True, False],  
......:             'Grade': grades})

In [132]: df.groupby('ExamYear').agg({'Participated': lambda x: x.value_counts()['yes'],  
......:             'Passed': lambda x: sum(x == 'yes'),  
......:             'Employed': lambda x : sum(x),  
......:             'Grade': lambda x : sum(x) / len(x)})

Out[132]:

<table>
<thead>
<tr>
<th>ExamYear</th>
<th>Participated</th>
<th>Passed</th>
<th>Employed</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>74.000000</td>
</tr>
<tr>
<td>2008</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>68.500000</td>
</tr>
<tr>
<td>2009</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>60.666667</td>
</tr>
</tbody>
</table>

Plot pandas DataFrame with year over year data

To create year and month crosstabulation:

In [133]: df = pd.DataFrame({'value': np.random.randn(36)},  
......:             index=pd.date_range('2011-01-01', freq='M', periods=36))

In [134]: pd.pivot_table(df, index=df.index.month, columns=df.index.year,  
......:             values='value', aggfunc='sum')

Out[134]:

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.560859</td>
<td>0.120930</td>
<td>0.516870</td>
</tr>
<tr>
<td>2</td>
<td>-0.589005</td>
<td>-0.210518</td>
<td>0.343125</td>
</tr>
<tr>
<td>3</td>
<td>-1.070678</td>
<td>-0.931184</td>
<td>2.137827</td>
</tr>
<tr>
<td>4</td>
<td>-1.681101</td>
<td>0.240647</td>
<td>0.452429</td>
</tr>
<tr>
<td>5</td>
<td>0.403776</td>
<td>-0.027462</td>
<td>0.483103</td>
</tr>
<tr>
<td>6</td>
<td>0.609862</td>
<td>0.033113</td>
<td>0.061495</td>
</tr>
<tr>
<td>7</td>
<td>0.387936</td>
<td>-0.658418</td>
<td>0.240767</td>
</tr>
<tr>
<td>8</td>
<td>1.815066</td>
<td>0.324102</td>
<td>0.782413</td>
</tr>
<tr>
<td>9</td>
<td>0.705200</td>
<td>-1.403048</td>
<td>0.628462</td>
</tr>
<tr>
<td>10</td>
<td>-0.668049</td>
<td>-0.581967</td>
<td>-0.880627</td>
</tr>
<tr>
<td>11</td>
<td>0.242501</td>
<td>-1.233862</td>
<td>0.777575</td>
</tr>
<tr>
<td>12</td>
<td>0.313421</td>
<td>-3.520876</td>
<td>-0.779367</td>
</tr>
</tbody>
</table>
7.5.4 Apply

Rolling Apply to Organize - Turning embedded lists into a multi-index frame

```
In [135]: df = pd.DataFrame(data={'A' : [[2,4,8,16],[100,200],[10,20,30]], 'B' : [['a','b','c'],['jj','kk'],['ccc']]),index=['I','II','III'])

In [136]: def SeriesFromSubList(aList):
    ...: return pd.Series(aList)
    ...:

In [137]: df_orgz = pd.concat(dict((ind,row.apply(SeriesFromSubList)) for ind,row in df.iterrows()))
```

Rolling Apply with a DataFrame returning a Series

Rolling Apply to multiple columns where function calculates a Series before a Scalar from the Series is returned

```
In [138]: df = pd.DataFrame(data=np.random.randn(2000,2)/10000,
                      index=pd.date_range('2001-01-01',periods=2000),
                      columns=['A','B']); df

Out[138]:
          A          B
2001-01-01 0.000032 -0.000004
2001-01-02 -0.000001  0.000207
2001-01-03  0.000120 -0.000220
2001-01-04 -0.000083 -0.000165
2001-01-05 -0.000047  0.000156
2001-01-06  0.000027  0.000104
2001-01-07 -0.000041 -0.000101
          ...           ...
2006-06-17 -0.000034  0.000034
2006-06-18  0.000002  0.000166
2006-06-19  0.000023 -0.000081
2006-06-20 -0.000061  0.000012
2006-06-21 -0.000111  0.000027
2006-06-22 -0.000061 -0.000009
2006-06-23  0.000074 -0.000138
[2000 rows x 2 columns]

In [139]: def gm(aDF,Const):
    ...:     v = (((aDF.A+aDF.B)+1).cumprod())-1)*Const
    ...:     return (aDF.index[0],v.iloc[-1])
    ...:

In [140]: S = pd.Series(dict((gm(df.iloc[i:min(i+51,len(df)-1)],5) for i inange(len(df)-50))))
    ...:
Out[140]:
2001-01-01 -0.001373
2001-01-02 -0.001705
2001-01-03 -0.002885
2001-01-04 -0.002384
2001-01-05 -0.002885
2001-01-06 -0.004700
2001-01-07 -0.005550
...
Rolling apply with a DataFrame returning a Scalar

Rolling Apply to multiple columns where function returns a Scalar (Volume Weighted Average Price)

```python
In [141]: rng = pd.date_range(start = '2014-01-01', periods = 100)
In [142]: df = pd.DataFrame({'Open' : np.random.randn(len(rng)),
                      'Close' : np.random.randn(len(rng)),
                      'Volume' : np.random.randint(100,2000,len(rng))},
                   index=rng); df
```

```plaintext
Out[142]:
Open   Close  Volume
2014-01-01  0.011174 -0.653039  1581
2014-01-02  0.214258  1.314205  1707
2014-01-03 -1.046922  -0.341915  1768
2014-01-04 -0.752902  -1.303586   836
2014-01-05 -0.410793   0.396288   694
2014-01-06  0.648401  -0.548006   796
2014-01-07  0.737320   0.481380   265
...     ...        ...   ...
2014-04-04  0.120378  -2.548128   564
2014-04-05  0.231661   0.223346  1908
2014-04-06  0.952664   1.228841  1090
2014-04-07 -0.176090   0.552784  1813
2014-04-08  1.781318  -0.795389  1103
2014-04-09 -0.753493  -0.018815  1456
2014-04-10 -1.047997   1.138197  1193
[100 rows x 3 columns]
```

```python
In [143]: def vwap(bars):

In [144]: window = 5

In [145]: s = pd.concat([pd.Series(vwap(df.iloc[i:i+window]), index=df.index[i+window])
                   for i in range(len(df)-window)]);

In [146]: s.round(2)
```

Out[146]:
```plaintext
2014-01-06  -0.03
2014-01-07   0.07
2014-01-08  -0.40
2014-01-09  -0.81
2014-01-10   0.63
2014-01-11  -0.86
2014-01-12  -0.36
...```

(continues on next page)
2014-04-04  -1.27
2014-04-05  -1.36
2014-04-06  -0.73
2014-04-07   0.04
2014-04-08   0.21
2014-04-09   0.07
2014-04-10   0.25
Length: 95, dtype: float64

7.6 Timeseries

Between times
Using indexer between time
Constructing a datetime range that excludes weekends and includes only certain times
Vectorized Lookup
Aggregation and plotting time series
Turn a matrix with hours in columns and days in rows into a continuous row sequence in the form of a time series.
How to rearrange a Python pandas DataFrame?
Dealing with duplicates when reindexing a timeseries to a specified frequency
Calculate the first day of the month for each entry in a DatetimeIndex

```
In [147]: dates = pd.date_range('2000-01-01', periods=5)

In [148]: dates.to_period(freq='M').to_timestamp()
Out[148]:
       '2000-01-01'], dtype='datetime64[ns]', freq=None)
```

7.6.1 Resampling

The Resample docs.
Using Grouper instead of TimeGrouper for time grouping of values
Time grouping with some missing values
Valid frequency arguments to Grouper
Grouping using a MultiIndex
Using TimeGrouper and another grouping to create subgroups, then apply a custom function
Resampling with custom periods
Resample intraday frame without adding new days
Resample minute data
Resample with groupby
### 7.7 Merge

The *Concat* docs. The *Join* docs.

Append two dataframes with overlapping index (emulate R `rbind`)

```
In [149]: rng = pd.date_range('2000-01-01', periods=6)
In [150]: df1 = pd.DataFrame(np.random.randn(6, 3), index=rng, columns=['A', 'B', 'C'])
In [151]: df2 = df1.copy()
```

Depending on df construction, *ignore_index* may be needed

```
In [152]: df = df1.append(df2, ignore_index=True); df
```

**Self Join of a DataFrame**

```
In [153]: df = pd.DataFrame(data={'Area': ['A'] * 5 + ['C'] * 2, ...: 'Bins': [110] * 2 + [160] * 3 + [40] * 2, ...: 'Test_0': [0, 1, 0, 1, 2, 0, 1], ...: 'Data': np.random.randn(7)}); df
```

```
In [154]: df['Test_1'] = df['Test_0'] - 1
In [155]: pd.merge(df, df, left_on=['Bins', 'Area', 'Test_0'], right_on=['Bins', 'Area', 'Test_1'], suffixes=('_L', '_R'))
```

How to set the index and join
KDB like asof join
Join with a criteria based on the values
Using searchsorted to merge based on values inside a range

7.8 Plotting

The Plotting docs.
Make Matplotlib look like R
Setting x-axis major and minor labels
Plotting multiple charts in an ipython notebook
Creating a multi-line plot
Plotting a heatmap
Annotate a time-series plot
Annotate a time-series plot #2
Generate Embedded plots in excel files using Pandas, Vincent and xlsxwriter
Boxplot for each quartile of a stratifying variable

```
In [156]: df = pd.DataFrame(
    ......:    {u'stratifying_var': np.random.uniform(0, 100, 20),
    ......:        u'price': np.random.normal(100, 5, 20)})
    ......:

In [157]: df[u'quartiles'] = pd.qcut(
    ......:    df[u'stratifying_var'],
    ......:        4,
    ......:        labels=[u'0-25%', u'25-50%', u'50-75%', u'75-100%'])
    ......:

In [158]: df.boxplot(column=u'price', by=u'quartiles')
Out[158]: <matplotlib.axes._subplots.AxesSubplot at 0x11f845470>
```
7.9 Data In/Out

Performance comparison of SQL vs HDF5

7.9.1 CSV

The CSV docs
read_csv in action
appending to a csv
Reading a csv chunk-by-chunk
Reading only certain rows of a csv chunk-by-chunk
Reading the first few lines of a frame
Reading a file that is compressed but not by gzip/bz2 (the native compressed formats which read_csv understands). This example shows a WinZipped file, but is a general application of opening the file within a context manager and using that handle to read. See here
Inferring dtypes from a file
Dealing with bad lines
Dealing with bad lines II

Reading CSV with Unix timestamps and converting to local timezone

Write a multi-row index CSV without writing duplicates

### 7.9.1.1 Reading multiple files to create a single DataFrame

The best way to combine multiple files into a single DataFrame is to read the individual frames one by one, put all of the individual frames into a list, and then combine the frames in the list using `pd.concat()`:

```python
for i in range(3):
    data = pd.DataFrame(np.random.randn(10, 4))
    data.to_csv('file{}.csv'.format(i))
```

```python
files = ['file_0.csv', 'file_1.csv', 'file_2.csv']
result = pd.concat([pd.read_csv(f) for f in files], ignore_index=True)
```

You can use the same approach to read all files matching a pattern. Here is an example using `glob`:

```python
import glob
files = glob.glob('file*.csv')
result = pd.concat([pd.read_csv(f) for f in files], ignore_index=True)
```

Finally, this strategy will work with the other `pd.read_*()` functions described in the `io docs`.

### 7.9.1.2 Parsing date components in multi-columns

Parsing date components in multi-columns is faster with a format

```python
i = pd.date_range('20000101', periods=10000)
df = pd.DataFrame(dict(year = i.year, month = i.month, day = i.day))
```

```python
%timeit pd.to_datetime(df.year*10000+df.month*100+df.day, format='%Y%m%d')
```

# simulate combining into a string, then parsing
```python
d = df.apply(lambda x: "%04d%02d%02d" % (x['year'],x['month'],x['day']), axis=1)
```

```python
d.head()
```

(continues on next page)
7.9.1.3 Skip row between header and data

In [165]: data = """";;;;
       .....;;;;;
       .....;;;;;
       .....;;;;;
       .....;;;;;
       .....;;;;;
       .....;;;;;
       .....;;;;;
       .....;;;;;
       .....;;;;;
       date;Param1;Param2;Param4;Param5
       .....;m2;°C;m2;m
       .....;;;;;
       01.01.1990 00:00;1;1;2;3
       01.01.1990 01:00;5;3;4;5
       01.01.1990 02:00;9;5;6;7
       01.01.1990 03:00;13;7;8;9
       01.01.1990 04:00;17;9;10;11
       01.01.1990 05:00;21;11;12;13
       """

In [166]: data = pd.read_csv(StringIO(data), sep=';', skiprows=[11,12],
                       index_col=0, parse_dates=True, header=10)

Out[166]:

<table>
<thead>
<tr>
<th>date</th>
<th>Param1</th>
<th>Param2</th>
<th>Param4</th>
<th>Param5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-01-01 00:00:00</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1990-01-01 01:00:00</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>1990-01-01 02:00:00</td>
<td>9</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>1990-01-01 03:00:00</td>
<td>13</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>1990-01-01 04:00:00</td>
<td>17</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>1990-01-01 05:00:00</td>
<td>21</td>
<td>11</td>
<td>12</td>
<td>13</td>
</tr>
</tbody>
</table>

Option 1: pass rows explicitly to skiprows

In [166]: pd.read_csv(StringIO(data), sep=';', skiprows=[11,12],
                       index_col=0, parse_dates=True, header=10)

Out[166]:

<table>
<thead>
<tr>
<th>date</th>
<th>Param1</th>
<th>Param2</th>
<th>Param4</th>
<th>Param5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-01-01 00:00:00</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1990-01-01 01:00:00</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>1990-01-01 02:00:00</td>
<td>9</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>1990-01-01 03:00:00</td>
<td>13</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>1990-01-01 04:00:00</td>
<td>17</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>1990-01-01 05:00:00</td>
<td>21</td>
<td>11</td>
<td>12</td>
<td>13</td>
</tr>
</tbody>
</table>

552 Chapter 7. Cookbook
Option 2: read column names and then data

```python
In [167]: pd.read_csv(StringIO(data), sep=';', header=10, nrows=10).columns
Out[167]: Index(['date', 'Param1', 'Param2', 'Param4', 'Param5'], dtype='object')

In [168]: columns = pd.read_csv(StringIO(data), sep=';', header=10, nrows=10).columns

In [169]: pd.read_csv(StringIO(data), sep=';', index_col=0,
......:     header=12, parse_dates=True, names=columns)
......:
Out[169]:
   date        Param1  Param2  Param4  Param5
1990-01-01  00:00:00     1      1      2      3
1990-01-01  01:00:00     5      3      4      5
1990-01-01  02:00:00     9      5      6      7
1990-01-01  03:00:00    13      7      8      9
1990-01-01  04:00:00    17      9     10     11
1990-01-01  05:00:00    21     11     12     13
```

7.9.2 SQL

The *SQL* docs
Reading from databases with SQL

7.9.3 Excel

The *Excel* docs
Reading from a filelike handle
Modifying formatting in XlsxWriter output

7.9.4 HTML

Reading HTML tables from a server that cannot handle the default request header

7.9.5 HDFStore

The *HDFStores* docs
Simple Queries with a Timestamp Index
Managing heterogeneous data using a linked multiple table hierarchy
Merging on-disk tables with millions of rows
Avoiding inconsistencies when writing to a store from multiple processes/threads
De-duplicating a large store by chunks, essentially a recursive reduction operation. Shows a function for taking in data from csv file and creating a store by chunks, with date parsing as well. See here
Creating a store chunk-by-chunk from a csv file
Appending to a store, while creating a unique index
Large Data work flows
Reading in a sequence of files, then providing a global unique index to a store while appending
Groupby on a HDFStore with low group density
Groupby on a HDFStore with high group density
Hierarchical queries on a HDFStore
Counting with a HDFStore
Troubleshoot HDFStore exceptions
Setting min_itemsize with strings
Using ptrepack to create a completely-sorted-index on a store
Storing Attributes to a group node

```
In [170]: df = pd.DataFrame(np.random.randn(8,3))
In [171]: store = pd.HDFStore('test.h5')
In [172]: store.put('df',df)

# you can store an arbitrary Python object via pickle
In [173]: store.get_storer('df').attrs.my_attribute = dict(A = 10)
In [174]: store.get_storer('df').attrs.my_attribute
Out[174]: {'A': 10}
```

### 7.9.6 Binary Files

Pandas readily accepts NumPy record arrays, if you need to read in a binary file consisting of an array of C structs. For example, given this C program in a file called `main.c` compiled with `gcc main.c -std=gnu99` on a 64-bit machine,

```
#include <stdio.h>
#include <stdint.h>

typedef struct _Data
{
    int32_t count;
    double avg;
    float scale;
} Data;

int main(int argc, const char *argv[])
{
    size_t n = 10;
    Data d[n];

    for (int i = 0; i < n; ++i)
    {
        d[i].count = i;
        d[i].avg = i + 1.0;
        d[i].scale = (float) i + 2.0f;
    }
```

(continues on next page)
the following Python code will read the binary file ’binary.dat’ into a pandas DataFrame, where each element of the struct corresponds to a column in the frame:

```python
def read_binary(data, names, offsets, formats):
    # Thesample code below is a simple, illustrative approach. In
    # practice it may be necessary to adapt the code based on
    # the specific details of the binary format.
    #
    # Import necessary libraries
    import numpy as np
    import pandas as pd

    # Define the data type
    dt = np.dtype({'names': names, 'offsets': offsets, 'formats': formats},
                   align=True)
    df = pd.DataFrame(np.fromfile(data, dt))
    return df

# Example

FILE *file = fopen("binary.dat", "wb");
fwrite(&d, sizeof(Data), n, file);
fclose(file);

    return 0;
}
```

Note: The offsets of the structure elements may be different depending on the architecture of the machine on which the file was created. Using a raw binary file format like this for general data storage is not recommended, as it is not cross platform. We recommended either HDF5 or msgpack, both of which are supported by pandas’ IO facilities.

### 7.10 Computation

Numerical integration (sample-based) of a time series

### 7.11 Timedeltas

The Timedeltas docs.

Using timedeltas

```python
In [175]: s = pd.Series(pd.date_range('2012-1-1', periods=3, freq='D'))
```

```python
In [176]: s - s.max()
```

```
Out[176]:
0    -2 days
1    -1 days
2     0 days
dtype: timedelta64[ns]
```

```python
In [177]: s.max() - s
```

```
Out[177]:
0     2 days
1     1 days
2     0 days
dtype: timedelta64[ns]
```
In [178]: s = datetime.datetime(2011,1,1,3,5)

   → 0 364 days 20:55:00
   1 365 days 20:55:00
   2 366 days 20:55:00
   dtype: timedelta64[ns]

In [179]: s + datetime.timedelta(minutes=5)

   → 0 2012-01-01 00:05:00
   1 2012-01-02 00:05:00
   2 2012-01-03 00:05:00
   dtype: datetime64[ns]

In [180]: datetime.datetime(2011,1,1,3,5) - s

   → 0 -365 days +03:05:00
   1 -366 days +03:05:00
   2 -367 days +03:05:00
   dtype: timedelta64[ns]

In [181]: datetime.timedelta(minutes=5) + s

   → 0 2012-01-01 00:05:00
   1 2012-01-02 00:05:00
   2 2012-01-03 00:05:00
   dtype: datetime64[ns]

Adding and subtracting deltas and dates

In [182]: deltas = pd.Series([datetime.timedelta(days=i) for i in range(3)])

In [183]: df = pd.DataFrame(dict(A=s, B=deltas)); df

Out[183]:
             A          B
   0 2012-01-01  0 days
   1 2012-01-02  1 days
   2 2012-01-03  2 days

In [184]: df['New Dates'] = df['A'] + df['B']

In [185]: df['Delta'] = df['A'] - df['New Dates']; df

Out[185]:
             A          B  New Dates  Delta
   0 2012-01-01  0 days  2012-01-01  0 days
   1 2012-01-02  1 days  2012-01-03 -1 days
   2 2012-01-03  2 days  2012-01-05 -2 days

In [186]: df.dtypes

   → A   datetime64[ns]
Another example

Values can be set to NaT using np.nan, similar to datetime

```
In [187]: y = s - s.shift(); y
Out[187]:
0    NaT
1    1 days
2    1 days
dtype: timedelta64[ns]

In [188]: y[1] = np.nan; y
Out[188]:
0    NaT
1    NaT
2    1 days
dtype: timedelta64[ns]
```

7.12 Aliasing Axis Names

To globally provide aliases for axis names, one can define these 2 functions:

```
In [189]: def set_axis_alias(cls, axis, alias):
    ....:     if axis not in cls._AXIS_NUMBERS:
    ....:         raise Exception("invalid axis \[\$s\] for alias \[\$s\]" % (axis, alias))
    ....:     cls._AXIS_ALIASES[alias] = axis
    ....:

In [190]: def clear_axis_alias(cls, axis, alias):
    ....:     if axis not in cls._AXIS_NUMBERS:
    ....:         raise Exception("invalid axis \[\$s\] for alias \[\$s\]" % (axis, alias))
    ....:     cls._AXIS_ALIASES.pop(alias, None)
    ....:

In [191]: set_axis_alias(pd.DataFrame,'columns', 'myaxis2')

In [192]: df2 = pd.DataFrame(np.random.randn(3,2),columns=['c1','c2'],index=['i1','i2','i3'])

In [193]: df2.sum(axis='myaxis2')
Out[193]:
   i1    0.745167
   i2   -0.176251
   i3    0.014354
dtype: float64

In [194]: clear_axis_alias(pd.DataFrame,'columns', 'myaxis2')
```
To create a dataframe from every combination of some given values, like R's `expand.grid()` function, we can create a dict where the keys are column names and the values are lists of the data values:

```python
In [195]: def expand_grid(data_dict):
    ...:     rows = itertools.product(*data_dict.values())
    ...:     return pd.DataFrame.from_records(rows, columns=data_dict.keys())

In [196]: df = expand_grid(
    ...:     {'height': [60, 70],
    ...:     'weight': [100, 140, 180],
    ...:     'sex': ['Male', 'Female']})

In [197]: df
Out[197]:
       height  weight sex
0       60      100  Male
1       60      100  Female
2       60      140   Male
3       60      140  Female
4       60      180   Male
5       60      180  Female
6       70      100   Male
7       70      100  Female
8       70      140   Male
9       70      140  Female
10      70      180   Male
11      70      180  Female
We’ll start with a quick, non-comprehensive overview of the fundamental data structures in pandas to get you started. The fundamental behavior about data types, indexing, and axis labeling / alignment apply across all of the objects. To get started, import NumPy and load pandas into your namespace:

```python
In [1]: import numpy as np
In [2]: import pandas as pd
```

Here is a basic tenet to keep in mind: **data alignment is intrinsic.** The link between labels and data will not be broken unless done so explicitly by you.

We’ll give a brief intro to the data structures, then consider all of the broad categories of functionality and methods in separate sections.

### 8.1 Series

*Series* is a one-dimensional labeled array capable of holding any data type (integers, strings, floating point numbers, Python objects, etc.). The axis labels are collectively referred to as the **index**. The basic method to create a Series is to call:

```python
>>> s = pd.Series(data, index=index)
```

Here, *data* can be many different things:

- a Python dict
- an ndarray
- a scalar value (like 5)

The passed **index** is a list of axis labels. Thus, this separates into a few cases depending on what **data** is:

**From ndarray**

If *data* is an ndarray, **index** must be the same length as *data*. If no index is passed, one will be created having values `[0, ..., len(data) - 1]`.

```python
In [3]: s = pd.Series(np.random.randn(5), index=['a', 'b', 'c', 'd', 'e'])
In [4]: s
Out[4]:
a    0.4691
b   -0.2829
```

(continues on next page)
c  -1.5091
d  -1.1356
e   1.2121
dtype: float64

In [5]: s.index
Out[5]: Index(['a', 'b', 'c', 'd', 'e'], dtype='object')

In [6]: pd.Series(np.random.randn(5))
Out[6]:
0  -0.1732
1   0.1192
2  -1.0442
3  -0.8618
4  -2.1046
dtype: float64

Note: pandas supports non-unique index values. If an operation that does not support duplicate index values is attempted, an exception will be raised at that time. The reason for being lazy is nearly all performance-based (there are many instances in computations, like parts of GroupBy, where the index is not used).

From dict

Series can be instantiated from dicts:

In [7]: d = {'b' : 1, 'a' : 0, 'c' : 2}

In [8]: pd.Series(d)
Out[8]:
b  1
a  0
c  2
dtype: int64

Note: When the data is a dict, and an index is not passed, the Series index will be ordered by the dict’s insertion order, if you’re using Python version >= 3.6 and Pandas version >= 0.23.

If you’re using Python < 3.6 or Pandas < 0.23, and an index is not passed, the Series index will be the lexically ordered list of dict keys.

In the example above, if you were on a Python version lower than 3.6 or a Pandas version lower than 0.23, the Series would be ordered by the lexical order of the dict keys (i.e. ['a', 'b', 'c'] rather than ['b', 'a', 'c']).

If an index is passed, the values in data corresponding to the labels in the index will be pulled out.

In [9]: d = {'a' : 0., 'b' : 1., 'c' : 2.}

In [10]: pd.Series(d)
Out[10]:
a  0.0
b  1.0
c  2.0
### 8.1. Series is ndarray-like

Series acts very similarly to ndarray, and is a valid argument to most NumPy functions. However, operations such as slicing will also slice the index.

```python
In [13]: s[0]
Out[13]: 0.46911229990718628

In [14]: s[:3]
Out[14]: a 0.4691
c -0.2829
d -1.5091
dtype: float64

In [15]: s[s > s.median()]
Out[15]: a 0.4691
e 1.2121
dtype: float64

In [16]: s[[4, 3, 1]]
Out[16]: e 1.2121
d -1.1356
b -0.2829
```

**Note:** NaN (not a number) is the standard missing data marker used in pandas.

From scalar value

If `data` is a scalar value, an index must be provided. The value will be repeated to match the length of `index`.

```python
In [12]: pd.Series(5., index=['a', 'b', 'c', 'd', 'e'])
Out[12]:
    a  5.0
    b  5.0
    c  5.0
    d  5.0
    e  5.0
dtype: float64
```

```python
In [11]: pd.Series(d, index=['b', 'c', 'd', 'a'])
Out[11]:
    b  1.0
    c  2.0
    d  NaN
    a  0.0
dtype: float64
```
We will address array-based indexing in a separate section

8.1.2 Series is dict-like

A Series is like a fixed-size dict in that you can get and set values by index label:

```
In [18]: s['a']
Out[18]: 0.46911229990718628
```

```
In [19]: s['e'] = 12.
```

```
In [20]: s
Out[20]:
a 0.4691
b -0.2829
c -1.5091
d -1.1356
e 12.0000
dtype: float64
```

```
In [21]: 'e' in s
Out[21]: True
```

```
In [22]: 'f' in s
Out[22]: False
```

If a label is not contained, an exception is raised:

```
>>> s['f']
KeyError: 'f'
```

Using the `get` method, a missing label will return `None` or specified default:

```
In [23]: s.get('f')
```

```
In [24]: s.get('f', np.nan)
Out[24]: nan
```

See also the section on attribute access.
8.1.3 Vectorized operations and label alignment with Series

When working with raw NumPy arrays, looping through value-by-value is usually not necessary. The same is true when working with Series in pandas. Series can also be passed into most NumPy methods expecting an ndarray.

```
In [25]: s + s
Out[25]:
  a    0.9382
  b   -0.5657
  c   -3.0181
  d   -2.2713
  e    24.0000
       dtype: float64

In [26]: s * 2
Out[26]:
  a    0.9382
  b   -0.5657
  c   -3.0181
  d   -2.2713
  e    24.0000
       dtype: float64

In [27]: np.exp(s)
Out[27]:
  a    1.5986
  b    0.7536
  c    0.2211
  d    0.3212
  e  162754.7914
       dtype: float64
```

A key difference between Series and ndarray is that operations between Series automatically align the data based on label. Thus, you can write computations without giving consideration to whether the Series involved have the same labels.

```
In [28]: s[1:] + s[:-1]
Out[28]:
  a     NaN
  b   -0.5657
  c   -3.0181
  d   -2.2713
  e     NaN
       dtype: float64
```

The result of an operation between unaligned Series will have the union of the indexes involved. If a label is not found in one Series or the other, the result will be marked as missing NaN. Being able to write code without doing any explicit data alignment grants immense freedom and flexibility in interactive data analysis and research. The integrated data alignment features of the pandas data structures set pandas apart from the majority of related tools for working with labeled data.

Note: In general, we chose to make the default result of operations between differently indexed objects yield the union of the indexes in order to avoid loss of information. Having an index label, though the data is missing, is typically important information as part of a computation. You of course have the option of dropping labels with
missing data via the **dropna** function.

### 8.1.4 Name attribute

Series can also have a *name* attribute:

```python
In [29]: s = pd.Series(np.random.randn(5), name='something')
In [30]: s
Out[30]:
            0   -0.4949
           1    1.0718
           2    0.7216
           3   -0.7068
           4   -1.0396
Name: something, dtype: float64
In [31]: s.name
Out[31]: 'something'
```

The Series *name* will be assigned automatically in many cases, in particular when taking 1D slices of DataFrame as you will see below.

New in version 0.18.0.

You can rename a Series with the **pandas.Series.rename()** method.

```python
In [32]: s2 = s.rename("different")
In [33]: s2.name
Out[33]: 'different'
```

Note that *s* and *s2* refer to different objects.

### 8.2 DataFrame

**DataFrame** is a 2-dimensional labeled data structure with columns of potentially different types. You can think of it like a spreadsheet or SQL table, or a dict of Series objects. It is generally the most commonly used pandas object.

Like Series, DataFrame accepts many different kinds of input:

- Dict of 1D ndarrays, lists, dicts, or Series
- 2-D numpy.ndarray
- Structured or record ndarray
- A Series
- Another DataFrame

Along with the data, you can optionally pass **index** (row labels) and **columns** (column labels) arguments. If you pass an index and / or columns, you are guaranteeing the index and / or columns of the resulting DataFrame. Thus, a dict of Series plus a specific index will discard all data not matching up to the passed index.

If axis labels are not passed, they will be constructed from the input data based on common sense rules.
Note: When the data is a dict, and columns is not specified, the DataFrame columns will be ordered by the dict's insertion order, if you are using Python version >= 3.6 and Pandas >= 0.23.

If you are using Python < 3.6 or Pandas < 0.23, and columns is not specified, the DataFrame columns will be the lexically ordered list of dict keys.

### 8.2.1 From dict of Series or dicts

The resulting index will be the union of the indexes of the various Series. If there are any nested dicts, these will first be converted to Series. If no columns are passed, the columns will be the ordered list of dict keys.

```
In [34]: d = {'one': pd.Series([1., 2., 3.], index=['a', 'b', 'c']),
       'two': pd.Series([1., 2., 3., 4.], index=['a', 'b', 'c', 'd'])}

In [35]: df = pd.DataFrame(d)

In [36]: df
Out[36]:
   one  two
  a 1.0  1.0  
b 2.0  2.0  
c 3.0  3.0  
d  NaN  4.0

In [37]: pd.DataFrame(d, index=['d', 'b', 'a'])
Out[37]:
   one  two
  d  NaN  4.0
  b  2.0  NaN
  a  1.0  NaN

In [38]: pd.DataFrame(d, index=['d', 'b', 'a'], columns=['two', 'three'])
   two  three
  d   NaN     4.0
  b  2.0     NaN
  a  1.0     NaN
```

The row and column labels can be accessed respectively by accessing the index and columns attributes:

Note: When a particular set of columns is passed along with a dict of data, the passed columns override the keys in the dict.

```
In [39]: df.index
Out[39]: Index(['a', 'b', 'c', 'd'], dtype='object')

In [40]: df.columns
Out[40]: Index(['one', 'two'], dtype='object')
```
8.2.2 From dict of ndarrays / lists

The ndarrays must all be the same length. If an index is passed, it must clearly also be the same length as the arrays. If no index is passed, the result will be range(n), where n is the array length.

```
In [41]: d = {'one': [1., 2., 3., 4.],
       ...:       'two': [4., 3., 2., 1.],
       ...: }

In [42]: pd.DataFrame(d)
Out[42]:
       one  two
0   1.0  4.0
1   2.0  3.0
2   3.0  2.0
3   4.0  1.0

In [43]: pd.DataFrame(d, index=['a', 'b', 'c', 'd'])
Out[43]:
       one  two
a   1.0  4.0
b   2.0  3.0
c   3.0  2.0
d   4.0  1.0

In [44]: data = np.zeros((2,), dtype=[('A', 'i4'), ('B', 'f4'), ('C', 'a10')])

In [45]: data[:] = [(1, 2., 'Hello'), (2, 3., 'World')]

In [46]: pd.DataFrame(data)
Out[46]:
      A    B        C
0  1.00  2.00  b'Hello'
1  2.00  3.00  b'World'

In [47]: pd.DataFrame(data, index=['first', 'second'])
Out[47]:
         A    B        C
first   1.00  2.00  b'Hello'
second  2.00  3.00  b'World'

In [48]: pd.DataFrame(data, columns=['C', 'A', 'B'])
      C    A    B
0  b'Hello'  1.00  2.00
1  b'World'  2.00  3.00
```

8.2.3 From structured or record array

This case is handled identically to a dict of arrays.

```
in [44]: data = np.zeros((2,), dtype=[('A', 'i4'), ('B', 'f4'), ('C', 'a10')])

in [45]: data[:] = [(1, 2., 'Hello'), (2, 3., 'World')]

in [46]: pd.DataFrame(data)
out[46]:
       A    B        C
0  1.00  2.00  b'Hello'
1  2.00  3.00  b'World'

in [47]: pd.DataFrame(data, index=['first', 'second'])
out[47]:
         A    B        C
first   1.00  2.00  b'Hello'
second  2.00  3.00  b'World'

in [48]: pd.DataFrame(data, columns=['C', 'A', 'B'])
→
      C    A    B
0  b'Hello'  1.00  2.00
1  b'World'  2.00  3.00
```

Note: DataFrame is not intended to work exactly like a 2-dimensional NumPy ndarray.
8.2.4 From a list of dicts

```python
In [49]: data2 = [('a': 1, 'b': 2), ('a': 5, 'b': 10, 'c': 20)]

In [50]: pd.DataFrame(data2)
Out[50]:
       a  b   c
0     1  2  NaN
1     5 10 20.0

In [51]: pd.DataFrame(data2, index=['first', 'second'])
Out[51]:
       a  b   c
first 1  2  NaN
second 5 10 20.0

In [52]: pd.DataFrame(data2, columns=['a', 'b'])
```

8.2.5 From a dict of tuples

You can automatically create a multi-indexed frame by passing a tuples dictionary.

```python
In [53]: pd.DataFrame({('a', 'b'): {('A', 'B'): 1, ('A', 'C'): 2},
                   ('a', 'a'): {('A', 'C'): 3, ('A', 'B'): 4},
                   ('b', 'a'): {('A', 'C'): 5, ('A', 'B'): 6},
                   ('b', 'b'): {('A', 'D'): 9, ('A', 'B'): 10}})
Out[53]:
        a   b
    b A  B  1.0 4.0 5.0 8.0 10.0
    C  2.0 3.0 6.0 7.0 NaN
    D NaN NaN NaN NaN  9.0
```

8.2.6 From a Series

The result will be a DataFrame with the same index as the input Series, and with one column whose name is the original name of the Series (only if no other column name provided).

Missing Data

Much more will be said on this topic in the Missing data section. To construct a DataFrame with missing data, we use np.nan to represent missing values. Alternatively, you may pass a numpy.MaskedArray as the data argument to the DataFrame constructor, and its masked entries will be considered missing.

8.2.7 Alternate Constructors

DataFrame.from_dict
DataFrame.from_dict takes a dict of dicts or a dict of array-like sequences and returns a DataFrame. It operates like the DataFrame constructor except for the orient parameter which is 'columns' by default, but which can be set to 'index' in order to use the dict keys as row labels.

In [54]: pd.DataFrame.from_dict(dict([('A', [1, 2, 3]), ('B', [4, 5, 6])]))
Out[54]:
    A  B
0  1  4
1  2  5
2  3  6

If you pass orient='index', the keys will be the row labels. In this case, you can also pass the desired column names:

In [55]: pd.DataFrame.from_dict(dict([('A', [1, 2, 3]), ('B', [4, 5, 6])]),  
                           orient='index', columns=['one', 'two', 'three'])
Out[55]:
     one  two  three
   A   1   2   3
   B   4   5   6

DataFrame.from_records takes a list of tuples or an ndarray with structured dtype. It works analogously to the normal DataFrame constructor, except that the resulting DataFrame index may be a specific field of the structured dtype. For example:

In [56]: data
Out[56]:
    array([(1, 2., b'Hello'), (2, 3., b'World')],  
           dtype=[('A', '<i4'), ('B', '<f4'), ('C', 'S10')])

In [57]: pd.DataFrame.from_records(data, index='C')
   A   B
C  b'Hello' 1  2.0
    b'World' 2  3.0

8.2.8 Column selection, addition, deletion

You can treat a DataFrame semantically like a dict of like-indexed Series objects. Getting, setting, and deleting columns works with the same syntax as the analogous dict operations:

In [58]: df['one']
Out[58]:
   a  1.0
   b  2.0
   c  3.0
d  NaN
Name: one, dtype: float64

In [59]: df['three'] = df['one'] * df['two']
In [60]: df['flag'] = df['one'] > 2

In [61]: df
Out[61]:
   one  two  three  flag
  a    1.0  1.0  1.0  False
  b    2.0  2.0  4.0  False
  c    3.0  3.0  9.0   True
  d  NaN  4.0  NaN  False

Columns can be deleted or popped like with a dict:

In [62]: del df['two']

In [63]: three = df.pop('three')

In [64]: df
Out[64]:
   one  flag
  a  1.0  False
  b  2.0  False
  c  3.0   True
  d  NaN  False

When inserting a scalar value, it will naturally be propagated to fill the column:

In [65]: df['foo'] = 'bar'

In [66]: df
Out[66]:
   one  flag  foo
  a  1.0  False   bar
  b  2.0  False  bar
  c  3.0   True  bar
  d  NaN  False  bar

When inserting a Series that does not have the same index as the DataFrame, it will be conformed to the DataFrame’s index:

In [67]: df['one_trunc'] = df['one'][:2]

In [68]: df
Out[68]:
   one  flag  foo  one_trunc
  a  1.0  False   bar  1.0
  b  2.0  False   bar  2.0
  c  3.0   True   bar  NaN
  d  NaN  False   bar  NaN

You can insert raw ndarrays but their length must match the length of the DataFrame’s index.

By default, columns get inserted at the end. The insert function is available to insert at a particular location in the columns:

In [69]: df.insert(1, 'bar', df['one'][:2])

In [70]: df
8.2.9 Assigning New Columns in Method Chains

Inspired by dplyr's `mutate` verb, DataFrame has an `assign()` method that allows you to easily create new columns that are potentially derived from existing columns.

In [71]: iris = pd.read_csv('data/iris.data')

In [72]: iris.head()

Out[72]:

<table>
<thead>
<tr>
<th>SepalLength</th>
<th>SepalWidth</th>
<th>PetalLength</th>
<th>PetalWidth</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>3.5</td>
<td>1.4</td>
<td>0.2</td>
<td>Iris-setosa</td>
</tr>
<tr>
<td>4.9</td>
<td>3.0</td>
<td>1.4</td>
<td>0.2</td>
<td>Iris-setosa</td>
</tr>
<tr>
<td>4.7</td>
<td>3.2</td>
<td>1.3</td>
<td>0.2</td>
<td>Iris-setosa</td>
</tr>
<tr>
<td>4.6</td>
<td>3.1</td>
<td>1.5</td>
<td>0.2</td>
<td>Iris-setosa</td>
</tr>
<tr>
<td>5.0</td>
<td>3.6</td>
<td>1.4</td>
<td>0.2</td>
<td>Iris-setosa</td>
</tr>
</tbody>
</table>

In [73]: (iris.assign(sepal_ratio = iris['SepalWidth'] / iris['SepalLength'])).head()

→

<table>
<thead>
<tr>
<th>SepalLength</th>
<th>SepalWidth</th>
<th>PetalLength</th>
<th>PetalWidth</th>
<th>Name</th>
<th>sepal_ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>3.5</td>
<td>1.4</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.6863</td>
</tr>
<tr>
<td>4.9</td>
<td>3.0</td>
<td>1.4</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.6122</td>
</tr>
<tr>
<td>4.7</td>
<td>3.2</td>
<td>1.3</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.6809</td>
</tr>
<tr>
<td>4.6</td>
<td>3.1</td>
<td>1.5</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.6739</td>
</tr>
<tr>
<td>5.0</td>
<td>3.6</td>
<td>1.4</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.7200</td>
</tr>
</tbody>
</table>

In the example above, we inserted a precomputed value. We can also pass in a function of one argument to be evaluated on the DataFrame being assigned to.

In [74]: iris.assign(sepal_ratio = lambda x: (x['SepalWidth'] / x['SepalLength'])).head()

→

<table>
<thead>
<tr>
<th>SepalLength</th>
<th>SepalWidth</th>
<th>PetalLength</th>
<th>PetalWidth</th>
<th>Name</th>
<th>sepal_ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>3.5</td>
<td>1.4</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.6863</td>
</tr>
<tr>
<td>4.9</td>
<td>3.0</td>
<td>1.4</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.6122</td>
</tr>
<tr>
<td>4.7</td>
<td>3.2</td>
<td>1.3</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.6809</td>
</tr>
<tr>
<td>4.6</td>
<td>3.1</td>
<td>1.5</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.6739</td>
</tr>
<tr>
<td>5.0</td>
<td>3.6</td>
<td>1.4</td>
<td>0.2</td>
<td>Iris-setosa</td>
<td>0.7200</td>
</tr>
</tbody>
</table>

`assign` always returns a copy of the data, leaving the original DataFrame untouched.

Passing a callable, as opposed to an actual value to be inserted, is useful when you don’t have a reference to the DataFrame at hand. This is common when using `assign` in a chain of operations. For example, we can limit the DataFrame to just those observations with a Sepal Length greater than 5, calculate the ratio, and plot:
Since a function is passed in, the function is computed on the DataFrame being assigned to. Importantly, this is the DataFrame that’s been filtered to those rows with sepal length greater than 5. The filtering happens first, and then the ratio calculations. This is an example where we didn’t have a reference to the filtered DataFrame available.

The function signature for `assign` is simply `**kwargs`. The keys are the column names for the new fields, and the values are either a value to be inserted (for example, a Series or NumPy array), or a function of one argument to be called on the DataFrame. A copy of the original DataFrame is returned, with the new values inserted.

Changed in version 0.23.0.

Starting with Python 3.6 the order of `**kwargs` is preserved. This allows for dependent assignment, where an expression later in `**kwargs` can refer to a column created earlier in the same `assign()`.

```
In [75]: (iris.query('SepalLength > 5')
    .....: .assign(SepalRatio = lambda x: x.SepalWidth / x.SepalLength,
    .....:     PetalRatio = lambda x: x.PetalWidth / x.PetalLength)
    .....: .plot(kind='scatter', x='SepalRatio', y='PetalRatio'))
Out[75]: <matplotlib.axes._subplots.AxesSubplot at 0x1c259fd7b8>
```

```
8.2. DataFrame
```

(continues on next page)
In the second expression, \( x['C'] \) will refer to the newly created column, that’s equal to \( dfa['A'] + dfa['B'] \).

To write code compatible with all versions of Python, split the assignment in two.

```python
In [78]: dependent = pd.DataFrame({"A": [1, 1, 1]})
In [79]: (dependent.assign(A=lambda x: x['A'] + 1)  
       .assign(B=lambda x: x['A'] + 2))
```

```
Out[79]:
    A  B  
0  2  4
1  2  4
2  2  4
```

**Warning:** Dependent assignment maybe subtly change the behavior of your code between Python 3.6 and older versions of Python.

If you wish write code that supports versions of python before and after 3.6, you’ll need to take care when passing `assign` expressions that

- Updating an existing column
- Referring to the newly updated column in the same `assign`

For example, we’ll update column “A” and then refer to it when creating “B”.

```python
>>> dependent = pd.DataFrame({"A": [1, 1, 1]})
>>> dependent.assign(A=lambda x: x["A"] + 1,  
                   B=lambda x: x["A"] + 2)
```

For Python 3.5 and earlier the expression creating B refers to the “old” value of A, [1, 1, 1]. The output is then

```
    A  B  
0  2  3
1  2  3
2  2  3
```

For Python 3.6 and later, the expression creating A refers to the “new” value of A, [2, 2, 2], which results in

```
    A  B  
0  2  4
1  2  4
2  2  4
```

### 8.2.10 Indexing / Selection

The basics of indexing are as follows:
### Operation

<table>
<thead>
<tr>
<th>Operation</th>
<th>Syntax</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select column</td>
<td><code>df[col]</code></td>
<td>Series</td>
</tr>
<tr>
<td>Select row by label</td>
<td><code>df.loc[label]</code></td>
<td>Series</td>
</tr>
<tr>
<td>Select row by integer location</td>
<td><code>df.iloc[loc]</code></td>
<td>Series</td>
</tr>
<tr>
<td>Slice rows</td>
<td><code>df[5:10]</code></td>
<td>DataFrame</td>
</tr>
<tr>
<td>Select rows by boolean vector</td>
<td><code>df[bool_vec]</code></td>
<td>DataFrame</td>
</tr>
</tbody>
</table>

Row selection, for example, returns a Series whose index is the columns of the DataFrame:

```python
In [80]: df.loc['b']
Out[80]:
one 2
bar 2
flag False
foo bar
one_trunc 2
Name: b, dtype: object
```

```python
In [81]: df.iloc[2]
Out[81]:
one 3
bar 3
flag True
foo bar
one_trunc NaN
Name: c, dtype: object
```

For a more exhaustive treatment of sophisticated label-based indexing and slicing, see the [section on indexing](#). We will address the fundamentals of reindexing / conforming to new sets of labels in the [section on reindexing](#).

#### 8.2.11 Data alignment and arithmetic

Data alignment between DataFrame objects automatically align on both the columns and the index (row labels). Again, the resulting object will have the union of the column and row labels.

```python
In [82]: df = pd.DataFrame(np.random.randn(10, 4), columns=['A', 'B', 'C', 'D'])
In [83]: df2 = pd.DataFrame(np.random.randn(7, 3), columns=['A', 'B', 'C'])
In [84]: df + df2
Out[84]:
         A    B       C    D
0   0.0457 -0.0141   1.3809 NaN
1  -0.9554 -1.5010   0.0372 NaN
2   0.6627   1.5348  -0.8597 NaN
3  -2.4529   1.2373  -0.1337 NaN
4   1.4145   1.9517  -2.3204 NaN
5  -0.4949  -1.6497  -1.0846 NaN
6   1.0476   0.7486  -0.8055 NaN
7   NaN     NaN     NaN     NaN
8   NaN     NaN     NaN     NaN
9   NaN     NaN     NaN     NaN
```

8.2. DataFrame
When doing an operation between DataFrame and Series, the default behavior is to align the Series index on the DataFrame columns, thus broadcasting row-wise. For example:

```
In [85]: df - df.iloc[0]
Out[85]:
       A    B    C    D
0  0.0000 0.0000 0.0000 0.0000
1 -1.3593 -0.2487 -0.4534 -1.7547
2  0.2531 0.8297 0.0100 -1.9912
3 -1.3111 0.0543 -1.7249 -1.6205
4  0.5730 1.5007 -0.6761 1.3673
5 -1.7412 0.7820 -1.2416 -2.0531
6 -1.2408 -0.8696 -0.1533 0.0004
7 -0.7439 0.4110 -0.9296 -0.2824
8 -1.1949 1.3207 0.2382 -1.4826
9  2.2938 1.8562 0.7733 -1.4465
```

In the special case of working with time series data, and the DataFrame index also contains dates, the broadcasting will be column-wise:

```
In [86]: index = pd.date_range('1/1/2000', periods=8)
In [87]: df = pd.DataFrame(np.random.randn(8, 3), index=index, columns=list('ABC'))
In [88]: df
Out[88]:
       A    B    C
2000-01-01 -1.2268 0.7698 -1.2812
2000-01-02 -0.7277 -0.1213 -0.0979
2000-01-03  0.6958  0.3417  0.9597
2000-01-04 -1.1103 -0.6200  0.1497
2000-01-05 -0.7323  0.6877  0.1764
2000-01-06  0.4033 -0.1550  0.3016
2000-01-07 -2.1799 -1.3698 -0.9542
2000-01-08  1.4627 -1.7432 -0.8266
```

```
In [89]: type(df['A'])
→ pandas.core.series.Series
In [90]: df - df['A']
```

(continues on next page)
Warning:

def - df['A']

is now deprecated and will be removed in a future release. The preferred way to replicate this behavior is

df.sub(df['A'], axis=0)

For explicit control over the matching and broadcasting behavior, see the section on flexible binary operations.

Operations with scalars are just as you would expect:

```
In [91]: df * 5 + 2
Out[91]:
      A   B   C
2000-01-01 -4.1341  5.8490 -4.4062
2000-01-02 -1.6385  1.3935  1.5106
2000-01-03  5.4789  3.7087  6.7986
2000-01-04 -3.5517 -1.0999  2.7487
2000-01-05 -1.6617  5.4387  2.8822
2000-01-06  4.0165  1.2252  3.5081
2000-01-07 -8.8993 -4.8492 -2.7710
2000-01-08  9.3135 -6.7158 -2.1330

In [92]: 1 / df

Out[92]:
     A   B   C
2000-01-01  0.8151  1.2990  0.7805
2000-01-02  1.3742 -8.2436 -10.2163
2000-01-03  0.4372  2.9262  1.0420
2000-01-04  0.9006 -1.6130  6.6779
2000-01-05  1.3655  1.4540  5.6675
2000-01-06  2.4795 -6.4537  3.3154
2000-01-07  0.4587  0.7300 -1.0480
2000-01-08  0.6837  0.5737  1.2098

In [93]: df ** 4

Out[93]:
     A       B       C
2000-01-01  2.2653  0.3512  2.6948e+00
2000-01-02  0.2804  0.0002  9.1796e-05
2000-01-03  0.2344  0.0136  8.4838e-01
2000-01-04  1.5199  0.1477  5.0286e-04
2000-01-05  0.2876  0.2237  9.6924e-04
2000-01-06  0.0265  0.0006  8.2769e-03
2000-01-07  22.5795  3.5212  8.2903e-01
2000-01-08  4.5774  9.2332  4.6683e-01
```
Boolean operators work as well:

```python
In [94]: df1 = pd.DataFrame({'a' : [1, 0, 1], 'b' : [0, 1, 1] }, dtype=bool)
In [95]: df2 = pd.DataFrame({'a' : [0, 1, 1], 'b' : [1, 1, 0] }, dtype=bool)
In [96]: df1 & df2
Out[96]:
    a  b
0  False  False
1  False   True
2   True  False
In [97]: df1 | df2
Out[97]:
    a  b
0  True  True
1  True  True
2  True  True
In [98]: df1 ^ df2
    a  b
0  True  True
1  True  False
2  False  True
In [99]: -df1
    a  b
0  False  True
1   True  False
2  False  False
```

### 8.2.12 Transposing

To transpose, access the `.T` attribute (also the `transpose` function), similar to an ndarray:

```python
# only show the first 5 rows
In [100]: df[:5].T
Out[100]:
A     -1.2268   -0.7277    0.6958  -1.1103   -0.7323
B      0.7698   -0.1213    0.3417  -0.6200    0.6877
C    -1.2812   -0.0979    0.9597   0.1497    0.1764
```

### 8.2.13 DataFrame interoperability with NumPy functions

Elementwise NumPy ufuncs (log, exp, sqrt, ...) and various other NumPy functions can be used with no issues on DataFrame, assuming the data within are numeric:

```python
In [101]: np.exp(df)
Out[101]: (continues on next page)
```
The dot method on DataFrame implements matrix multiplication:

```python
In [103]: df.T.dot(df)
Out[103]:
   A   B   C
A 11.3419 -0.0598 3.0080
B -0.0598 6.5206 2.0833
C  3.0080  2.0833 4.3105
```

Similarly, the dot method on Series implements dot product:

```python
In [104]: s1 = pd.Series(np.arange(5,10))
In [105]: s1.dot(s1)
Out[105]: 255
```

DataFrame is not intended to be a drop-in replacement for ndarray as its indexing semantics are quite different in places from a matrix.

### 8.2.14 Console display

Very large DataFrames will be truncated to display them in the console. You can also get a summary using `info()`. (Here I am reading a CSV version of the baseball dataset from the plyr R package):

```python
In [106]: baseball = pd.read_csv('data/baseball.csv')
In [107]: print(baseball)
```

<table>
<thead>
<tr>
<th>id</th>
<th>player</th>
<th>year</th>
<th>stint</th>
<th>...</th>
<th>hbp</th>
<th>sh</th>
<th>sf</th>
<th>gidp</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>womacto01</td>
<td>2006</td>
<td>2</td>
<td></td>
<td>0.0</td>
<td>3.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>1</td>
<td>schilcu01</td>
<td>2006</td>
<td>1</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>98</td>
<td>alumo01</td>
<td>2007</td>
<td>1</td>
<td></td>
<td>2.0</td>
<td>0.0</td>
<td>3.0</td>
<td>13.0</td>
</tr>
<tr>
<td>99</td>
<td>alomasa02</td>
<td>2007</td>
<td>1</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
pandas: powerful Python data analysis toolkit, Release 0.23.2

[100 rows x 23 columns]

In [108]: baseball.info()

---<class 'pandas.core.frame.DataFrame'>
RangeIndex: 100 entries, 0 to 99
Data columns (total 23 columns):
id    100 non-null int64
player    100 non-null object
year     100 non-null int64
stint    100 non-null int64
team     100 non-null object
lg       100 non-null object
g        100 non-null int64
ab       100 non-null int64
r        100 non-null int64
h        100 non-null int64
X2b      100 non-null int64
X3b      100 non-null int64
hr       100 non-null int64
rbi      100 non-null float64
sb       100 non-null float64
cs       100 non-null float64
bb       100 non-null int64
so       100 non-null float64
ibb      100 non-null float64
hbp      100 non-null float64
sh       100 non-null float64
sf       100 non-null float64
gidp     100 non-null float64
dtypes: float64(9), int64(11), object(3)
memory usage: 18.0+ KB

However, using to_string will return a string representation of the DataFrame in tabular form, though it won’t always fit the console width:

In [109]: print(baseball.iloc[-20:, :12].to_string())

<table>
<thead>
<tr>
<th>id</th>
<th>player</th>
<th>year</th>
<th>stint</th>
<th>team</th>
<th>lg</th>
<th>g</th>
<th>ab</th>
<th>r</th>
<th>h</th>
<th>X2b</th>
<th>X3b</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>finlest01</td>
<td>2007</td>
<td>1</td>
<td>COL</td>
<td>NL</td>
<td>43</td>
<td>94</td>
<td>9</td>
<td>17</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>81</td>
<td>embrea01</td>
<td>2007</td>
<td>1</td>
<td>OAK</td>
<td>AL</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>82</td>
<td>edmonji01</td>
<td>2007</td>
<td>1</td>
<td>SLN</td>
<td>NL</td>
<td>117</td>
<td>365</td>
<td>39</td>
<td>92</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>83</td>
<td>easleda01</td>
<td>2007</td>
<td>1</td>
<td>NYN</td>
<td>NL</td>
<td>76</td>
<td>193</td>
<td>24</td>
<td>54</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>84</td>
<td>delgaca01</td>
<td>2007</td>
<td>1</td>
<td>NYN</td>
<td>NL</td>
<td>139</td>
<td>538</td>
<td>71</td>
<td>139</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>85</td>
<td>cornirh01</td>
<td>2007</td>
<td>1</td>
<td>CIN</td>
<td>NL</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>86</td>
<td>coninje01</td>
<td>2007</td>
<td>2</td>
<td>NYN</td>
<td>NL</td>
<td>21</td>
<td>41</td>
<td>2</td>
<td>8</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>87</td>
<td>coninje01</td>
<td>2007</td>
<td>1</td>
<td>CIN</td>
<td>NL</td>
<td>80</td>
<td>215</td>
<td>23</td>
<td>57</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>88</td>
<td>clemero02</td>
<td>2007</td>
<td>1</td>
<td>NYA</td>
<td>AL</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>89</td>
<td>claytro01</td>
<td>2007</td>
<td>2</td>
<td>BOS</td>
<td>AL</td>
<td>8</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>90</td>
<td>claytro01</td>
<td>2007</td>
<td>1</td>
<td>TOR</td>
<td>AL</td>
<td>69</td>
<td>189</td>
<td>23</td>
<td>48</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>91</td>
<td>cirilje01</td>
<td>2007</td>
<td>2</td>
<td>ARI</td>
<td>NL</td>
<td>28</td>
<td>40</td>
<td>6</td>
<td>8</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>92</td>
<td>cirilje01</td>
<td>2007</td>
<td>1</td>
<td>MIN</td>
<td>AL</td>
<td>50</td>
<td>153</td>
<td>18</td>
<td>40</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>93</td>
<td>bondsba01</td>
<td>2007</td>
<td>1</td>
<td>SFW</td>
<td>NL</td>
<td>126</td>
<td>340</td>
<td>75</td>
<td>94</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>94</td>
<td>biggicr01</td>
<td>2007</td>
<td>1</td>
<td>HOU</td>
<td>NL</td>
<td>141</td>
<td>517</td>
<td>68</td>
<td>130</td>
<td>31</td>
<td>3</td>
</tr>
<tr>
<td>95</td>
<td>benitar01</td>
<td>2007</td>
<td>2</td>
<td>FLO</td>
<td>NL</td>
<td>34</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>96</td>
<td>benitar01</td>
<td>2007</td>
<td>1</td>
<td>SFW</td>
<td>NL</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(continues on next page)
Wide DataFrames will be printed across multiple rows by default:

```python
In [110]: pd.DataFrame(np.random.randn(3, 12))
Out[110]:
   0   1   2  3   4  ...   7   8
  --- --- --- --- ---  ...   --- ---
    0 -0.345352 1.314232 0.690579 0.995761 2.396780 ... -0.317441 -1.236269 0.0281461 0.030711 0.109121
    1 -2.182937 0.380396 0.084844 0.432390 1.519970 ... 0.274230 0.132885 -0.744471
    2  0.206053 -0.251905 -2.213588 1.063327 1.266143 ... 0.408204 -1.048089 -0.964980 -0.845696 -1.340896 ... 1.682706 -1.717693 0.0281461 0.030711 0.109121

[3 rows x 12 columns]
```

You can change how much to print on a single row by setting the `display.width` option:

```python
In [111]: pd.set_option('display.width', 40) # default is 80
In [112]: pd.DataFrame(np.random.randn(3, 12))
Out[112]:
   0   1   2  3   4  ...   7   8
  --- --- --- --- ---  ...   --- ---
    0  1.262731 1.289997 0.082423 -0.055758 0.536580 ... -0.034571 -2.484478 -0.744471
    1  1.126203 -0.977349 1.474071 -0.064034 -1.282782 ... 0.441153 2.353925 0.0281461 0.030711 0.109121
    2  0.758527 1.729689 -0.964980 -0.845696 -1.340896 ... 1.682706 -1.717693 0.0281461 0.030711 0.109121

[3 rows x 12 columns]
```

You can adjust the max width of the individual columns by setting `display.max_colwidth`

```python
In [113]: datafile={'filename': ['filename_01', 'filename_02'],
     ...:               'path': ['media/user_name/storage/folder_01/filename_01",
     ...:                        "media/user_name/storage/folder_02/filename_02"]}
     ...
In [114]: pd.set_option('display.max_colwidth',30)
In [115]: pd.DataFrame(datafile)
Out[115]:

<table>
<thead>
<tr>
<th>filename</th>
<th>path</th>
</tr>
</thead>
<tbody>
<tr>
<td>filename_01</td>
<td>media/user_name/storage/folder_01/filename_01</td>
</tr>
<tr>
<td>filename_02</td>
<td>media/user_name/storage/folder_02/filename_02</td>
</tr>
</tbody>
</table>
```

```python
In [116]: pd.set_option('display.max_colwidth',100)
In [117]: pd.DataFrame(datafile)
Out[117]:

<table>
<thead>
<tr>
<th>filename</th>
<th>path</th>
</tr>
</thead>
<tbody>
<tr>
<td>filename_01</td>
<td>media/user_name/storage/folder_01/filename_01</td>
</tr>
<tr>
<td>filename_02</td>
<td>media/user_name/storage/folder_02/filename_02</td>
</tr>
</tbody>
</table>
```

(continues on next page)
8.2.15 DataFrame column attribute access and IPython completion

If a DataFrame column label is a valid Python variable name, the column can be accessed like an attribute:

```
In [118]: df = pd.DataFrame({'foo1' : np.random.randn(5),
                      'foo2' : np.random.randn(5)})

In [119]: df
Out[119]:
  foo1    foo2
0  1.171216 -0.858447
1  0.520260  0.306996
2 -1.197071 -0.028665
3 -1.066969  0.384316
4 -0.303421  1.574159
```

The columns are also connected to the IPython completion mechanism so they can be tab-completed:

```
In [5]: df.fo<TAB>
df.foo1 df.foo2
```

8.3 Panel

**Warning:** In 0.20.0, Panel is deprecated and will be removed in a future version. See the section Deprecate Panel.

Panel is a somewhat less-used, but still important container for 3-dimensional data. The term panel data is derived from econometrics and is partially responsible for the name pandas: pan(el)-da(ta)-s. The names for the 3 axes are intended to give some semantic meaning to describing operations involving panel data and, in particular, econometric analysis of panel data. However, for the strict purposes of slicing and dicing a collection of DataFrame objects, you may find the axis names slightly arbitrary:

- **items:** axis 0, each item corresponds to a DataFrame contained inside
- **major_axis:** axis 1, it is the index (rows) of each of the DataFrames
• **minor_axis**: axis 2, it is the **columns** of each of the DataFrames

Construction of Panels works about like you would expect:

### 8.3.1 From 3D ndarray with optional axis labels

```python
In [121]: wp = pd.Panel(np.random.randn(2, 5, 4), items=['Item1', 'Item2'],
                   major_axis=pd.date_range('1/1/2000', periods=5),
                   minor_axis=['A', 'B', 'C', 'D'])

In [122]: wp
Out[122]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2000-01-01 00:00:00 to 2000-01-05 00:00:00
Minor_axis axis: A to D
```

### 8.3.2 From dict of DataFrame objects

```python
In [123]: data = {'Item1' : pd.DataFrame(np.random.randn(4, 3)),
          'Item2' : pd.DataFrame(np.random.randn(4, 2))}

In [124]: pd.Panel(data)
Out[124]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 4 (major_axis) x 3 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 0 to 3
Minor_axis axis: 0 to 2
```

Note that the values in the dict need only be **convertible to DataFrame**. Thus, they can be any of the other valid inputs to DataFrame as per above.

One helpful factory method is `Panel.from_dict`, which takes a dictionary of DataFrames as above, and the following named parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>intersect</td>
<td>False</td>
<td>drops elements whose indices do not align</td>
</tr>
<tr>
<td>orient</td>
<td>items</td>
<td>use minor to use DataFrames' columns as panel items</td>
</tr>
</tbody>
</table>

For example, compare to the construction above:

```python
In [125]: pd.Panel.from_dict(data, orient='minor')
Out[125]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 4 (major_axis) x 2 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 0 to 2
Minor_axis axis: Item1 to Item2
```

Orient is especially useful for mixed-type DataFrames. If you pass a dict of DataFrame objects with mixed-type columns, all of the data will get upcasted to `dtype=object` unless you pass `orient='minor'`:

---

8.3. Panel 581
In [126]: df = pd.DataFrame({'a': ['foo', 'bar', 'baz'],
                      'b': np.random.randn(3)})

In [127]: df
Out[127]:
    a     b
0  foo -0.308853
1  bar -0.681087
2  baz  0.377953

In [128]: data = {'item1': df, 'item2': df}

In [129]: panel = pd.Panel.from_dict(data, orient='minor')

In [130]: panel['a']
Out[130]:
    item1  item2
0    foo    foo
1    bar    bar
2    baz    baz

In [131]: panel['b']
Out[131]:
    item1  item2
0 -0.308853 -0.308853
1 -0.681087 -0.681087
2  0.377953  0.377953

In [132]: panel['b'].dtypes
Out[132]:
item1  float64
item2  float64
dtype: object

Note: Panel, being less commonly used than Series and DataFrame, has been slightly neglected feature-wise. A number of methods and options available in DataFrame are not available in Panel.

8.3.3 From DataFrame using to_panel method

to_panel converts a DataFrame with a two-level index to a Panel.

In [133]: midx = pd.MultiIndex(levels=[['one', 'two'], ['x', 'y']],
                        labels=[[1, 1, 0, 0],
                                [1, 0, 1, 0]])

In [134]: df = pd.DataFrame({'A': [1, 2, 3, 4], 'B': [5, 6, 7, 8]}, index=midx)

In [135]: df.to_panel()
Out[135]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 2 (major_axis) x 2 (minor_axis)
Items axis: A to B

(continues on next page)
Major_axis axis: one to two
Minor_axis axis: x to y

8.3.4 Item selection / addition / deletion

Similar to DataFrame functioning as a dict of Series, Panel is like a dict of DataFrames:

```
In [136]: wp['Item1']
Out[136]:
          A         B         C         D
2000-01-01 1.588931 0.476720 0.473424 -0.242861
2000-01-02 -0.014805 -0.284319 0.650776 -1.461665
2000-01-03 -1.137707 -0.891060 -0.693921 1.613616
2000-01-04  0.464000  0.227371 -0.696922  1.613616
2000-01-05 -2.290613 -1.134623 -1.561819 -0.260838
```

```
In [137]: wp['Item3'] = wp['Item1'] / wp['Item2']
```

The API for insertion and deletion is the same as for DataFrame. And as with DataFrame, if the item is a valid Python identifier, you can access it as an attribute and tab-complete it in IPython.

8.3.5 Transposing

A Panel can be rearranged using its `transpose` method (which does not make a copy by default unless the data are heterogeneous):

```
In [138]: wp.transpose(2, 0, 1)
Out[138]:
<class 'pandas.core.panel.Panel'>
Dimensions: 4 (items) x 3 (major_axis) x 5 (minor_axis)
Items axis: A to D
Major_axis axis: Item1 to Item3
Minor_axis axis: 2000-01-01 00:00:00 to 2000-01-05 00:00:00
```

8.3.6 Indexing / Selection

<table>
<thead>
<tr>
<th>Operation</th>
<th>Syntax</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select item</td>
<td>wp[item]</td>
<td>DataFrame</td>
</tr>
<tr>
<td>Get slice at major_axis label</td>
<td>wp.major_xs(val)</td>
<td>DataFrame</td>
</tr>
<tr>
<td>Get slice at minor_axis label</td>
<td>wp.minor_xs(val)</td>
<td>DataFrame</td>
</tr>
</tbody>
</table>

For example, using the earlier example data, we could do:

```
In [139]: wp['Item1']
Out[139]:
          A         B         C         D
2000-01-01 1.588931 0.476720 0.473424 -0.242861
2000-01-02 -0.014805 -0.284319 0.650776 -1.461665
2000-01-03 -1.137707 -0.891060 -0.693921 1.613616
2000-01-04  0.464000  0.227371 -0.696922  1.613616
2000-01-05 -2.290613 -1.134623 -1.561819 -0.260838
```

(continues on next page)
2000-01-05 -2.290613 -1.134623 -1.561819 -0.260838

```python
In [140]: wp.major_xs(wp.major_axis[2])

→ Item1 Item2 Item3
A 1.137707 0.800193 1.421791
B -0.891060 0.782098 1.139320
C -0.693921 -1.069094 0.649074
D 1.613616 -1.099248 1.467927
```

```python
Out[140]:
```

```
In [141]: wp.minor_axis

→ Index(['A', 'B', 'C', 'D'], dtype='object')
```

```python
In [142]: wp.minor_xs('C')

→ Item1 Item2 Item3
2000-01-01 0.473424 -0.902937 -0.524316
2000-01-02 0.650776 -1.144073 -0.568824
2000-01-03 -0.693921 -1.069094 0.649074
2000-01-04 -0.496922 0.661084 -0.751678
2000-01-05 -1.561819 -1.056652 1.478083
```

8.3.7 Squeezing

Another way to change the dimensionality of an object is to squeeze a 1-len object, similar to `wp['Item1']`.

```python
In [143]: wp.reindex(items=['Item1']).squeeze()
```

```
Out[143]:
```

```python
In [144]: wp.reindex(items=['Item1'], minor=['B']).squeeze()

→
2000-01-01 0.476720
2000-01-02 -0.284319
2000-01-03 -0.891060
2000-01-04 0.227371
2000-01-05 -1.134623
Freq: D, Name: B, dtype: float64
```

8.3.8 Conversion to DataFrame

A Panel can be represented in 2D form as a hierarchically indexed DataFrame. See the section `hierarchical indexing` for more on this. To convert a Panel to a DataFrame, use the `to_frame` method:
In [145]: panel = pd.Panel(np.random.randn(3, 5, 4), items=['one', 'two', 'three'],
                   major_axis=pd.date_range('1/1/2000', periods=5),
                   minor_axis=['a', 'b', 'c', 'd'])

In [146]: panel.to_frame()
Out[146]:

<table>
<thead>
<tr>
<th>major</th>
<th>minor</th>
<th>one</th>
<th>two</th>
<th>three</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-01</td>
<td>a</td>
<td>0.493672</td>
<td>1.219492</td>
<td>-1.290493</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>-2.461467</td>
<td>0.062297</td>
<td>0.787872</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>-1.553902</td>
<td>-0.110388</td>
<td>1.515707</td>
</tr>
<tr>
<td></td>
<td>d</td>
<td>2.015523</td>
<td>-1.184357</td>
<td>-0.276487</td>
</tr>
<tr>
<td>2000-01-02</td>
<td>a</td>
<td>-1.833722</td>
<td>-0.558081</td>
<td>-0.223762</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>1.771740</td>
<td>0.077849</td>
<td>1.397431</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>-0.670027</td>
<td>0.629498</td>
<td>1.503874</td>
</tr>
<tr>
<td></td>
<td>d</td>
<td>0.049307</td>
<td>-1.035260</td>
<td>-0.478905</td>
</tr>
<tr>
<td>2000-01-03</td>
<td>a</td>
<td>-0.521493</td>
<td>-0.438229</td>
<td>-0.135950</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>-3.201750</td>
<td>0.503703</td>
<td>-0.730327</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>0.792716</td>
<td>0.413086</td>
<td>-0.033277</td>
</tr>
<tr>
<td></td>
<td>d</td>
<td>0.146111</td>
<td>-1.139050</td>
<td>0.281151</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>a</td>
<td>1.903247</td>
<td>0.660342</td>
<td>-1.298915</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>-0.747169</td>
<td>0.464794</td>
<td>-2.819487</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>-0.309038</td>
<td>-0.309337</td>
<td>-0.851985</td>
</tr>
<tr>
<td></td>
<td>d</td>
<td>0.393876</td>
<td>-0.649593</td>
<td>-1.106952</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>a</td>
<td>1.861468</td>
<td>0.683758</td>
<td>-0.937731</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>0.936527</td>
<td>-0.643834</td>
<td>-1.537770</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>1.255746</td>
<td>0.421287</td>
<td>0.555759</td>
</tr>
<tr>
<td></td>
<td>d</td>
<td>-2.655452</td>
<td>1.032814</td>
<td>-2.277282</td>
</tr>
</tbody>
</table>

8.4 Deprecate Panel

Over the last few years, pandas has increased in both breadth and depth, with new features, datatype support, and manipulation routines. As a result, supporting efficient indexing and functional routines for Series, DataFrame and Panel has contributed to an increasingly fragmented and difficult-to-understand codebase.

The 3-D structure of a Panel is much less common for many types of data analysis, than the 1-D of the Series or the 2-D of the DataFrame. Going forward it makes sense for pandas to focus on these areas exclusively.

Oftentimes, one can simply use a MultiIndex DataFrame for easily working with higher dimensional data.

In addition, the xarray package was built from the ground up, specifically in order to support the multi-dimensional analysis that is one of Panel’s main usecases. Here is a link to the xarray panel-transition documentation.

In [147]: p = tm.makePanel()

In [148]: p
Out[148]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 30 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2000-01-03 00:00:00 to 2000-02-11 00:00:00
Minor_axis axis: A to D

Convert to a MultiIndex DataFrame.
In [149]: p.to_frame()
Out[149]:

<table>
<thead>
<tr>
<th>major</th>
<th>minor</th>
<th>ItemA</th>
<th>ItemB</th>
<th>ItemC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-03</td>
<td>A</td>
<td>-0.390201</td>
<td>-1.624062</td>
<td>-0.605044</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1.562443</td>
<td>0.483103</td>
<td>0.583129</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>-1.085663</td>
<td>0.768159</td>
<td>-0.273458</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>0.136235</td>
<td>-0.021763</td>
<td>-0.700648</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>A</td>
<td>1.207122</td>
<td>-0.758514</td>
<td>0.878404</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.763264</td>
<td>0.061495</td>
<td>-0.876690</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>-1.114738</td>
<td>0.225441</td>
<td>-0.335117</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>0.886313</td>
<td>-0.047152</td>
<td>-1.166607</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>A</td>
<td>0.178690</td>
<td>-0.560859</td>
<td>-0.921485</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.162027</td>
<td>0.240767</td>
<td>-1.919354</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>-0.058216</td>
<td>0.543294</td>
<td>-0.476268</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>-1.350722</td>
<td>0.088472</td>
<td>-0.367236</td>
</tr>
<tr>
<td>2000-01-06</td>
<td>A</td>
<td>-1.004168</td>
<td>-0.589005</td>
<td>-0.200312</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>-0.902704</td>
<td>0.782413</td>
<td>-0.572707</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>-0.486768</td>
<td>0.771931</td>
<td>-1.765602</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>-0.886348</td>
<td>-0.857435</td>
<td>1.296674</td>
</tr>
<tr>
<td>2000-01-07</td>
<td>A</td>
<td>-1.377627</td>
<td>-1.070678</td>
<td>0.522423</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1.106010</td>
<td>0.628462</td>
<td>-1.736484</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>1.685148</td>
<td>-0.968145</td>
<td>0.578223</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>-1.013316</td>
<td>-2.503786</td>
<td>0.641385</td>
</tr>
<tr>
<td>2000-01-10</td>
<td>A</td>
<td>0.499281</td>
<td>-1.681101</td>
<td>0.722511</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>-0.199234</td>
<td>-0.880627</td>
<td>-1.335113</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0.112572</td>
<td>-1.176383</td>
<td>0.242697</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>1.920906</td>
<td>-1.058041</td>
<td>-0.779432</td>
</tr>
<tr>
<td>2000-01-11</td>
<td>A</td>
<td>-1.405256</td>
<td>0.403776</td>
<td>-1.702486</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.458265</td>
<td>0.777575</td>
<td>-1.244471</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>-1.495309</td>
<td>-3.192716</td>
<td>0.208129</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>-0.388231</td>
<td>-0.657981</td>
<td>0.602456</td>
</tr>
<tr>
<td>2000-01-12</td>
<td>A</td>
<td>0.162565</td>
<td>0.609862</td>
<td>-0.709535</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.491048</td>
<td>-0.779367</td>
<td>0.347339</td>
</tr>
<tr>
<td></td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>2000-02-02</td>
<td>C</td>
<td>-0.303961</td>
<td>-0.463752</td>
<td>-0.288962</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>0.104050</td>
<td>1.116086</td>
<td>0.506445</td>
</tr>
<tr>
<td>2000-02-03</td>
<td>A</td>
<td>-2.338595</td>
<td>-0.581967</td>
<td>-0.801820</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>-0.557697</td>
<td>-0.033731</td>
<td>-0.176382</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0.625555</td>
<td>-0.055289</td>
<td>0.875359</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>0.174068</td>
<td>-0.443915</td>
<td>1.626369</td>
</tr>
<tr>
<td>2000-02-04</td>
<td>A</td>
<td>-0.374279</td>
<td>-1.233862</td>
<td>-0.915751</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.381353</td>
<td>-1.108761</td>
<td>-1.970108</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>-0.059268</td>
<td>-0.360853</td>
<td>-0.614618</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>-0.439461</td>
<td>-0.200491</td>
<td>0.429518</td>
</tr>
<tr>
<td>2000-02-07</td>
<td>A</td>
<td>-2.359958</td>
<td>-3.520876</td>
<td>-0.288156</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1.337122</td>
<td>-0.314399</td>
<td>-1.044208</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0.249698</td>
<td>0.728197</td>
<td>0.565375</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>-0.741343</td>
<td>1.092633</td>
<td>0.013910</td>
</tr>
<tr>
<td>2000-02-08</td>
<td>A</td>
<td>-1.157886</td>
<td>0.516870</td>
<td>-1.199945</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>-1.531095</td>
<td>-0.860626</td>
<td>-0.821179</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>1.103949</td>
<td>1.326768</td>
<td>0.068184</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>-0.079673</td>
<td>-1.675194</td>
<td>-0.458272</td>
</tr>
<tr>
<td>2000-02-09</td>
<td>A</td>
<td>-0.551865</td>
<td>0.343125</td>
<td>-0.072869</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1.331458</td>
<td>0.370397</td>
<td>-1.914267</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>-1.087532</td>
<td>0.208927</td>
<td>0.788871</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>-0.922875</td>
<td>0.437234</td>
<td>-1.531004</td>
</tr>
</tbody>
</table>
Alternatively, one can convert to an xarray `DataArray`.

```python
In [150]: p.to_xarray()
Out[150]:
<xarray.DataArray (items: 3, major_axis: 30, minor_axis: 4)>
array([[[-0.390201, 1.562443, -1.085663, 0.136235],
       [1.207122, 0.763264, -1.114738, 0.886313],
       ...
       [1.592673, -0.571329, 1.998044, 0.303638],
       [1.559318, -0.026671, -0.244548, -0.917368]],
      [[-1.624062, 0.483103, 0.768159, -0.021763],
       [-0.758514, 0.061495, 0.225441, -0.047152],
       ...
       [2.137827, -1.761442, 0.292058, 0.388254],
       [0.452429, -0.899454, -2.019610, 0.479630]],
      [[-0.605044, 0.583129, -0.273458, -0.700648],
       [0.878404, -0.876690, -0.335117, -1.166607],
       ...
       [-1.828749, -0.826439, -0.280343, -0.500569],
       [-1.716981, 0.124808, 0.931536, 0.870690]]])
Coordinates:
* items (items) object 'ItemA' 'ItemB' 'ItemC'
* major_axis (major_axis) datetime64[ns] 2000-01-03 2000-01-04 2000-01-05 ...
* minor_axis (minor_axis) object 'A' 'B' 'C' 'D'
```

You can see the full-documentation for the `xarray` package.
Here we discuss a lot of the essential functionality common to the pandas data structures. Here’s how to create some of the objects used in the examples from the previous section:

In [1]: index = pd.date_range('1/1/2000', periods=8)
In [2]: s = pd.Series(np.random.randn(5), index=['a', 'b', 'c', 'd', 'e'])
In [3]: df = pd.DataFrame(np.random.randn(8, 3), index=index,
\                      columns=['A', 'B', 'C'])
\                      ...
In [4]: wp = pd.Panel(np.random.randn(2, 5, 4), items=['Item1', 'Item2'],
\                      major_axis=pd.date_range('1/1/2000', periods=5),
\                      minor_axis=['A', 'B', 'C', 'D'])
\                      ...

9.1 Head and Tail

To view a small sample of a Series or DataFrame object, use the head() and tail() methods. The default number of elements to display is five, but you may pass a custom number.

In [5]: long_series = pd.Series(np.random.randn(1000))
In [6]: long_series.head()
Out[6]:
0   0.229453
1   0.304418
2   0.736135
3  -0.859631
4  -0.424100
dtype: float64

In [7]: long_series.tail(3)
Out[7]:
997  -0.351587
998   1.136249
999  -0.448789
dtype: float64
9.2 Attributes and the raw ndarray(s)

pandas objects have a number of attributes enabling you to access the metadata

- **shape**: gives the axis dimensions of the object, consistent with ndarray

- Axis labels
  - **Series**: *index* (only axis)
  - **DataFrame**: *index* (rows) and *columns*
  - **Panel**: *items*, *major_axis*, and *minor_axis*

Note, these attributes can be safely assigned to!

```python
In [8]: df[:2]
Out[8]:
         A         B         C
2000-01-01 0.048869 -1.360687 -0.479010
2000-01-02 -0.859661 -0.231595 -0.527750

In [9]: df.columns = [x.lower() for x in df.columns]

In [10]: df
Out[10]:
         a         b         c
2000-01-01 0.048869 -1.360687 -0.479010
2000-01-02 -0.859661 -0.231595 -0.527750
2000-01-03 1.296337  0.150680  0.123836
2000-01-04 0.571764  1.555563 -0.823761
2000-01-05 0.535420  1.032853  1.469725
2000-01-06 1.304124  1.449735  0.203109
2000-01-07 1.032011  0.969818  0.962723
2000-01-08 1.382083  0.938794  0.669142
```

To get the actual data inside a data structure, one need only access the **values** property:

```python
In [11]: s.values
Out[11]: array([-1.9339,  0.3773,  0.7341,  2.1416, -0.0112])

In [12]: df.values
Out[12]:
array([[ 0.0489, -1.3607, -0.479 ],
       [-0.8597, -0.2316, -0.5278],
       [-1.2963,  0.1507,  0.1238],
       [ 0.5718,  1.5556, -0.8238],
       [ 0.5354, -1.0329,  1.4697],
       [ 1.3041,  1.4497,  0.2031],
       [-1.032 ,  0.9698, -0.9627],
       [ 1.3821, -0.9388,  0.6691]])

In [13]: wp.values
array([[-0.4336, -0.2736,  0.6804, -0.3084],
       [-0.2761,  1.8212, -1.9936, -1.9274],
       [-2.0279,  1.625 ,  0.5511,  3.0593],
       [ 0.4553, -0.0307,  0.9357,  1.0612],
       ...])
```

(continues on next page)
If a DataFrame or Panel contains homogeneously-typed data, the ndarray can actually be modified in-place, and the changes will be reflected in the data structure. For heterogeneous data (e.g. some of the DataFrame’s columns are not all the same dtype), this will not be the case. The values attribute itself, unlike the axis labels, cannot be assigned to.

**Note:** When working with heterogeneous data, the dtype of the resulting ndarray will be chosen to accommodate all of the data involved. For example, if strings are involved, the result will be of object dtype. If there are only floats and integers, the resulting array will be of float dtype.

### 9.3 Accelerated operations

pandas has support for accelerating certain types of binary numerical and boolean operations using the `numexpr` library and the `bottleneck` libraries.

These libraries are especially useful when dealing with large data sets, and provide large speedups. `numexpr` uses smart chunking, caching, and multiple cores. `bottleneck` is a set of specialized cython routines that are especially fast when dealing with arrays that have `nans`.

Here is a sample (using 100 column x 100,000 row DataFrames):

<table>
<thead>
<tr>
<th>Operation</th>
<th>0.11.0 (ms)</th>
<th>Prior Version (ms)</th>
<th>Ratio to Prior</th>
</tr>
</thead>
<tbody>
<tr>
<td>df1 &gt; df2</td>
<td>13.32</td>
<td>125.35</td>
<td>0.1063</td>
</tr>
<tr>
<td>df1 * df2</td>
<td>21.71</td>
<td>36.63</td>
<td>0.5928</td>
</tr>
<tr>
<td>df1 + df2</td>
<td>22.04</td>
<td>36.50</td>
<td>0.6039</td>
</tr>
</tbody>
</table>

You are highly encouraged to install both libraries. See the section *Recommended Dependencies* for more installation info.

These are both enabled to be used by default, you can control this by setting the options:

New in version 0.20.0.

```python
pd.set_option('compute.use_bottleneck', False)
pd.set_option('compute.use_numexpr', False)
```

### 9.4 Flexible binary operations

With binary operations between pandas data structures, there are two key points of interest:

- Broadcasting behavior between higher- (e.g. DataFrame) and lower-dimensional (e.g. Series) objects.
- Missing data in computations.

We will demonstrate how to manage these issues independently, though they can be handled simultaneously.
9.4.1 Matching / broadcasting behavior

DataFrame has the methods `add()`, `sub()`, `mul()`, `div()` and related functions `radd()`, `rsub()`... for carrying out binary operations. For broadcasting behavior, Series input is of primary interest. Using these functions, you can use to either match on the `index` or `columns` via the `axis` keyword:

In [14]: df = pd.DataFrame({'one' : pd.Series(np.random.randn(3), index=['a', 'b', 'c →']),
                     'two' : pd.Series(np.random.randn(4), index=['a', 'b', 'c →', 'd']),
                     'three' : pd.Series(np.random.randn(3), index=['b', 'c', →'d'])))

In [15]: df
Out[15]:
   one  two  three
a -1.101558 1.124472 NaN
b -0.177289 2.487104 -0.634293
c  0.462215 -0.486066 1.931194
d   NaN -0.456288 -1.222918

In [16]: row = df.iloc[1]

In [17]: column = df['two']

In [18]: df.sub(row, axis='columns')
Out[18]:
   one  two  three
a  -0.924269 -1.362632 NaN
b   0.000000  0.000000  0.000000
c  0.639504  2.973170  2.565487
d  -2.943392  0.000000  0.588625

In [19]: df.sub(row, axis=1)

In [20]: df.sub(column, axis='index')

In [21]: df.sub(column, axis=0)
Furthermore you can align a level of a multi-indexed DataFrame with a Series.

```python
In [22]: dfmi = df.copy()
In [23]: dfmi.index = pd.MultiIndex.from_tuples([(1,'a'),(1,'b'),(1,'c'),(2,'a')],
                                            names=['first','second'])
In [24]: dfmi.sub(column, axis=0, level='second')
Out[24]:
   one    two    three
first  
   second
  1 a  -2.226031  0.00000      NaN
  b  -2.664393  0.00000  -3.121397
  c   0.948280  0.00000   2.417260
  2 a      NaN  -1.58076  -2.347391
```

With Panel, describing the matching behavior is a bit more difficult, so the arithmetic methods instead (and perhaps confusingly?) give you the option to specify the broadcast axis. For example, suppose we wished to demean the data over a particular axis. This can be accomplished by taking the mean over an axis and broadcasting over the same axis:

```python
In [25]: major_mean = wp.mean(axis='major')
In [26]: major_mean
Out[26]:
   Item1    Item2
A -0.878036 -0.092218
B -0.060128  0.529811
C  0.099453 -0.715139
D  0.248599 -0.186535
In [27]: wp.sub(major_mean, axis='major')
```

And similarly for axis="items" and axis="minor".

**Note:** I could be convinced to make the axis argument in the DataFrame methods match the broadcasting behavior of Panel. Though it would require a transition period so users can change their code.

Series and Index also support the `divmod()` builtin. This function takes the floor division and modulo operation at the same time returning a two-tuple of the same type as the left hand side. For example:

```python
In [28]: s = pd.Series(np.arange(10))
In [29]: s
Out[29]:
```

9.4. Flexible binary operations
In [30]: div, rem = divmod(s, 3)

In [31]: div
Out[31]:
0 0
1 0
2 0
3 1
4 1
5 1
6 2
7 2
8 2
9 3
dtype: int64

In [32]: rem
Out[32]:
0 0
1 1
2 2
3 0
4 1
5 2
6 0
7 1
8 2
9 0
dtype: int64

In [33]: idx = pd.Index(np.arange(10))

In [34]: idx
Out[34]: Int64Index([0, 1, 2, 3, 4, 5, 6, 7, 8, 9], dtype='int64')

In [35]: div, rem = divmod(idx, 3)

In [36]: div
Out[36]: Int64Index([0, 0, 0, 1, 1, 1, 2, 2, 2, 3], dtype='int64')

In [37]: rem
Out[37]: Int64Index([0, 1, 2, 0, 1, 2, 0, 1, 2, 0], dtype='int64')
We can also do elementwise `divmod()`:

```python
In [38]: div, rem = divmod(s, [2, 2, 3, 4, 4, 5, 5, 6, 6])
In [39]: div
Out[39]:
        0  1  2  3  4  5  6  7  8  9
0     0  0  0  0  0  0  0  0  0  0
1     1  1  1  1  1  1  1  1  1  1
2     2  2  2  2  2  2  2  2  2  2
dtype: int64
In [40]: rem
Out[40]:
        0  1  2  3  4  5  6  7  8  9
0     0  0  0  0  0  0  0  0  0  0
1     1  1  1  1  1  1  1  1  1  1
2     2  2  2  2  2  2  2  2  2  2
dtype: int64
```

### 9.4.2 Missing data / operations with fill values

In Series and DataFrame, the arithmetic functions have the option of inputting a `fill_value`, namely a value to substitute when at most one of the values at a location are missing. For example, when adding two DataFrame objects, you may wish to treat NaN as 0 unless both DataFrames are missing that value, in which case the result will be NaN (you can later replace NaN with some other value using `fillna` if you wish).

```python
In [41]: df
Out[41]:
     one  two  three
a -1.101558  1.124472  NaN
b -0.177289  2.487104 -0.634293
c  0.462215 -0.486066  1.931194
d    NaN -0.456288 -1.222918
In [42]: df2
Out[42]:
     one  two  three
a -1.101558  1.124472  1.000000
b -0.177289  2.487104 -0.634293
c  0.462215 -0.486066  1.931194
d    NaN -0.456288 -1.222918
```

(continues on next page)
9.4.3 Flexible Comparisons

Series and DataFrame have the binary comparison methods `eq`, `ne`, `lt`, `gt`, `le`, and `ge` whose behavior is analogous to the binary arithmetic operations described above:

```python
In [45]: df.gt(df2)
Out[45]:
   one  two  three
a  False False False
b  False False False
c  False False False
d  False False False

In [46]: df2.ne(df)
   →  
   one  two  three
   a  False False True
   b  False False False
   c  False False False
   d  True  False False
```

These operations produce a pandas object of the same type as the left-hand-side input that is of dtype `bool`. These `boolean` objects can be used in indexing operations, see the section on `Boolean indexing`.

9.4.4 Boolean Reductions

You can apply the reductions: `empty`, `any()`, `all()`, and `bool()` to provide a way to summarize a boolean result.

```python
In [47]: (df > 0).all()
Out[47]:
   one  False
   two  False
   three False
```
You can reduce to a final boolean value.

```
In [49]: (df > 0).any().any()
Out[49]: True
```

You can test if a pandas object is empty, via the `empty` property.

```
In [50]: df.empty
Out[50]: False
```

```
In [51]: pd.DataFrame(columns=list('ABC')).empty
Out[51]: True
```

To evaluate single-element pandas objects in a boolean context, use the method `bool()`:

```
In [52]: pd.Series([True]).bool()
Out[52]: True
```

```
In [53]: pd.Series([False]).bool()
Out[53]: False
```

```
In [54]: pd.DataFrame([True]).bool()
Out[54]: True
```

```
In [55]: pd.DataFrame([False]).bool()
Out[55]: False
```

**Warning:** You might be tempted to do the following:

```
>>> if df:
...    ...
```

Or

```
>>> df and df2
```

These will both raise errors, as you are trying to compare multiple values.

*ValueError:* The truth value of an array *is* ambiguous. Use `a.empty`, `a.any()` or `a.
all()`.

See *gotchas* for a more detailed discussion.
9.4.5 Comparing if objects are equivalent

Often you may find that there is more than one way to compute the same result. As a simple example, consider \( df + df \) and \( df \times 2 \). To test that these two computations produce the same result, given the tools shown above, you might imagine using \((df + df == df \times 2).all()\). But in fact, this expression is False:

```
In [56]: df + df == df * 2
Out[56]:
    one  two  three
   a    True  True  False
   b    True  True   True
   c    True  True   True
   d   False  True   True
```

Notice that the boolean DataFrame \( df + df == df \times 2 \) contains some False values! This is because NaNs do not compare as equals:

```
In [58]: np.nan == np.nan
Out[58]: False
```

So, NDFrames (such as Series, DataFrames, and Panels) have an \( \text{equals()} \) method for testing equality, with NaNs in corresponding locations treated as equal.

```
In [59]: (df + df).equals(df * 2)
Out[59]: True
```

Note that the Series or DataFrame index needs to be in the same order for equality to be True:

```
In [60]: df1 = pd.DataFrame({'col': ['foo', 0, np.nan]})
In [61]: df2 = pd.DataFrame({'col': [np.nan, 0, 'foo']}, index=[2, 1, 0])
In [62]: df1.equals(df2)
Out[62]: False
In [63]: df1.equals(df2.sort_index())
Out[63]: True
```

9.4.6 Comparing array-like objects

You can conveniently perform element-wise comparisons when comparing a pandas data structure with a scalar value:

```
In [64]: pd.Series(['foo', 'bar', 'baz']) == 'foo'
Out[64]:
0   True
1  False
2  False
dtype: bool
```
In [65]: pd.Index(['foo', 'bar', 'baz']) == 'foo'
Out[65]: array([ True, False, False], dtype=bool)

Pandas also handles element-wise comparisons between different array-like objects of the same length:

In [66]: pd.Series(['foo', 'bar', 'baz']) == pd.Index(['foo', 'bar', 'qux'])
Out[66]:
0   True
1   True
2  False
dtype: bool

In [67]: pd.Series(['foo', 'bar', 'baz']) == np.array(['foo', 'bar', 'qux'])
Out[67]:
0   True
1   True
2  False
dtype: bool

Trying to compare Index or Series objects of different lengths will raise a ValueError:

In [55]: pd.Series(['foo', 'bar', 'baz']) == pd.Series(['foo', 'bar'])
ValueError: Series lengths must match to compare

In [56]: pd.Series(['foo', 'bar', 'baz']) == pd.Series(['foo'])
ValueError: Series lengths must match to compare

Note that this is different from the NumPy behavior where a comparison can be broadcast:

In [68]: np.array([1, 2, 3]) == np.array([2])
Out[68]: array([False, True, False], dtype=bool)

or it can return False if broadcasting can not be done:

In [69]: np.array([1, 2, 3]) == np.array([1, 2])
Out[69]: False

9.4.7 Combining overlapping data sets

A problem occasionally arising is the combination of two similar data sets where values in one are preferred over the other. An example would be two data series representing a particular economic indicator where one is considered to be of “higher quality”. However, the lower quality series might extend further back in history or have more complete data coverage. As such, we would like to combine two DataFrame objects where missing values in one DataFrame are conditionally filled with like-labeled values from the other DataFrame. The function implementing this operation is `combine_first()`, which we illustrate:

In [70]: df1 = pd.DataFrame({'A': [1., np.nan, 3., 5., np.nan],
                    'B': [np.nan, 2., 3., np.nan, 6.]})

In [71]: df2 = pd.DataFrame({'A': [5., 2., 4., np.nan, 3., 7.],
                    'B': [np.nan, np.nan, 3., 4., 6., 8.]})
9.4.8 General DataFrame Combine

The `combine_first()` method above calls the more general `DataFrame.combine()`. This method takes another DataFrame and a combiner function, aligns the input DataFrame and then passes the combiner function pairs of Series (i.e., columns whose names are the same).

So, for instance, to reproduce `combine_first()` as above:
9.5 Descriptive statistics

There exists a large number of methods for computing descriptive statistics and other related operations on :class:`Series`, :class:`DataFrame`, and :class:`Panel`. Most of these are aggregations (hence producing a lower-dimensional result) like :meth:`sum()`, :meth:`mean()`, and :meth:`quantile()`, but some of them, like :meth:`cumsum()` and :meth:`cumprod()`, produce an object of the same size. Generally speaking, these methods take an axis argument, just like :py:class:`ndarray.{sum, std, ...}`, but the axis can be specified by name or integer:

- **Series**: no axis argument needed
- **DataFrame**: “index” (axis=0, default), “columns” (axis=1)
- **Panel**: “items” (axis=0), “major” (axis=1, default), “minor” (axis=2)

For example:

```
In [77]: df
Out[77]:
    one     two     three
  a -1.101558  1.124472    NaN
  b -0.177289  2.487104 -0.634293
  c  0.462215 -0.486066  1.931194
  d    NaN    -0.456288 -1.222918

In [78]: df.mean(0)
Out[78]:
\n→
  one  -0.272211
  two   0.667306
  three  0.024661
dtype: float64

In [79]: df.mean(1)
Out[79]:
\n→
  a   0.011457
  b   0.558507
  c   0.635781
  d  -0.839603
dtype: float64
```

All such methods have a `skipna` option signaling whether to exclude missing data (True by default):

```
In [80]: df.sum(0, skipna=False)
Out[80]:
  one  NaN
  two  2.669223
  three NaN

dtype: float64

In [81]: df.sum(axis=1, skipna=True)
Out[81]:
\n→
  a  0.022914
  b  1.675522
  c  1.907343
  d -1.679206
dtype: float64
```

9.5. Descriptive statistics
Combined with the broadcasting / arithmetic behavior, one can describe various statistical procedures, like standardization (rendering data zero mean and standard deviation 1), very concisely:

```python
In [82]: ts_stand = (df - df.mean()) / df.std()
In [83]: ts_stand.std()
Out[83]:
   one  1.0
   two  1.0
   three 1.0
dtype: float64
In [84]: xs_stand = df.sub(df.mean(1), axis=0).div(df.std(1), axis=0)
In [85]: xs_stand.std(1)
Out[85]:
a  1.0
b  1.0
c  1.0
d  1.0
dtype: float64
```

Note that methods like `cumsum()` and `cumprod()` preserve the location of NaN values. This is somewhat different from `expanding()` and `rolling()`. For more details please see this note.

Here is a quick reference summary table of common functions. Each also takes an optional `level` parameter which applies only if the object has a *hierarchical index*.

```python
In [86]: df.cumsum()
Out[86]:
     one    two    three
   a -1.101558 1.124472   NaN
   b -1.278848 3.611576 -0.634293
   c -0.816633 3.125511  1.296901
   d  NaN  2.669223  0.073983
```
### 9.5. Descriptive statistics

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>Number of non-NA observations</td>
</tr>
<tr>
<td>sum</td>
<td>Sum of values</td>
</tr>
<tr>
<td>mean</td>
<td>Mean of values</td>
</tr>
<tr>
<td>mad</td>
<td>Mean absolute deviation</td>
</tr>
<tr>
<td>median</td>
<td>Arithmetic median of values</td>
</tr>
<tr>
<td>min</td>
<td>Minimum</td>
</tr>
<tr>
<td>max</td>
<td>Maximum</td>
</tr>
<tr>
<td>mode</td>
<td>Mode</td>
</tr>
<tr>
<td>abs</td>
<td>Absolute Value</td>
</tr>
<tr>
<td>prod</td>
<td>Product of values</td>
</tr>
<tr>
<td>std</td>
<td>Bessel-corrected sample standard deviation</td>
</tr>
<tr>
<td>var</td>
<td>Unbiased variance</td>
</tr>
<tr>
<td>sem</td>
<td>Standard error of the mean</td>
</tr>
<tr>
<td>skew</td>
<td>Sample skewness (3rd moment)</td>
</tr>
<tr>
<td>kurt</td>
<td>Sample kurtosis (4th moment)</td>
</tr>
<tr>
<td>quantile</td>
<td>Sample quantile (value at %)</td>
</tr>
<tr>
<td>cumsum</td>
<td>Cumulative sum</td>
</tr>
<tr>
<td>cumprod</td>
<td>Cumulative product</td>
</tr>
<tr>
<td>cummax</td>
<td>Cumulative maximum</td>
</tr>
<tr>
<td>cummin</td>
<td>Cumulative minimum</td>
</tr>
</tbody>
</table>

Note that by chance some NumPy methods, like `mean`, `std`, and `sum`, will exclude NAs on Series input by default:

```python
In [87]: np.mean(df['one'])
Out[87]: -0.27221094480450114

In [88]: np.mean(df['one'].values)
Out[88]: nan
```

`Series.nunique()` will return the number of unique non-NA values in a Series:

```python
In [89]: series = pd.Series(np.random.randn(500))
In [90]: series[20:500] = np.nan
In [91]: series[10:20] = 5
In [92]: series.nunique()
Out[92]: 11
```

#### 9.5.1 Summarizing data: `describe`

There is a convenient `describe()` function which computes a variety of summary statistics about a Series or the columns of a DataFrame (excluding NAs of course):

```python
In [93]: series = pd.Series(np.random.randn(1000))
In [94]: series[:2] = np.nan
In [95]: series.describe()
```

(continues on next page)
count 500.000000
mean -0.032127
std 1.067484
min -3.463789
25% -0.725523
50% -0.053230
75% 0.679790
max 3.120271
dtype: float64

In [96]: frame = pd.DataFrame(np.random.randn(1000, 5), columns=['a', 'b', 'c', 'd', 'e'])

In [97]: frame.iloc[::2] = np.nan

In [98]: frame.describe()

Out[98]:

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>500.000000</td>
<td>500.000000</td>
<td>500.000000</td>
<td>500.000000</td>
<td>500.000000</td>
</tr>
<tr>
<td>mean</td>
<td>-0.045109</td>
<td>-0.052045</td>
<td>0.024520</td>
<td>0.006117</td>
<td>0.001141</td>
</tr>
<tr>
<td>std</td>
<td>1.029268</td>
<td>1.002320</td>
<td>1.042793</td>
<td>1.040134</td>
<td>1.005207</td>
</tr>
<tr>
<td>min</td>
<td>-2.915767</td>
<td>-3.294023</td>
<td>-3.610499</td>
<td>-2.907036</td>
<td>-3.010899</td>
</tr>
<tr>
<td>25%</td>
<td>-0.763783</td>
<td>-0.720389</td>
<td>-0.609600</td>
<td>-0.665896</td>
<td>-0.682900</td>
</tr>
<tr>
<td>50%</td>
<td>-0.086033</td>
<td>-0.048843</td>
<td>0.006093</td>
<td>0.043191</td>
<td>-0.001651</td>
</tr>
<tr>
<td>75%</td>
<td>0.663399</td>
<td>0.620980</td>
<td>0.728382</td>
<td>0.735973</td>
<td>0.656439</td>
</tr>
<tr>
<td>max</td>
<td>3.400646</td>
<td>2.925597</td>
<td>3.416896</td>
<td>3.331522</td>
<td>3.007143</td>
</tr>
</tbody>
</table>

You can select specific percentiles to include in the output:

In [99]: series.describe(percentiles=[.05, .25, .75, .95])

Out[99]:

<table>
<thead>
<tr>
<th></th>
<th>count</th>
<th>mean</th>
<th>std</th>
<th>min</th>
<th>5%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>95%</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>500.000000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>-0.032127</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>std</td>
<td>1.067484</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>min</td>
<td>-3.463789</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5%</td>
<td>-1.733545</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25%</td>
<td>-0.725523</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td>-0.053230</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75%</td>
<td>0.679790</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>95%</td>
<td>1.854383</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>max</td>
<td>3.120271</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

dtype: float64

By default, the median is always included.

For a non-numerical Series object, describe() will give a simple summary of the number of unique values and most frequently occurring values:

In [100]: s = pd.Series(['a', 'a', 'b', 'b', 'a', 'a', np.nan, 'c', 'd', 'a'])

In [101]: s.describe()

Out[101]:

<table>
<thead>
<tr>
<th></th>
<th>count</th>
<th>unique</th>
<th>top</th>
<th>freq</th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>9</td>
<td>4</td>
<td>a</td>
<td>5</td>
</tr>
</tbody>
</table>

dtype: object
Note that on a mixed-type DataFrame object, `describe()` will restrict the summary to include only numerical columns or, if none are, only categorical columns:

```python
In [102]: frame = pd.DataFrame({'a': ['Yes', 'Yes', 'No', 'No'], 'b': range(4)})

In [103]: frame.describe()
Out[103]:
   b
count 4.000000
mean 1.500000
std  1.290994
min  0.000000
25%  0.750000
50%  1.500000
75%  2.250000
max  3.000000
```

This behaviour can be controlled by providing a list of types as `include/exclude` arguments. The special value `all` can also be used:

```python
In [104]: frame.describe(include=['object'])
Out[104]:
   a
count 4
unique 2
top Yes
freq 2

In [105]: frame.describe(include=['number'])
Out[105]:
   b
count 4.000000
mean 1.500000
std  1.290994
min  0.000000
25%  0.750000
50%  1.500000
75%  2.250000
max  3.000000

In [106]: frame.describe(include='all')
Out[106]:
   →
   a   b
count 4  4.000000
unique 2  NaN
top Yes  NaN
freq 2  NaN
mean  NaN  1.500000
std  NaN  1.290994
min  NaN  0.000000
25%  NaN  0.750000
50%  NaN  1.500000
75%  NaN  2.250000
max  NaN  3.000000
```

That feature relies on `select_dtypes`. Refer to there for details about accepted inputs.

9.5. Descriptive statistics 605
9.5.2 Index of Min/Max Values

The `idxmin()` and `idxmax()` functions on Series and DataFrame compute the index labels with the minimum and maximum corresponding values:

```python
In [107]: s1 = pd.Series(np.random.randn(5))
In [108]: s1
Out[108]:
0   -1.649461
1    0.169660
2    1.246181
3    0.131682
4    -2.001988
dtype: float64
In [109]: s1.idxmin(), s1.idxmax()
Out[109]:
(4, 2)
```

```python
In [110]: df1 = pd.DataFrame(np.random.randn(5,3), columns=['A','B','C'])
In [111]: df1
Out[111]:
   A          B          C
0 -1.273023  0.870502  0.214583
1  0.088452 -0.173364  1.207466
2  0.546121  0.409515 -0.310515
3  0.585014 -0.490528 -0.054639
4 -0.239226  0.701089  0.228656
In [112]: df1.idxmin(axis=0)
Out[112]:
   A   B   C
0  0   3   2
dtype: int64
In [113]: df1.idxmax(axis=1)
Out[113]:
   0  1  2
A  B  A
C  B
```

When there are multiple rows (or columns) matching the minimum or maximum value, `idxmin()` and `idxmax()` return the first matching index:

```python
In [114]: df3 = pd.DataFrame([2, 1, 1, 3, np.nan], columns=['A'], index=list('edcba'))
In [115]: df3
Out[115]:
   A
---
e  2.0
```

(continues on next page)
9.5.3 Value counts (histogramming) / Mode

The `value_counts()` Series method and top-level function computes a histogram of a 1D array of values. It can also be used as a function on regular arrays:

```python
In [117]: data = np.random.randint(0, 7, size=50)

In [118]: data
Out[118]:
array([3, 3, 0, 2, 1, 0, 5, 5, 3, 6, 1, 5, 6, 2, 0, 0, 6, 3, 3, 5, 0, 4, 3,
      3, 3, 0, 6, 1, 3, 5, 5, 0, 4, 0, 6, 3, 6, 5, 4, 3, 2, 1, 5, 0, 1, 1,
      6, 4, 1, 4])

In [119]: s = pd.Series(data)

In [120]: s.value_counts()
Out[120]:
3   11
0    9
5    8
6    7
1    7
4    5
2    3
dtype: int64

In [121]: pd.value_counts(data)
Out[121]:
3   11
0    9
5    8
6    7
1    7
4    5
2    3
dtype: int64
```

Similarly, you can get the most frequently occurring value(s) (the mode) of the values in a Series or DataFrame:

```python
In [122]: s5 = pd.Series([1, 1, 3, 3, 3, 5, 5, 7, 7, 7])

In [123]: s5.mode()
```
9.5.4 Discretization and quantiling

Continuous values can be discretized using the \texttt{cut()} (bins based on values) and \texttt{qcut()} (bins based on sample quantiles) functions:

\begin{verbatim}
In [126]: arr = np.random.randn(20)
In [127]: factor = pd.cut(arr, 4)
\end{verbatim}

\begin{verbatim}
Out[128]:
[(-2.611, -1.58], (0.473, 1.499], (-2.611, -1.58], (-1.58, -0.554], (-0.554, 0.473], ...
          , (0.473, 1.499], (0.473, 1.499], (-0.554, 0.473], (-0.554, 0.473]
Length: 20
Categories (4, interval[float64]): 
[(-2.611, -1.58] < (-1.58, -0.554] < (-0.554, 0.473] < (0.473, 1.499]]
\end{verbatim}

\begin{verbatim}
In [129]: factor = pd.cut(arr, [-5, -1, 0, 1, 5])
\end{verbatim}

\begin{verbatim}
In [130]: factor
Out[130]:
[(-5, -1], (0, 1], (-5, -1], (-1, 0], (-1, 0], ..., (1, 5], (1, 5], (-1, 0], (-1, 0], ...
          , (-1, 0], (1, 5]
Length: 20
Categories (4, interval[int64]): 
[(-5, -1] < (-1, 0] < (0, 1] < (1, 5]
\end{verbatim}

\texttt{qcut()} computes sample quantiles. For example, we could slice up some normally distributed data into equal-size quartiles like so:

\begin{verbatim}
In [131]: arr = np.random.randn(30)
In [132]: factor = pd.qcut(arr, [0, .25, .5, .75, 1])
\end{verbatim}

\begin{verbatim}
In [133]: factor
Out[133]:
[(0.544, 1.976], (0.544, 1.976], (-1.255, -0.375], (0.544, 1.976], (-0.103, 0.544], ...
          , (-0.103, 0.544], (0.544, 1.976], (-0.103, 0.544], (-1.255, -0.375], (-0.375, -0.
          103]]
Length: 30
\end{verbatim}
Categories (4, interval[float64]): [(-1.255, -0.375) < (-0.375, -0.103) < (-0.103, 0.544) < (0.544, 1.976)]

In [134]: pd.value_counts(factor)

\[...
Out[134]:

\[
\begin{align*}
0.544, 1.976] & 8 \\
(-1.255, -0.375] & 8 \\
(-0.103, 0.544] & 7 \\
(-0.375, -0.103] & 7 \\
dtype: int64
\end{align*}
\]

We can also pass infinite values to define the bins:

In [135]: arr = np.random.randn(20)

In [136]: factor = pd.cut(arr, [-np.inf, 0, np.inf])

In [137]: factor

Out[137]:

\[
\begin{align*}
(0.0, \inf], (0.0, \inf], (0.0, \inf], (0.0, \inf], (-\inf, 0.0], ..., (-\inf, 0.0], (-\inf, 0.0], (0.0, \inf] \\
\end{align*}
\]

Length: 20
Categories (2, interval[float64]): [(-inf, 0.0] < (0.0, inf]

9.6 Function application

To apply your own or another library’s functions to pandas objects, you should be aware of the three methods below. The appropriate method to use depends on whether your function expects to operate on an entire DataFrame or Series, row- or column-wise, or elementwise.

1. **Tablewise Function Application**: pipe()  
2. **Row or Column-wise Function Application**: apply()  
3. **Aggregation API**: agg() and transform()  
4. **Applying Elementwise Functions**: applymap()

9.6.1 Tablewise Function Application

DataFrames and Series can of course just be passed into functions. However, if the function needs to be called in a chain, consider using the pipe() method. Compare the following

```python
# f, g, and h are functions taking and returning "DataFrames"
>>> f(g(h(df), arg1=1), arg2=2, arg3=3)
```

with the equivalent

```python
>>> (df.pipe(h)
   .pipe(g, arg1=1)
   .pipe(f, arg2=2, arg3=3)
)
```
Pandas encourages the second style, which is known as method chaining. pipe makes it easy to use your own or another library’s functions in method chains, alongside pandas’ methods.

In the example above, the functions f, g, and h each expected the DataFrame as the first positional argument. What if the function you wish to apply takes its data as, say, the second argument? In this case, provide pipe with a tuple of (callable, data_keyword). pipe will route the DataFrame to the argument specified in the tuple.

For example, we can fit a regression using statsmodels. Their API expects a formula first and a DataFrame as the second argument, data. We pass in the function, keyword pair (sm.ols, 'data') to pipe:

```python
In [138]: import statsmodels.formula.api as sm
In [139]: bb = pd.read_csv('data/baseball.csv', index_col='id')
In [140]: (bb.query('h > 0')
.....: .assign(ln_h = lambda df: np.log(df.h))
.....: .pipe((sm.ols, 'data'), 'hr ~ ln_h + year + g + C(lg)')
.....: .fit()
.....: .summary()
.....: )
```

```
Out[140]:
<class 'statsmodels.iolib.summary.Summary'>

OLS Regression Results
==============================================================================
Dep. Variable: hr R-squared: 0.685
Model: OLS Adj. R-squared: 0.665
Method: Least Squares F-statistic: 34.28
Date: Thu, 05 Jul 2018 Prob (F-statistic): 3.48e-15
Time: 17:07:05 Log-Likelihood: -205.92
No. Observations: 68 AIC: 421.8
Df Residuals: 63 BIC: 432.9
Df Model: 4
Covariance Type: nonrobust
===============================================================================
coef std err      t    P>|t|      [0.025      0.975]
-------------------------------------------------------------------------------
Intercept  -8484.7720   4664.146  -1.819  0.074    -1.78e+04    835.780
C(lg)[T.NL]  -2.2736    1.325  -1.716  0.091     -4.922     0.375
ln_h  -1.3542    0.875  -1.547  0.127     -3.103     0.395
year  4.2277    2.324   1.819  0.074     -0.417     8.872
g  0.1841    0.029    6.258  0.000      0.125     0.243
-------------------------------------------------------------------------------
Omnibus: 10.875 Durbin-Watson: 1.999
Prob(Omnibus): 0.004 Jarque-Bera (JB): 17.298
Skew: 0.537 Prob(JB): 0.000175
Kurtosis: 5.225 Cond. No. 1.49e+07

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
    specified.
[2] The condition number is large, 1.49e+07. This might indicate that there are
    strong multicollinearity or other numerical problems.

```
We encourage you to view the source code of pipe().

### 9.6.2 Row or Column-wise Function Application

Arbitrary functions can be applied along the axes of a DataFrame using the apply() method, which, like the descriptive statistics methods, takes an optional axis argument:

```python
In [141]: df.apply(np.mean)
Out[141]:
<table>
<thead>
<tr>
<th></th>
<th>one</th>
<th>two</th>
<th>three</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.272211</td>
<td>0.667306</td>
<td>0.024661</td>
</tr>
<tr>
<td>dtype: float64</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In [142]: df.apply(np.mean, axis=1)
Out[142]:
<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.011457</td>
<td>0.558507</td>
<td>0.635781</td>
<td>-0.839603</td>
</tr>
<tr>
<td>dtype: float64</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In [143]: df.apply(lambda x: x.max() - x.min())
Out[143]:
<table>
<thead>
<tr>
<th></th>
<th>one</th>
<th>two</th>
<th>three</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.563773</td>
<td>2.973170</td>
<td>3.154112</td>
</tr>
<tr>
<td>dtype: float64</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In [144]: df.apply(np.cumsum)
Out[144]:
<table>
<thead>
<tr>
<th></th>
<th>one</th>
<th>two</th>
<th>three</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-1.101558</td>
<td>1.124472</td>
<td>NaN</td>
</tr>
<tr>
<td></td>
<td>-1.278848</td>
<td>3.611576</td>
<td>-0.634293</td>
</tr>
<tr>
<td></td>
<td>-0.816633</td>
<td>3.125511</td>
<td>1.296901</td>
</tr>
<tr>
<td></td>
<td>NaN</td>
<td>2.669223</td>
<td>0.073983</td>
</tr>
</tbody>
</table>
```

The apply() method will also dispatch on a string method name:

```python
In [145]: df.apply('mean')
Out[145]:
<table>
<thead>
<tr>
<th></th>
<th>one</th>
<th>two</th>
<th>three</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.272211</td>
<td>0.667306</td>
<td>0.024661</td>
</tr>
<tr>
<td>dtype: float64</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

(continues on next page)
The return type of the function passed to `apply()` affects the type of the final output from `DataFrame.apply` for the default behaviour:

- If the applied function returns a `Series`, the final output is a `DataFrame`. The columns match the index of the `Series` returned by the applied function.
- If the applied function returns any other type, the final output is a `Series`.

This default behaviour can be overridden using the `result_type`, which accepts three options: `reduce`, `broadcast`, and `expand`. These will determine how list-likes return values expand (or not) to a `DataFrame`.

`apply()` combined with some cleverness can be used to answer many questions about a data set. For example, suppose we wanted to extract the date where the maximum value for each column occurred:

```python
In [148]: tsdf = pd.DataFrame(np.random.randn(1000, 3), columns=['A', 'B', 'C'],
                       index=pd.date_range('1/1/2000', periods=1000))
In [149]: tsdf.apply(lambda x: x.idxmax())
```

```
Out[149]:
A  2001-04-25
B  2002-05-31
C  2002-09-25
dtype: datetime64[ns]
```

You may also pass additional arguments and keyword arguments to the `apply()` method. For instance, consider the following function you would like to apply:

```python
def subtract_and_divide(x, sub, divide=1):
    return (x - sub) / divide
```

You may then apply this function as follows:

```python
df.apply(subtract_and_divide, args=(5,), divide=3)
```

Another useful feature is the ability to pass `Series` methods to carry out some `Series` operation on each column or row:

```python
In [150]: tsdf
```

```
Out[150]:
     A        B        C
2000-01-01 -0.720299  0.546303 -0.082042
2000-01-02  0.200295 -0.577554 -0.908402
2000-01-03  0.102533  1.653614  0.303319
2000-01-04  NaN      NaN      NaN
2000-01-05  NaN      NaN      NaN
2000-01-06  NaN      NaN      NaN
2000-01-07  NaN      NaN      NaN
```

(continues on next page)
Finally, `apply()` takes an argument `raw` which is False by default, which converts each row or column into a Series before applying the function. When set to True, the passed function will instead receive an ndarray object, which has positive performance implications if you do not need the indexing functionality.

### 9.6.3 Aggregation API

New in version 0.20.0.

The aggregation API allows one to express possibly multiple aggregation operations in a single concise way. This API is similar across pandas objects, see `groupby API`, the `window functions API`, and the `resample API`. The entry point for aggregation is `DataFrame.aggregate()`, or the alias `DataFrame.agg()`.

We will use a similar starting frame from above:

```
In [152]: tsdf = pd.DataFrame(np.random.randn(10, 3), columns=['A', 'B', 'C'],
                           index=pd.date_range('1/1/2000', periods=10))

In [153]: tsdf.iloc[3:7] = np.nan

In [154]: tsdf
```

```
Out[154]:
              A         B         C
2000-01-01  0.170247 -0.916844  0.835024
2000-01-02  1.259919  0.801111  0.445614
2000-01-03  1.453046  2.430373  0.653093
2000-01-04   NaN        NaN        NaN
2000-01-05   NaN        NaN        NaN
2000-01-06   NaN        NaN        NaN
2000-01-07   NaN        NaN        NaN
2000-01-08 -1.874526  0.569822 -0.609644
2000-01-09  0.812462  0.565894 -1.461363
2000-01-10 -0.985475  1.388154 -0.078747
```

Using a single function is equivalent to `apply()`. You can also pass named methods as strings. These will return a Series of the aggregated output:

```python
In [151]: tsdf.apply(pd.Series.interpolate)
```

```
Out[151]:
             A         B         C
2000-01-01 -0.720299  0.546303 -0.082042
2000-01-02  0.200295 -0.577554 -0.908402
2000-01-03  0.102533  1.653614  0.303319
2000-01-04  0.188539  1.391201  0.272754
2000-01-05  0.274546  1.128788  0.242189
2000-01-06  0.360553  0.866374  0.211624
2000-01-07  0.446559  0.603961  0.181059
2000-01-08  0.532566  0.341548  0.150493
2000-01-09  0.624468  0.604838  0.181059
2000-01-10  0.716369  0.866374  0.211624
```

```
In [151]: tsdf.apply(pd.Series.interpolate, raw=True)
```

```
Out[151]:
             A         B         C
2000-01-01 -0.720299  0.546303 -0.082042
2000-01-02  0.200295 -0.577554 -0.908402
2000-01-03  0.102533  1.653614  0.303319
2000-01-04  0.188539  1.391201  0.272754
2000-01-05  0.274546  1.128788  0.242189
2000-01-06  0.360553  0.866374  0.211624
2000-01-07  0.446559  0.603961  0.181059
2000-01-08  0.532566  0.341548  0.150493
2000-01-09  0.624468  0.604838  0.181059
2000-01-10  0.716369  0.866374  0.211624
```
In [155]: tsdf.agg(np.sum)
Out[155]:
A  0.835673
B  4.838510
C -0.216025
dtype: float64

In [156]: tsdf.agg('sum')
Out[156]:
A  0.835673
B  4.838510
C -0.216025
dtype: float64

# these are equivalent to a `.sum()` because we are aggregating on a single function
In [157]: tsdf.sum()
Out[157]:
A  0.835673  
B  4.838510  
C -0.216025  
dtype: float64

Single aggregations on a Series this will return a scalar value:

In [158]: tsdf.A.agg('sum')
Out[158]: 0.83567297915820504

9.6.3.1 Aggregating with multiple functions

You can pass multiple aggregation arguments as a list. The results of each of the passed functions will be a row in the resulting DataFrame. These are naturally named from the aggregation function.

In [159]: tsdf.agg(['sum'])
Out[159]:
   A     B      C
sum 0.835673  4.838510 -0.216025

Multiple functions yield multiple rows:

In [160]: tsdf.agg(['sum', 'mean'])
Out[160]:
   A     B      C
sum 0.835673  4.838510 -0.216025
mean 0.139279  0.806418 -0.036004

On a Series, multiple functions return a Series, indexed by the function names:

In [161]: tsdf.A.agg(['sum', 'mean'])
Out[161]:
   sum     mean
Name: A, dtype: float64

Passing a lambda function will yield a `<lambda>` named row:
In [162]: tsdf.A.agg(['sum', lambda x: x.mean()])
Out[162]:
    sum 0.835673
    <lambda> 0.139279
Name: A, dtype: float64

Passing a named function will yield that name for the row:

In [163]: def mymean(x):
    .....:     return x.mean()
    .....:

In [164]: tsdf.A.agg(['sum', mymean])
Out[164]:
    sum 0.835673
    mymean 0.139279
Name: A, dtype: float64

### 9.6.3.2 Aggregating with a dict

Passing a dictionary of column names to a scalar or a list of scalars, to DataFrame.agg allows you to customize which functions are applied to which columns. Note that the results are not in any particular order, you can use an OrderedDict instead to guarantee ordering.

In [165]: tsdf.agg(dict('A': 'mean', 'B': 'sum'))
Out[165]:
    A 0.139279
    B 4.838510
dtype: float64

Passing a list-like will generate a DataFrame output. You will get a matrix-like output of all of the aggregators. The output will consist of all unique functions. Those that are not noted for a particular column will be NaN:

In [166]: tsdf.agg(dict('A': ['mean', 'min'], 'B': 'sum'))
Out[166]:
    A     B
    mean 0.139279 NaN
    min -1.874526 NaN
    sum NaN 4.83851

### 9.6.3.3 Mixed Dtypes

When presented with mixed dtypes that cannot aggregate, .agg will only take the valid aggregations. This is similar to how groupby .agg works.

In [167]: mdf = pd.DataFrame({'A': [1, 2, 3],
                   'B': [1., 2., 3.],
                   'C': ['foo', 'bar', 'baz'],
                   'D': pd.date_range('20130101', periods=3))

In [168]: mdf.dtypes
Out[168]:
          A  int64

(continues on next page)
B      float64  
C     object     
D    datetime64[ns]  
dtype: object

In [169]: mdf.agg(['min', 'sum'])
Out[169]:
   A    B     C     D
min 1.0  1.0  bar  2013-01-01
sum 6.0  6.0  foobarbaz       NaT

9.6.3.4 Custom describe

With `.agg()` is it possible to easily create a custom describe function, similar to the built in `describe` function.

In [170]: from functools import partial
In [171]: q_25 = partial(pd.Series.quantile, q=0.25)
In [172]: q_25.__name__ = '25%'
In [173]: q_75 = partial(pd.Series.quantile, q=0.75)
In [174]: q_75.__name__ = '75%'
In [175]: tsdf.agg(['count', 'mean', 'std', 'min', q_25, 'median', q_75, 'max'])
Out[175]:
   A       B       C
count  6.000000  6.000000  6.000000
mean   0.139279  0.806418 -0.036004
std    1.323362  1.100830  0.874990
min   -1.874526 -0.916844 -1.461363
25%   -0.696544  0.566876 -0.476920
median 0.491354  0.685467  0.183433
75%   1.148055  1.241393  0.601223
max   1.453046  2.430373  0.835024

9.6.4 Transform API

New in version 0.20.0.

The `transform()` method returns an object that is indexed the same (same size) as the original. This API allows you to provide multiple operations at the same time rather than one-by-one. Its API is quite similar to the `.agg` API.

We create a frame similar to the one used in the above sections.

In [176]: tsdf = pd.DataFrame(np.random.randn(10, 3), columns=['A', 'B', 'C'],
                         index=pd.date_range('1/1/2000', periods=10))
In [177]: tsdf.iloc[3:7] = np.nan
In [178]: tsdf
Out[178]:
   A       B       C
0  0.046130 -0.431515  0.830173
1  0.732372  0.367200  0.084369
2 -0.186271  0.429106 -0.292791
3  1.069902  0.466821 -0.316469
4  0.232460  0.092117 -0.626224
5 -1.177275 -0.081943  0.987846
6 -0.177268  0.072035 -0.032987
7  1.149230 -0.162028  0.591057
8 -0.733425 -0.888261  0.001652
9 -2.224104 -1.563507  0.168814

(continues on next page)
Transform the entire frame. `.transform()` allows input functions as: a NumPy function, a string function name or a user defined function.

In [179]: tsdf.transform(np.abs)

Out[179]:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-01</td>
<td>0.578465</td>
<td>0.503335</td>
</tr>
<tr>
<td>2000-01-02</td>
<td>0.767147</td>
<td>0.266046</td>
</tr>
<tr>
<td>2000-01-03</td>
<td>0.195348</td>
<td>0.722247</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>2000-01-06</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>2000-01-07</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>2000-01-08</td>
<td>0.556397</td>
<td>0.542165</td>
</tr>
<tr>
<td>2000-01-09</td>
<td>-1.010924</td>
<td>-0.672504</td>
</tr>
<tr>
<td>2000-01-10</td>
<td>0.354653</td>
<td>0.563622</td>
</tr>
</tbody>
</table>

In [180]: tsdf.transform('abs')

In [181]: tsdf.transform(lambda x: x.abs())

9.6. Function application
Here `transform()` received a single function; this is equivalent to a ufunc application.

```python
In [182]: np.abs(tsdf)
Out[182]:
         A         B         C
2000-01-01  0.578465  0.503335  0.987140
2000-01-02  0.767147  0.266046  1.083797
2000-01-03  0.195348  0.722247  0.894537
2000-01-04  NaN      NaN      NaN
2000-01-05  NaN      NaN      NaN
2000-01-06  NaN      NaN      NaN
2000-01-07  NaN      NaN      NaN
2000-01-08  0.556397  0.542165  0.308675
2000-01-09  1.010924  0.672504  1.139222
2000-01-10  0.354653  0.563622  0.365106
Freq: D, Name: A, dtype: float64
```

Passing a single function to `.transform()` with a `Series` will yield a single `Series` in return.

```python
In [183]: tsdf.A.transform(np.abs)
Out[183]:
         A
2000-01-01  0.578465
2000-01-02  0.767147
2000-01-03  0.195348
2000-01-04  NaN
2000-01-05  NaN
2000-01-06  NaN
2000-01-07  NaN
2000-01-08  0.556397
2000-01-09  1.010924
2000-01-10  0.354653
Freq: D, Name: A, dtype: float64
```

### 9.6.4.1 Transform with multiple functions

Passing multiple functions will yield a column multi-indexed DataFrame. The first level will be the original frame column names; the second level will be the names of the transforming functions.

```python
In [184]: tsdf.transform([np.abs, lambda x: x+1])
Out[184]:
            A          B          C
        absolute <lambda> absolute <lambda> absolute <lambda>
2000-01-01  0.578465  0.421535  0.503335  0.496665  0.987140  0.012860
2000-01-02  0.767147  0.232853  0.266046  0.733954  1.083797  2.083797
2000-01-03  0.195348  1.195348  0.722247  1.722247  0.894537  0.105463
2000-01-04  NaN      NaN      NaN      NaN      NaN      NaN
2000-01-05  NaN      NaN      NaN      NaN      NaN      NaN
2000-01-06  NaN      NaN      NaN      NaN      NaN      NaN
2000-01-07  NaN      NaN      NaN      NaN      NaN      NaN
2000-01-08  0.556397  0.443603  0.542165  1.542165  0.308675  0.691325
2000-01-09  1.010924  1.010924  0.672504  0.327496  1.139222  2.139222
2000-01-10  0.354653  1.354653  0.563622  1.563622  0.365106  0.634894
```
Passing multiple functions to a Series will yield a DataFrame. The resulting column names will be the transforming functions.

```python
In [185]: tsdf.A.transform([np.abs, lambda x: x+1])
Out[185]:
          absolute <lambda>
2000-01-01  0.578465  0.421535
2000-01-02  0.767147  0.232853
2000-01-03  0.195348  1.195348
2000-01-04  NaN         NaN
2000-01-05  NaN         NaN
2000-01-06  NaN         NaN
2000-01-07  NaN         NaN
2000-01-08  0.556397  0.443603
2000-01-09  1.010924 -0.010924
2000-01-10  0.354653  1.354653
```

### 9.6.4.2 Transferring with a dict

Passing a dict of functions will allow selective transforming per column.

```python
In [186]: tsdf.transform({'A': np.abs, 'B': lambda x: x+1})
Out[186]:
     A  B
2000-01-01  0.578465  0.496665
2000-01-02  0.767147  0.733954
2000-01-03  0.195348  1.722247
2000-01-04  NaN       NaN
2000-01-05  NaN       NaN
2000-01-06  NaN       NaN
2000-01-07  NaN       NaN
2000-01-08  0.556397  1.542165
2000-01-09  1.010924  0.327496
2000-01-10  0.354653  1.563622
```

Passing a dict of lists will generate a multi-indexed DataFrame with these selective transforms.

```python
In [187]: tsdf.transform({'A': np.abs, 'B': [lambda x: x+1, 'sqrt']})
Out[187]:
     A  B
2000-01-01  0.578465  0.496665   NaN
2000-01-02  0.767147  0.733954   NaN
2000-01-03  0.195348  1.722247  0.849851
2000-01-04  NaN       NaN       NaN
2000-01-05  NaN       NaN       NaN
2000-01-06  NaN       NaN       NaN
2000-01-07  NaN       NaN       NaN
2000-01-08  0.556397  1.542165  0.750748
2000-01-09  1.010924  0.327496   NaN
2000-01-10  0.354653  1.563622  0.750748
```

### 9.6.5 Applying Elementwise Functions

Since not all functions can be vectorized (accept NumPy arrays and return another array or value), the methods `applymap()` on DataFrame and analogously `map()` on Series accept any Python function taking a single value and...
returning a single value. For example:

```python
In [188]: df4
Out[188]:
    one     two     three
   a -1.101558  1.124472  NaN
   b -0.177289  2.487104 -0.634293
   c  0.462215 -0.486066  1.931194
   d  NaN -0.456288 -1.222918
```

```python
In [189]: f = lambda x: len(str(x))
In [190]: df4['one'].map(f)
Out[190]:
   a    19
   b    20
   c    18
   d     3
Name: one, dtype: int64
```

```python
In [191]: df4.applymap(f)
Out[191]:
     one     two     three
   a    19    18      3
   b    20    18     19
   c    18    20    18
   d     3    19     19
```

*Series.map()* has an additional feature; it can be used to easily “link” or “map” values defined by a secondary series. This is closely related to *merging/joining functionality*:

```python
In [192]: s = pd.Series(['six', 'seven', 'six', 'seven', 'six'],
                   index=['a', 'b', 'c', 'd', 'e'])
In [193]: t = pd.Series({'six' : 6., 'seven' : 7.})
In [194]: s
Out[194]:
   a  six
   b  seven
   c  six
   d  seven
   e  six
   dtype: object
In [195]: s.map(t)
Out[195]:
   a    6.0
   b    7.0
   c    6.0
   d    7.0
   e    6.0
   dtype: float64
```
9.6.6 Applying with a Panel

Applying with a Panel will pass a Series to the applied function. If the applied function returns a Series, the result of the application will be a Panel. If the applied function reduces to a scalar, the result of the application will be a DataFrame.

In [196]: import pandas.util.testing as tm

In [197]: panel = tm.makePanel(5)

In [198]: panel
Out[198]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: A to D

In [199]: panel['ItemA']

A transformational apply.

In [200]: result = panel.apply(lambda x: x*2, axis='items')

In [201]: result
Out[201]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: A to D

In [202]: result['ItemA']

A reduction operation.

In [203]: panel.apply(lambda x: x.dtype, axis='items')
Out[203]:
   A        B        C        D
2000-01-03 float64  float64  float64  float64
2000-01-04 float64  float64  float64  float64
2000-01-05 float64  float64  float64  float64

(continues on next page)
A similar reduction type operation.

```
In [204]: panel.apply(lambda x: x.sum(), axis='major_axis')
```

```
Out[204]:
    ItemA  ItemB  ItemC
A    1.841893  0.918017 -1.160547
B    3.488158 -2.629773  0.603397
C   -3.164692  0.805970  0.806501
D    0.653349 -0.152299  0.252577
```

This last reduction is equivalent to:

```
In [205]: panel.sum('major_axis')
```

```
Out[205]:
    ItemA  ItemB  ItemC
A    1.841893  0.918017 -1.160547
B    3.488158 -2.629773  0.603397
C   -3.164692  0.805970  0.806501
D    0.653349 -0.152299  0.252577
```

A transformation operation that returns a Panel, but is computing the z-score across the major_axis.

```
In [206]: result = panel.apply(
.....:     lambda x: (x-x.mean())/x.std(),
.....:     axis='major_axis')
```

```
In [207]: result
```

```
Out[207]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 5 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-07 00:00:00
Minor_axis axis: A to D
```

```
In [208]: result['ItemA']
```

```
    A  B  C  D
2000-01-03  0.585813 -0.102070 -1.394063  0.201263
2000-01-04 -1.496089 -1.295066  0.434343  1.318766
2000-01-05  1.142642  1.413112  0.661833 -0.431942
2000-01-06 -0.323445 -0.405085 -0.683386  0.305017
2000-01-07  0.091079  0.389108  0.981273 -1.393105
```

Apply can also accept multiple axes in the axis argument. This will pass a DataFrame of the cross-section to the applied function.

```
In [209]: f = lambda x: ((x.T-x.mean(1))/x.std(1)).T
```

```
In [210]: result = panel.apply(f, axis = ['items','major_axis'])
```

```
In [211]: result
```

```
(continues on next page)
```
9.7 Reindexing and altering labels

`reindex()` is the fundamental data alignment method in pandas. It is used to implement nearly all other features relying on label-alignment functionality. To `reindex` means to conform the data to match a given set of labels along a particular axis. This accomplishes several things:

- Reorders the existing data to match a new set of labels
- Inserts missing value (NA) markers in label locations where no data for that label existed
- If specified, fill data for missing labels using logic (highly relevant to working with time series data)

Here is a simple example:
Here, the \textit{f} label was not contained in the Series and hence appears as \textit{NaN} in the result.

With a DataFrame, you can simultaneously reindex the index and columns:

You may also use \texttt{reindex} with an \textit{axis} keyword:

Note that the \texttt{Index} objects containing the actual axis labels can be \texttt{shared} between objects. So if we have a Series and a DataFrame, the following can be done:

\begin{Verbatim}
In [222]: rs = s.reindex(df.index)
In [223]: rs
Out[223]:
\end{Verbatim}
This means that the reindexed Series’s index is the same Python object as the DataFrame’s index.

New in version 0.21.0.

`DataFrame.reindex()` also supports an “axis-style” calling convention, where you specify a single `labels` argument and the `axis` it applies to.

```
In [225]: df.reindex(['c', 'f', 'b'], axis='index')
Out[225]:
   one  two  three
c 0.462215 -0.486066 1.931194
f NaN    NaN   NaN
b -0.177289 2.487104 -0.634293
```

```
In [226]: df.reindex(['three', 'two', 'one'], axis='columns')
```

See also:

*MultiIndex / Advanced Indexing* is an even more concise way of doing reindexing.

---

**Note:** When writing performance-sensitive code, there is a good reason to spend some time becoming a reindexing ninja: *many operations are faster on pre-aligned data*. Adding two unaligned DataFrames internally triggers a reindexing step. For exploratory analysis you will hardly notice the difference (because `reindex` has been heavily optimized), but when CPU cycles matter sprinkling a few explicit `reindex` calls here and there can have an impact.

### 9.7.1 Reindexing to align with another object

You may wish to take an object and reindex its axes to be labeled the same as another object. While the syntax for this is straightforward albeit verbose, it is a common enough operation that the `reindex_like()` method is available to make this simpler:

```
In [227]: df2
Out[227]:
   one  two
a -1.101558 1.124472
b -0.634293 2.487104
```

```
In [228]: df3
```

(continues on next page)
9.7.2 Aligning objects with each other with align

The `align()` method is the fastest way to simultaneously align two objects. It supports a `join` argument (related to joining and merging):

- `join='outer'`: take the union of the indexes (default)
- `join='left'`: use the calling object’s index
- `join='right'`: use the passed object’s index
- `join='inner'`: intersect the indexes

It returns a tuple with both of the reindexed Series:

```python
In [230]: s = pd.Series(np.random.randn(5), index=['a', 'b', 'c', 'd', 'e'])
In [231]: s1 = s[:4]
In [232]: s2 = s[1:]
In [233]: s1.align(s2)
```

```
Out[233]:
(a 0.505453
 b 1.788110
 c -0.405908
d -0.801912
 e NaN          
           dtype: float64, a NaN
           b 1.788110
           c -0.405908
d -0.801912
e 0.768460      
           dtype: float64)
```

```python
In [234]: s1.align(s2, join='inner')
```

```
Out[234]:
(b 1.788110
 c -0.405908
d -0.801912
           dtype: float64, b 1.788110
           c -0.405908
           d -0.801912
```
In [235]: s1.align(s2, join='left')

\n\n
Out[235]:
\n\n
( a  0.505453
 b  1.788110
c -0.405908
d -0.801912
dtype: float64)

For DataFrames, the join method will be applied to both the index and the columns by default:

In [236]: df.align(df2, join='inner')

Out[236]:

( one two
 a -1.101558  1.124472
 b -0.177289  2.487104
c  0.462215 -0.486066, one two
 a -1.101558  1.124472
 b -0.177289  2.487104
c  0.462215 -0.486066)

You can also pass an axis option to only align on the specified axis:

In [237]: df.align(df2, join='inner', axis=0)

Out[237]:

( one two three
 a -1.101558 NaN  1.124472
 b -0.177289 -0.634293  2.487104
c  0.462215  1.931194 NaN, one two
 a -1.101558  1.124472
 b -0.177289  2.487104
c  0.462215 -0.486066)

If you pass a Series to DataFrame.align(), you can choose to align both objects either on the DataFrame’s index or columns using the axis argument:

In [238]: df.align(df2.iloc[0], axis=1)

Out[238]:

( one three two
 a -1.101558 NaN  1.124472
 b -0.177289 -0.634293  2.487104
c  0.462215  1.931194 -0.456288, one two
 a -1.101558  1.124472
 b -0.177289  2.487104
c  0.462215 -0.486066)

9.7. Reindexing and altering labels

627
9.7.3 Filling while reindexing

`reindex()` takes an optional parameter `method` which is a filling method chosen from the following table:

<table>
<thead>
<tr>
<th>Method</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>pad / ffill</td>
<td>Fill values forward</td>
</tr>
<tr>
<td>bfill / backfill</td>
<td>Fill values backward</td>
</tr>
<tr>
<td>nearest</td>
<td>Fill from the nearest index value</td>
</tr>
</tbody>
</table>

We illustrate these fill methods on a simple Series:

```
In [239]: rng = pd.date_range('1/3/2000', periods=8)
In [240]: ts = pd.Series(np.random.randn(8), index=rng)
In [241]: ts2 = ts[[0, 3, 6]]
In [242]: ts
Out[242]:
2000-01-03  0.466284
2000-01-04  0.457411
2000-01-05 -0.364060
2000-01-06  0.785367
2000-01-07 -1.463093
2000-01-08  1.187315
2000-01-09 -0.493153
2000-01-10 -1.323445
Freq: D, dtype: float64
```

```
In [243]: ts2
→
2000-01-03  0.466284
2000-01-06  0.785367
2000-01-09 -0.493153
dtype: float64
```

```
In [244]: ts2.reindex(ts.index)
→
2000-01-03  0.466284
2000-01-04  NaN
2000-01-05  NaN
2000-01-06  0.785367
2000-01-07  NaN
2000-01-08  NaN
2000-01-09 -0.493153
2000-01-10  NaN
Freq: D, dtype: float64
```

```
In [245]: ts2.reindex(ts.index, method='ffill')
→
2000-01-03  0.466284
2000-01-04  0.466284
2000-01-05  0.466284
2000-01-06  0.785367
```

(continues on next page)
2000-01-07  0.785367
2000-01-08  0.785367
2000-01-09  -0.493153
2000-01-10  -0.493153
Freq: D, dtype: float64

In [246]: ts2.reindex(ts.index, method='bfill')

    2000-01-03  0.466284
    2000-01-04  0.466284
    2000-01-05  0.785367
    2000-01-06  0.785367
    2000-01-07  -0.493153
    2000-01-08  -0.493153
    2000-01-09  NaN
    2000-01-10  NaN
Freq: D, dtype: float64

In [247]: ts2.reindex(ts.index, method='nearest')

    2000-01-03  0.466284
    2000-01-04  0.466284
    2000-01-05  0.466284
    2000-01-06  0.785367
    2000-01-07  0.785367
    2000-01-08  -0.493153
    2000-01-09  -0.493153
    2000-01-10  -0.493153
Freq: D, dtype: float64

These methods require that the indexes are ordered increasing or decreasing.

Note that the same result could have been achieved using `fillna` (except for method='nearest') or `interpolate`:

In [248]: ts2.reindex(ts.index).fillna(method='ffill')

Out[248]:
    2000-01-03  0.466284
    2000-01-04  0.466284
    2000-01-05  0.466284
    2000-01-06  0.785367
    2000-01-07  0.785367
    2000-01-08  -0.493153
    2000-01-09  -0.493153
    2000-01-10  -0.493153
Freq: D, dtype: float64

`reindex()` will raise a ValueError if the index is not monotonically increasing or decreasing. `fillna()` and `interpolate()` will not perform any checks on the order of the index.

### 9.7.4 Limits on filling while reindexing

The `limit` and `tolerance` arguments provide additional control over filling while reindexing. Limit specifies the maximum count of consecutive matches:
In [249]: ts2.reindex(ts.index, method='ffill', limit=1)
Out[249]:
2000-01-03 0.466284
2000-01-04 0.466284
2000-01-05 NaN
2000-01-06 0.785367
2000-01-07 0.785367
2000-01-08 NaN
2000-01-09 -0.493153
2000-01-10 -0.493153
Freq: D, dtype: float64

In contrast, tolerance specifies the maximum distance between the index and indexer values:

In [250]: ts2.reindex(ts.index, method='ffill', tolerance='1 day')
Out[250]:
2000-01-03 0.466284
2000-01-04 0.466284
2000-01-05 NaN
2000-01-06 0.785367
2000-01-07 0.785367
2000-01-08 NaN
2000-01-09 -0.493153
2000-01-10 -0.493153
Freq: D, dtype: float64

Notice that when used on a DatetimeIndex, TimedeltaIndex or PeriodIndex, tolerance will coerced into a Timedelta if possible. This allows you to specify tolerance with appropriate strings.

### 9.7.5 Dropping labels from an axis

A method closely related to reindex is the drop() function. It removes a set of labels from an axis:

In [251]: df
Out[251]:
   one   two   three
a -1.101558 1.124472 NaN
b -0.177289 2.487104 -0.634293
c 0.462215 -0.486066 1.931194
d NaN -0.456288 -1.222918

In [252]: df.drop(['a', 'd'], axis=0)
Out[252]:
   one   two   three
b -0.177289 2.487104 -0.634293
c 0.462215 -0.486066 1.931194

In [253]: df.drop(['one'], axis=1)
Out[253]:
   two   three
a 1.124472 NaN
b 2.487104 -0.634293
c -0.486066 1.931194
d -0.456288 -1.222918

Chapter 9. Essential Basic Functionality
Note that the following also works, but is a bit less obvious / clean:

```python
In [254]: df.reindex(df.index.difference(['a', 'd']))
Out[254]:
         one    two    three
b  -0.177289  2.487104 -0.634293
c   0.462215 -0.486066  1.931194
```

### 9.7.6 Renaming / mapping labels

The `rename()` method allows you to relabel an axis based on some mapping (a dict or Series) or an arbitrary function.

```python
In [255]: s
Out[255]:
a    0.505453
b    1.788110
c   -0.405908
d   -0.801912
e    0.768460
dtype: float64
In [256]: s.rename(str.upper)
    →
       A   0.505453  
       B    1.788110
       C   -0.405908
       D   -0.801912
       E    0.768460
dtype: float64
```

If you pass a function, it must return a value when called with any of the labels (and must produce a set of unique values). A dict or Series can also be used:

```python
In [257]: df.rename(columns={'one': 'foo', 'two': 'bar'},
       index={'a': 'apple', 'b': 'banana', 'd': 'durian'})
Out[257]:
         foo    bar    three
apple -1.101558  1.124472   NaN
banana -0.177289  2.487104 -0.634293
c  0.462215 -0.486066  1.931194
durian   NaN   -0.456288  1.222918
```

If the mapping doesn’t include a column/index label, it isn’t renamed. Note that extra labels in the mapping don’t throw an error.

New in version 0.21.0.

`DataFrame.rename()` also supports an “axis-style” calling convention, where you specify a single `mapper` and the `axis` to apply that mapping to.

```python
In [258]: df.rename({'one': 'foo', 'two': 'bar'}, axis='columns')
Out[258]:
         foo    bar    three
a -1.101558  1.124472   NaN
b -0.177289  2.487104 -0.634293
```

(continues on next page)
The `rename()` method also provides an `inplace` named parameter that is by default `False` and copies the underlying data. Pass `inplace=True` to rename the data in place.

New in version 0.18.0.

Finally, `rename()` also accepts a scalar or list-like for altering the `Series.name` attribute.

```
In [260]: s.rename("scalar-name")
Out[260]:
a  0.505453  
b  1.788110  
c -0.405908  
d -0.801912  
e  0.768460  
Name: scalar-name, dtype: float64
```

The Panel class has a related `rename_axis()` class which can rename any of its three axes.

### 9.8 Iteration

The behavior of basic iteration over pandas objects depends on the type. When iterating over a Series, it is regarded as array-like, and basic iteration produces the values. Other data structures, like DataFrame and Panel, follow the dict-like convention of iterating over the “keys” of the objects.

In short, basic iteration (`for i in object`) produces:

- **Series**: values
- **DataFrame**: column labels
- **Panel**: item labels

Thus, for example, iterating over a DataFrame gives you the column names:

```
In [261]: df = pd.DataFrame({'col1': np.random.randn(3), 'col2': np.random.randn(3)})
     ....:
     .....:
     .....:
     index=['a', 'b', 'c'])
     ....:
     .....:
In [262]: for col in df:
     .....:
     .....:
     print(col)
     .....:
     >>> col1
     >>> col2
```
Pandas objects also have the dict-like `iteritems()` method to iterate over the (key, value) pairs.

To iterate over the rows of a DataFrame, you can use the following methods:

- **iterrows():** Iterate over the rows of a DataFrame as (index, Series) pairs. This converts the rows to Series objects, which can change the dtypes and has some performance implications.
- **itertuples():** Iterate over the rows of a DataFrame as namedtuples of the values. This is a lot faster than `iterrows()`, and is in most cases preferable to use to iterate over the values of a DataFrame.

**Warning:** Iterating through pandas objects is generally slow. In many cases, iterating manually over the rows is not needed and can be avoided with one of the following approaches:

- Look for a vectorized solution: many operations can be performed using built-in methods or NumPy functions, (boolean) indexing, ...
- When you have a function that cannot work on the full DataFrame/Series at once, it is better to use `apply()` instead of iterating over the values. See the docs on [function application](#).
- If you need to do iterative manipulations on the values but performance is important, consider writing the inner loop with cython or numba. See the [enhancing performance](#) section for some examples of this approach.

**Warning:** You should never modify something you are iterating over. This is not guaranteed to work in all cases. Depending on the data types, the iterator returns a copy and not a view, and writing to it will have no effect!

For example, in the following case setting the value has no effect:

```python
In [263]: df = pd.DataFrame({'a': [1, 2, 3], 'b': ['a', 'b', 'c']})

In [264]: for index, row in df.iterrows():
   ...:     row['a'] = 10
   ...:

In [265]: df
Out[265]:
   a  b
0  1  a
1  2  b
2  3  c
```

### 9.8.1 `iteritems`

Consistent with the dict-like interface, `iteritems()` iterates through key-value pairs:

- **Series:** (index, scalar value) pairs
- **DataFrame:** (column, Series) pairs
- **Panel:** (item, DataFrame) pairs

For example:

```python
In [266]: for item, frame in wp.iteritems():
   ...:     print(item)
   ...:     print(frame)
   ...:
(continues on next page)
```
9.8.2 iterrows

iterrows() allows you to iterate through the rows of a DataFrame as Series objects. It returns an iterator yielding each index value along with a Series containing the data in each row:

```
In [267]: for row_index, row in df.iterrows():
    ..:      print('%s
    ..:      %s' % (row_index, row))
    ..:      
0
  a  1
  b  a
Name: 0, dtype: object
1
  a  2
  b  b
Name: 1, dtype: object
2
  a  3
  b  c
Name: 2, dtype: object
```

Note: Because iterrows() returns a Series for each row, it does not preserve dtypes across the rows (dtypes are preserved across columns for DataFrames). For example,

```
In [268]: df_orig = pd.DataFrame([[1, 1.5]], columns=['int', 'float'])

In [269]: df_orig.dtypes
Out[269]:
int       int64
float     float64
dtype: object

In [270]: row = next(df_orig.iterrows())[1]

In [271]: row
Out[271]:
int   1.0
float 1.5
Name: 0, dtype: float64
```
All values in `row`, returned as a Series, are now upcasted to floats, also the original integer value in column `x`:

```
In [272]: row['int'].dtype
Out[272]: dtype('float64')

In [273]: df_orig['int'].dtype
Out[273]: dtype('int64')
```

To preserve dtypes while iterating over the rows, it is better to use `itertuples()` which returns namedtuples of the values and which is generally much faster than `iterrows()`.

For instance, a contrived way to transpose the DataFrame would be:

```
In [274]: df2 = pd.DataFrame({'x': [1, 2, 3], 'y': [4, 5, 6]})

In [275]: print(df2)
   x  y
0 1 4
1 2 5
2 3 6

In [276]: print(df2.T)

In [277]: df2_t = pd.DataFrame([{idx: values} for idx, values in df2.iterrows()])

In [278]: print(df2_t)
   0 1
x 1 2
y 4 5
```

### 9.8.3 `itertuples`

The `itertuples()` method will return an iterator yielding a namedtuple for each row in the DataFrame. The first element of the tuple will be the row’s corresponding index value, while the remaining values are the row values.

For instance:

```
In [279]: for row in df.itertuples():
   ....:     print(row)
   ....:
Pandas(Index=0, a=1, b='a')
Pandas(Index=1, a=2, b='b')
Pandas(Index=2, a=3, b='c')
```

This method does not convert the row to a Series object; it merely returns the values inside a namedtuple. Therefore, `itertuples()` preserves the data type of the values and is generally faster as `iterrows()`.

**Note**: The column names will be renamed to positional names if they are invalid Python identifiers, repeated, or start with an underscore. With a large number of columns (>255), regular tuples are returned.
9.9 .dt accessor

Series has an accessor to succinctly return datetime like properties for the values of the Series, if it is a date-
time/period like Series. This will return a Series, indexed like the existing Series.

```python
# datetime
In [280]: s = pd.Series(pd.date_range('20130101 09:10:12', periods=4))

In [281]: s
Out[281]:
  0  2013-01-01 09:10:12
  1  2013-01-02 09:10:12
  2  2013-01-03 09:10:12
  3  2013-01-04 09:10:12
dtype: datetime64[ns]

In [282]: s.dt.hour
→
  0  9
  1  9
  2  9
  3  9
dtype: int64

In [283]: s.dt.second
→
  0  12
  1  12
  2  12
  3  12
dtype: int64

In [284]: s.dt.day
→
  0  1
  1  2
  2  3
  3  4
dtype: int64
```

This enables nice expressions like this:

```python
In [285]: s[s.dt.day==2]
Out[285]:
  1  2013-01-02 09:10:12
dtype: datetime64[ns]
```

You can easily produces tz aware transformations:

```python
In [286]: stz = s.dt.tz_localize('US/Eastern')

In [287]: stz
Out[287]:
  0  2013-01-01 09:10:12-05:00
```

(continues on next page)
You can also chain these types of operations:

```python
In [289]: s.dt.tz_localize('UTC').dt.tz_convert('US/Eastern')
```

```
Out[289]:
0  2013-01-01 04:10:12-05:00
1  2013-01-02 04:10:12-05:00
2  2013-01-03 04:10:12-05:00
3  2013-01-04 04:10:12-05:00
dtype: datetime64[ns, US/Eastern]
```

You can also format datetime values as strings with `Series.dt.strftime()` which supports the same format as the standard `strftime()`.

```python
# DatetimeIndex
In [290]: s = pd.Series(pd.date_range('20130101', periods=4))

In [291]: s
```

```
Out[291]:
0    2013-01-01
1    2013-01-02
2    2013-01-03
3    2013-01-04
dtype: datetime64[ns]
```

```python
In [292]: s.dt.strftime('%Y/%m/%d')
```

```
Out[292]:
0    2013/01/01
1    2013/01/02
2    2013/01/03
3    2013/01/04
```

```python
# PeriodIndex
In [293]: s = pd.Series(pd.period_range('20130101', periods=4))

In [294]: s
```

```
Out[294]:
0    2013-01-01
1    2013-01-02
2    2013-01-03
3    2013-01-04
```

```python
In [295]: s.dt.strftime('%Y/%m/%d')
```

```
Out[295]:
0    2013/01/01
1    2013/01/02
2    2013/01/03
3    2013/01/04
```

(continues on next page)
The `.dt` accessor works for period and timedelta dtypes.

```python
# period
In [296]: s = pd.Series(pd.period_range('20130101', periods=4, freq='D'))

In [297]: s
Out[297]:
0 2013-01-01
1 2013-01-02
2 2013-01-03
3 2013-01-04
dtype: object

In [298]: s.dt.year
Out[298]:
0 2013
1 2013
2 2013
3 2013
dtype: int64

In [299]: s.dt.day
Out[299]:
0 1
1 2
2 3
3 4
dtype: int64
```

```python
# timedelta
In [300]: s = pd.Series(pd.timedelta_range('1 day 00:00:05', periods=4, freq='s'))

In [301]: s
Out[301]:
0 1 days 00:00:05
1 1 days 00:00:06
2 1 days 00:00:07
3 1 days 00:00:08
dtype: timedelta64[ns]

In [302]: s.dt.days
Out[302]:
0 1
1 1
2 1
3 1
dtype: int64
```

(continues on next page)
In [303]: s.dt.seconds

Out[303]:
0   5
1   6
2   7
3   8
dtype: int64

In [304]: s.dt.components

Out[304]:
days hours minutes seconds milliseconds microseconds nanoseconds
0   1   0   0    5    0    0    0
1   1   0   0    6    0    0    0
2   1   0   0    7    0    0    0
3   1   0   0    8    0    0    0

Note: Series.dt will raise a TypeError if you access with a non-datetime-like values.

9.10 Vectorized string methods

Series is equipped with a set of string processing methods that make it easy to operate on each element of the array. Perhaps most importantly, these methods exclude missing/NA values automatically. These are accessed via the Series's str attribute and generally have names matching the equivalent (scalar) built-in string methods. For example:

In [305]: s = pd.Series(['A', 'B', 'C', 'Aaba', 'Baca', np.nan, 'CABA', 'dog ➾', 'cat'])

In [306]: s.str.lower()
Out[306]:
0   a
1   b
2   c
3  aaba
4   baca
5   NaN
6   caba
7    dog
8    cat
dtype: object

Powerful pattern-matching methods are provided as well, but note that pattern-matching generally uses regular expressions by default (and in some cases always uses them).

Please see Vectorized String Methods for a complete description.
9.11 Sorting

Pandas supports three kinds of sorting: sorting by index labels, sorting by column values, and sorting by a combination of both.

9.11.1 By Index

The `Series.sort_index()` and `DataFrame.sort_index()` methods are used to sort a pandas object by its index levels.

```python
In [307]: df = pd.DataFrame({'one' : pd.Series(np.random.randn(3), index=['a', 'b', 'c
˓→']),
                   'two' : pd.Series(np.random.randn(4), index=['a', 'b', 'c
˓→', 'd']),
                   'three' : pd.Series(np.random.randn(3), index=['b', 'c',
˓→', 'd']))
.....:
In [308]: unsorted_df = df.reindex(index=['a', 'd', 'c', 'b'],
                         columns=['three', 'two', 'one'])
.....:
In [309]: unsorted_df
Out[309]:
    three  two  one
   a  NaN  0.708543  0.036274
   d -0.540166  0.586626  NaN
   c  0.410238  1.121731  1.044630
   b -0.282532 -2.038777 -0.490032

# DataFrame
In [310]: unsorted_df.sort_index()

Out[310]:
    three  two  one
   a  NaN  0.708543  0.036274
   d -0.540166  0.586626  NaN
   c  0.410238  1.121731  1.044630
   b -0.282532 -2.038777 -0.490032

In [311]: unsorted_df.sort_index(ascending=False)

Out[311]:
    three  two  one
   d -0.540166  0.586626  NaN
   c  0.410238  1.121731  1.044630
   b -0.282532 -2.038777 -0.490032
   a  NaN  0.708543  0.036274

In [312]: unsorted_df.sort_index(axis=1)

Out[312]:
    one  three  two
   a  0.036274  NaN  0.708543
   d  NaN -0.540166  0.586626
   c  1.044630  0.410238  1.121731
```
# Series

In [313]: unsorted_df['three'].sort_index()

Out[313]:
   a    NaN
   b -0.282532
   c  0.410238
   d -0.540166
Name: three, dtype: float64

## 9.11.2 By Values

The `Series.sort_values()` method is used to sort a `Series` by its values. The `DataFrame.sort_values()` method is used to sort a `DataFrame` by its column or row values. The optional `by` parameter to `DataFrame.sort_values()` may used to specify one or more columns to use to determine the sorted order.

In [314]: df1 = pd.DataFrame({'one':[2,1,1,1],'two':[1,3,2,4],'three':[5,4,3,2]})

In [315]: df1.sort_values(by='two')
Out[315]:
   one two three
0  2  1   5
2  1  2   3
1  1  3   4
3  1  4   2

The `by` parameter can take a list of column names, e.g.:

In [316]: df1[['one', 'two', 'three']].sort_values(by=['one','two'])
Out[316]:
   one two three
2  1  2   3
1  1  3   4
3  1  4   2
0  2  1   5

These methods have special treatment of NA values via the `na_position` argument:

In [317]: s[2] = np.nan

In [318]: s.sort_values()
Out[318]:
0     A
3   Aaba
1      B
4    Baca
6     CABA
8      cat
7      dog
2   NaN
5     NaN
dtype: object
9.11.3 By Indexes and Values

New in version 0.23.0.

Strings passed as the by parameter to `DataFrame.sort_values()` may refer to either columns or index level names.

```python
# Build MultiIndex
In [320]: idx = pd.MultiIndex.from_tuples([('a', 1), ('a', 2), ('a', 2),
                                        ('b', 2), ('b', 1), ('b', 1)],
                                        names=['first', 'second'])

# Build DataFrame
In [321]: df_multi = pd.DataFrame({'A': np.arange(6, 0, -1)},
                                        index=idx)

In [322]: df_multi
Out[322]:
   A
first second
a  1   6
  2   5
  2   4
b  2   3
  1   2
  1   1

Sort by ‘second’ (index) and ‘A’ (column)

In [323]: df_multi.sort_values(by=['second', 'A'])
Out[323]:
   A
first second
b  1   1
  1   2
a  1   6
b  2   3
a  2   4
  2   5
```
**Note:** If a string matches both a column name and an index level name then a warning is issued and the column takes precedence. This will result in an ambiguity error in a future version.

### 9.11.4 searchsorted

Series has the `searchsorted()` method, which works similarly to `numpy.ndarray.searchsorted()`.

```python
In [325]: ser = pd.Series([1, 2, 3])
In [326]: ser.searchsorted([0, 3])
Out[326]: array([0, 2])
In [327]: ser.searchsorted([0, 4])
Out[327]: array([0, 3])
In [328]: ser.searchsorted([1, 3], side='right')
Out[328]: array([1, 3])
In [329]: ser.searchsorted([1, 3], side='left')
Out[329]: array([0, 2])
In [330]: ser = pd.Series([3, 1, 2])
In [331]: ser.searchsorted([0, 3], sorter=np.argsort(ser))
Out[331]: array([0, 2])
```

### 9.11.5 smallest / largest values

Series has the `nsmallest()` and `nlargest()` methods which return the smallest or largest $n$ values. For a large Series this can be much faster than sorting the entire Series and calling `head(n)` on the result.

```python
In [332]: s = pd.Series(np.random.permutation(10))
In [333]: s
Out[333]:
0     8
1     2
2     9
3     5
4     6
5     0
6     1
7     7
8     4
9     3
dtype: int64
In [334]: s.sort_values()
Out[334]:
5     0
6     1
```

(continues on next page)
In [335]: s.nsmallest(3)
Out[335]:
\n→
5 0
6 1
1 2
dtype: int64

In [336]: s.nlargest(3)
Out[336]:
\n→
2 9
0 8
7 7
dtype: int64

Dataframe also has the `nlargest` and `nsmallest` methods.

In [337]: df = pd.DataFrame({
'a': [-2, -1, 1, 10, 8, 11, -1],
.....:
'b': list('abdceff'),
.....:
'c': [1.0, 2.0, 4.0, 3.2, np.nan, 3.0, 4.0]})

In [338]: df.nlargest(3, 'a')
Out[338]:
       a  b  c
5  11  f  3.0
3  10  c  3.2
4   8  e  NaN

In [339]: df.nlargest(5, ['a', 'c'])
Out[339]:
       a  b  c
6 -1  f  4.0
5  11  f  3.0
3  10  c  3.2
4   8  e  NaN
2   1  d  4.0

In [340]: df.nsmallest(3, 'a')
\n→
      a  b  c
0  -2  a  1.0
1  -1  b  2.0
6  -1  f  4.0
In [341]: df.nsmallest(5, ['a', 'c'])

→  

Out[341]:

→  

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a</td>
<td>b</td>
<td>c</td>
</tr>
<tr>
<td>0</td>
<td>-2</td>
<td>a</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>d</td>
<td>4.0</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>e</td>
<td>NaN</td>
</tr>
<tr>
<td>1</td>
<td>-1</td>
<td>b</td>
<td>2.0</td>
</tr>
<tr>
<td>6</td>
<td>-1</td>
<td>f</td>
<td>4.0</td>
</tr>
</tbody>
</table>

9.11.6 Sorting by a multi-index column

You must be explicit about sorting when the column is a multi-index, and fully specify all levels to by.

\begin{verbatim}
In [342]: df1.columns = pd.MultiIndex.from_tuples([('a','one'), ('a','two'), ('b','three')])

In [343]: df1.sort_values(by=('a','two'))
\end{verbatim}

Out[343]:

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>one</td>
<td>two</td>
<td>three</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

9.12 Copying

The copy() method on pandas objects copies the underlying data (though not the axis indexes, since they are immutable) and returns a new object. Note that it is seldom necessary to copy objects. For example, there are only a handful of ways to alter a DataFrame in-place:

- Inserting, deleting, or modifying a column.
- Assigning to the index or columns attributes.
- For homogeneous data, directly modifying the values via the values attribute or advanced indexing.

To be clear, no pandas method has the side effect of modifying your data; almost every method returns a new object, leaving the original object untouched. If the data is modified, it is because you did so explicitly.

9.13 dtypes

The main types stored in pandas objects are float, int, bool, datetime64[ns] and datetime64[ns, tz], timedelta[ns], category and object. In addition these dtypes have item sizes, e.g. int64 and int32. See Series with TZ for more detail on datetime64[ns, tz] dtypes.

A convenient dtypes attribute for DataFrame returns a Series with the data type of each column.
C = 'foo',
D = pd.Timestamp('20010102'),
E = pd.Series([1.0]*3).astype('float32'),
F = False,
G = pd.Series([1]*3,dtype='int8'))

In [345]: dft
Out[345]:
   A     B    C     D   E    F    G
0  0.809 1 foo 2001-01-02 1.0 False 1
1  0.128 1 foo 2001-01-02 1.0 False 1
2  0.776 1 foo 2001-01-02 1.0 False 1

In [346]: dft.dtypes
Out[346]:
A float64
B int64
C object
D datetime64[ns]
E float32
F bool
G int8
dtype: object

On a Series object, use the dtype attribute.

In [347]: dft['A'].dtype
Out[347]: dtype('float64')

If a pandas object contains data with multiple dtypes in a single column, the dtype of the column will be chosen to accommodate all of the data types (object is the most general).

# these ints are coerced to floats
In [348]: pd.Series([1, 2, 3, 4, 5, 6.])
Out[348]:
0    1.0
1    2.0
2    3.0
3    4.0
4    5.0
5    6.0
dtype: float64

# string data forces an object dtype
In [349]: pd.Series([1, 2, 3, 6., 'foo'])
Out[349]:
0    1
1    2
2    3
3    6
4    foo
dtype: object

The number of columns of each type in a DataFrame can be found by calling get_dtype_counts().
In [350]: dft.get_dtype_counts()
Out[350]:
float64 1
float32 1
int64 1
int8 1
datetime64[ns] 1
bool 1
object 1
dtype: int64

Numeric dtypes will propagate and can coexist in DataFrames. If a dtype is passed (either directly via the dtype keyword, a passed ndarray, or a passed Series), then it will be preserved in DataFrame operations. Furthermore, different numeric dtypes will NOT be combined. The following example will give you a taste.

In [351]: df1 = pd.DataFrame(np.random.randn(8, 1), columns=['A'], dtype='float32')
In [352]: df1
Out[352]:
     A
0  0.890400
1  0.283331
2 -0.303613
3 -1.192210
4  0.065420
5  0.455918
6  2.008328
7  0.188942

In [353]: df1.dtypes
A float32
dtype: object

In [354]: df2 = pd.DataFrame(dict( A = pd.Series(np.random.randn(8), dtype='float16'),
                          B = pd.Series(np.random.randn(8)),
                          C = pd.Series(np.array(np.random.randn(8), dtype='uint8')) ))

In [355]: df2
Out[355]:
     A       B     C
0 -0.454346  0.200071 255
1 -0.916504 -0.557756 255
2 -0.303613  1.492210 255
3 -0.149118  0.654200 255
4 -1.255918  0.455918 255
5  0.106098  0.188942 255
6  0.849045  0.916868 255
7 -0.021000 -0.949458 255

In [356]: df2.dtypes
A float16
(continues on next page)
### 9.13.1 defaults

By default integer types are `int64` and float types are `float64`, regardless of platform (32-bit or 64-bit). The following will all result in `int64` dtypes.

```python
In [357]: pd.DataFrame([1, 2], columns=['a']).dtypes
Out[357]:
da  int64
dtype: object

In [358]: pd.DataFrame({'a': [1, 2]}).dtypes
Out[358]:
a  int64
dtype: object

In [359]: pd.DataFrame({'a': 1}, index=list(range(2))).dtypes
Out[359]:
a  int64
dtype: object
```

Note that Numpy will choose *platform-dependent* types when creating arrays. The following **WILL** result in `int32` on 32-bit platform.

```python
In [360]: frame = pd.DataFrame(np.array([1, 2]))
```

### 9.13.2 upcasting

Types can potentially be *upcasted* when combined with other types, meaning they are promoted from the current type (e.g. `int` to `float`).

```python
In [361]: df3 = df1.reindex_like(df2).fillna(value=0.0) + df2

In [362]: df3
Out[362]:
   A          B          C
0  0.436054  0.200071  255.0
1 -0.633173 -0.557756  255.0
2  0.337012 -0.141988   0.0
3  1.483571 -0.174060   0.0
4  0.057555  0.258626   0.0
5  0.251695  0.941688   0.0
6  1.908231 -1.849045   0.0
7 -0.213158 -0.949458   0.0

In [363]: df3.dtypes
```

(continues on next page)
The `values` attribute on a DataFrame return the *lower-common-denominator* of the dtypes, meaning the dtype that can accommodate **ALL** of the types in the resulting homogeneous dtyped NumPy array. This can force some upcasting.

```
In [364]: df3.values.dtype
Out[364]: dtype('float64')
```

### 9.13.3 astype

You can use the `astype()` method to explicitly convert dtypes from one to another. These will by default return a copy, even if the dtype was unchanged (pass `copy=False` to change this behavior). In addition, they will raise an exception if the astype operation is invalid.

Upcasting is always according to the `numpy` rules. If two different dtypes are involved in an operation, then the more general one will be used as the result of the operation.

```
In [365]: df3
Out[365]:
    A      B      C
0  0.436054  0.200071  255.0
1 -0.633173 -0.557756  255.0
2  0.337012 -0.141988   0.0
3  1.483571 -0.174060   0.0
4  0.057555  0.258626   0.0
5  0.251695  0.941688   0.0
6  1.908231 -1.849045   0.0
7 -0.213158 -0.949458   0.0
```

```
In [366]: df3.dtypes
Out[366]:
A    float32
B    float64
C    float64
dtype: object
```

# conversion of dtypes
```
In [367]: df3.astype('float32').dtypes
```

```
In [368]: dft = pd.DataFrame({'a': [1,2,3], 'b': [4,5,6], 'c': [7, 8, 9]})

In [369]: dft[['a','b']] = dft[['a','b']].astype(np.uint8)

In [370]: dft
```

(continues on next page)
New in version 0.19.0.

Convert certain columns to a specific dtype by passing a dict to `astype()`.

```python
In [372]: dft1 = pd.DataFrame({'a': [1,0,1], 'b': [4,5,6], 'c': [7, 8, 9]})
In [373]: dft1 = dft1.astype({'a': np.bool, 'c': np.float64})
```

```
Out[374]:
   a  b  c
0   True  4  7.0
1   False  5  8.0
2   True  6  9.0
```

```python
In [375]: dft1.dtypes
```

```
˓→
a  bool
b  int64
c  float64
dtype: object
```

**Note:** When trying to convert a subset of columns to a specified type using `astype()` and `loc()`, upcasting occurs. `loc()` tries to fit in what we are assigning to the current dtypes, while `[]` will overwrite them taking the dtype from the right hand side. Therefore the following piece of code produces the unintended result.

```python
In [376]: dft = pd.DataFrame({'a': [1,2,3], 'b': [4,5,6], 'c': [7, 8, 9]})
In [377]: dft.loc[:, ['a', 'b']].astype(np.uint8).dtypes
```

```
Out[377]:
a  uint8
b  uint8
dtype: object
```

```python
In [378]: dft.loc[:, ['a', 'b']] = dft.loc[:, ['a', 'b']].astype(np.uint8)
In [379]: dft.dtypes
```

```
Out[379]:
a  int64
b  int64
c  int64
```

(continues on next page)
9.13.4 object conversion

pandas offers various functions to try to force conversion of types from the object dtype to other types. In cases where the data is already of the correct type, but stored in an object array, the `DataFrame.infer_objects()` and `Series.infer_objects()` methods can be used to soft convert to the correct type.

```
In [380]: import datetime

In [381]: df = pd.DataFrame([[1, 2],
                     ['a', 'b'],
                     [datetime.datetime(2016, 3, 2), datetime.datetime(2016, 3, 2)]])

In [382]: df = df.T

In [383]: df
Out[383]:
     0    1
0  1 a  2016-03-02
1  2 b  2016-03-02

In [384]: df.dtypes
Out[384]:
0  object
1  object
2  object
dtype: object
```

Because the data was transposed the original inference stored all columns as object, which `infer_objects` will correct.

```
In [385]: df.infer_objects().dtypes
Out[385]:
0  int64
1  object
2  datetime64[ns]
dtype: object
```

The following functions are available for one dimensional object arrays or scalars to perform hard conversion of objects to a specified type:

- `to_numeric()` (conversion to numeric dtypes)
  - `In [386]: m = ['1.1', 2, 3]
  - `In [387]: pd.to_numeric(m)
  - `Out [387]: array([1.1, 2.0, 3.0])`

- `to_datetime()` (conversion to datetime objects)
To force a conversion, we can pass in an `errors` argument, which specifies how pandas should deal with elements that cannot be converted to desired dtype or object. By default, `errors='raise'`, meaning that any errors encountered will be raised during the conversion process. However, if `errors='coerce'`, these errors will be ignored and pandas will convert problematic elements to `pd.NaT` (for datetime and timedelta) or `np.nan` (for numeric). This might be useful if you are reading in data which is mostly of the desired dtype (e.g. numeric, datetime), but occasionally has non-conforming elements intermixed that you want to represent as missing:

```python
In [400]: import datetime
In [401]: m = ['apple', datetime.datetime(2016, 3, 2)]
In [402]: pd.to_datetime(m, errors='ignore')
Out[402]: array([  'apple', datetime.datetime(2016, 3, 2, 0, 0)], dtype=object)
In [403]: m = ['apple', 2, 3]
In [404]: pd.to_numeric(m, errors='ignore')
Out[404]: array(['apple', 2, 3], dtype=object)
In [405]: m = ['apple', pd.Timedelta('1day')]
```

The `errors` parameter has a third option of `errors='ignore'`, which will simply return the passed in data if it encounters any errors with the conversion to a desired data type:
In addition to object conversion, `to_numeric()` provides another argument `downcast`, which gives the option of
downcasting the newly (or already) numeric data to a smaller dtype, which can conserve memory:

```
In [407]: m = ['1', 2, 3]
In [408]: pd.to_numeric(m, downcast='integer')  # smallest signed int dtype
Out[408]: array([1, 2, 3], dtype=int8)
In [409]: pd.to_numeric(m, downcast='signed')  # same as 'integer'
Out[409]: array([1, 2, 3], dtype=int8)
In [410]: pd.to_numeric(m, downcast='unsigned')  # smallest unsigned int dtype
Out[410]: array([1, 2, 3], dtype=uint8)
In [411]: pd.to_numeric(m, downcast='float')  # smallest float dtype
Out[411]: array([ 1., 2., 3.], dtype=float32)
```

As these methods apply only to one-dimensional arrays, lists or scalars; they cannot be used directly on multi-
dimensional objects such as DataFrames. However, with `apply()`, we can “apply” the function over each column
efficiently:

```
In [412]: import datetime
In [413]: df = pd.DataFrame([['2016-07-09', datetime.datetime(2016, 3, 2)]] * 2, dtype='O')
In [414]: df
Out[414]:
   0     1
0 2016-07-09 2016-03-02 00:00:00
1 2016-07-09 2016-03-02 00:00:00
In [415]: df.apply(pd.to_datetime)
Out[415]:
   0     1
0 2016-07-09 2016-03-02
1 2016-07-09 2016-03-02
In [416]: df = pd.DataFrame([['1.1', 2, 3]] * 2, dtype='O')
In [417]: df
Out[417]:
   0     1     2
0   1.1   2.0   3.0
1   1.1   2.0   3.0
In [418]: df.apply(pd.to_numeric)
Out[418]:
   0     1     2
0   1.0   2.0   3.0
1   1.0   2.0   3.0
```

(continues on next page)
1 1.1 2 3

In [419]: df = pd.DataFrame([['5us', pd.Timedelta('1day')]] * 2, dtype='O')

In [420]: df
Out[420]:
     0         1
0  5us 1 days 00:00:00  
1  5us 1 days 00:00:00

In [421]: df.apply(pd.to_timedelta)
Out[421]:
     0         1
0 00:00:00.000005 1 days  
1 00:00:00.000005 1 days

9.13.5 gotchas

Performing selection operations on integer type data can easily upcast the data to floating. The dtype of the input data will be preserved in cases where nans are not introduced. See also Support for integer NA.

In [422]: dfi = df.astype('int32')

In [423]: dfi['E'] = 1

In [424]: dfi
Out[424]:
     A   B   C   E
0  0  0  255   1
1  0  0  255   1
2  2  0  0   1
3  3  1  0   1
4  0  0  0   1
5  0  0  0   1
6  1 -1  0   1
7  0  0  0   1

In [425]: dfi.dtypes
Out[425]:
     A   B   C   E
int32 int32 int32 int64
dtype: object

In [426]: casted = dfi[dfi>0]

In [427]: casted
Out[427]:
     A     B     C   E
0 NaN NaN 255.0   1
1 NaN NaN 255.0   1
2 NaN NaN  NaN   1
3 1.0 NaN NaN 1
4 NaN NaN NaN 1
5 NaN NaN NaN 1
6 1.0 NaN NaN 1
7 NaN NaN NaN 1

In [428]: casted.dtypes

Out[428]:
A float64
B float64
C float64
E int64
dtype: object

While float dtypes are unchanged.

In [429]: dfa = df3.copy()
In [430]: dfa['A'] = dfa['A'].astype('float32')
In [431]: dfa.dtypes
Out[431]:
A float32
B float64
C float64
dtype: object
In [432]: casted = dfa[df2>0]
In [433]: casted
Out[433]:
   A       B       C
0 NaN  0.200071  255.0
1 NaN   NaN  255.0
2 0.337012  NaN   NaN
3 1.483571  NaN   NaN
4 NaN  0.258626   NaN
5 NaN  0.941688   NaN
6 NaN   NaN   NaN
7 NaN   NaN   NaN
In [434]: casted.dtypes

Out[434]:
A float32
B float64
C float64
dtype: object

9.14 Selecting columns based on dtype

The `select_dtypes()` method implements subsetting of columns based on their `dtype`. First, let's create a `DataFrame` with a slew of different dtypes:

In [435]: df = pd.DataFrame({'string': list('abc'),
                       'int64': list(range(1, 4)),
                       'uint8': np.arange(3, 6).astype('u1'),
                       'float64': np.arange(4.0, 7.0),
                       'bool1': [True, False, True],
                       'bool2': [False, True, False],
                       'dates': pd.date_range('now', periods=3).values,
                       'category': pd.Series(list('ABC')).astype('category'))

In [436]: df['tdeltas'] = df.dates.diff()

In [437]: df['uint64'] = np.arange(3, 6).astype('u8')

In [438]: df['other_dates'] = pd.date_range('20130101', periods=3).values

In [439]: df['tz_aware_dates'] = pd.date_range('20130101', periods=3, tz='US/Eastern')

In [440]: df
Out[440]:
   string  int64  uint8  float64  ...  tdeltas  uint64  other_dates
   dates    tz_aware_dates
0  a       1       3       4.0  ...  NaT        3  2013-01-01
1  b       2       4       5.0  ...   1 days    4  2013-01-02
2  c       3       5       6.0  ...   1 days    5  2013-01-03

[3 rows x 12 columns]

And the dtypes:

In [441]: df.dtypes
Out[441]:
string     object
int64      int64
uint8      uint8
float64    float64
bool1      bool
bool2      bool
dates      datetime64[ns]
category   category
tdeltas    timedelta64[ns]
tz_aware_dates  datetime64[ns, US/Eastern]
int64      uint64
others     datetime64[ns]
dtype: object

`select_dtypes()` has two parameters `include` and `exclude` that allow you to say “give me the columns with these dtypes” (include) and/or “give the columns without these dtypes” (exclude).

For example, to select bool columns:

In [442]: df.select_dtypes(include=[bool])
Out[442]:
   bool1  bool2
0   True  False
You can also pass the name of a dtype in the NumPy dtype hierarchy:

```python
In [443]: df.select_dtypes(include=['bool'])
Out[443]:
   bool1  bool2
0   True  False
1  False   True
2   True  False
```

`select_dtypes()` also works with generic dtypes as well.

For example, to select all numeric and boolean columns while excluding unsigned integers:

```python
In [444]: df.select_dtypes(include=['number', 'bool'], exclude=['unsignedinteger'])
Out[444]:
     int64  float64   bool1   bool2       tdeltas
0  1.0      4.0   True   False         NaT
1  2.0      5.0  False   True       1 days
2  3.0      6.0   True   False       1 days
```

To select string columns you must use the `object` dtype:

```python
In [445]: df.select_dtypes(include=['object'])
Out[445]:
    string
0    a
1    b
2    c
```

To see all the child dtypes of a generic `dtype` like `numpy.number` you can define a function that returns a tree of child dtypes:

```python
In [446]: def subdtypes(dtype):
       ....:     subs = dtype.__subclasses__()
       ....:     if not subs:
       ....:         return dtype
       ....:     return [dtype, [subdtypes(dt) for dt in subs]]
```

All NumPy dtypes are subclasses of `numpy.generic`:

```python
In [447]: subdtypes(np.generic)
Out[447]:
[numpy.generic,
 [[numpy.number,
   [[numpy.integer,
     [[numpy.signedinteger,
       [numpy.int8,
         numpy.int16,
         numpy.int32,
         numpy.int64,
         numpy.int64,
         numpy.timedelta64]],
     [numpy.unsignedinteger,
      [numpy.timedelta64]]]]]]
```
[numpy.uint8,  
numpy.uint16,  
numpy.uint32,  
numpy.uint64,  
numpy.uint64]],  
[numpy.inexact,  
[[numpy.float32, numpy.float64, numpy.float128]],  
[numpy.complex64, numpy.complex128, numpy.complex256]],  
numpy.flexible,  
[[numpy.character, [numpy.bytes_, numpy.str_]],  
[numpy.bool_]],  
numpy.datetime64,  
numpy.object_]]

Note: Pandas also defines the types category and datetime64[ns, tz], which are not integrated into the normal NumPy hierarchy and won’t show up with the above function.
Series and Index are equipped with a set of string processing methods that make it easy to operate on each element of the array. Perhaps most importantly, these methods exclude missing/NA values automatically. These are accessed via the `str` attribute and generally have names matching the equivalent (scalar) built-in string methods:

```
In [1]: s = pd.Series(['A', 'B', 'C', 'Aaba', 'Baca', np.nan, 'CABA', 'dog', 'cat'])

In [2]: s.str.lower()
Out[2]:
0    a
1    b
2    c
3   aaba
4   baca
5   NaN
6    caba
7    dog
8    cat
dtype: object

In [3]: s.str.upper()
Out[3]:
0    A
1    B
2    C
3   AABA
4   BACA
5   NaN
6    CABA
7    DOG
8    CAT
dtype: object

In [4]: s.str.len()
Out[4]:
0    1.0
1    1.0
2    1.0
3    4.0
4    4.0
5    NaN
6    4.0
7    3.0
```
The string methods on Index are especially useful for cleaning up or transforming DataFrame columns. For instance, you may have columns with leading or trailing whitespace:

```
In [9]: df = pd.DataFrame(randn(3, 2), columns=[' Column A ', ' Column B '],
                      index=range(3))
In [10]: df
```

```
     Column A     Column B
   0 -1.425575 -1.336299
   1  0.740933  1.032121
   2 -1.585660  0.913812
```

Since `df.columns` is an Index object, we can use the `.str` accessor

```
In [11]: df.columns.str.strip()
Out[11]: Index([' Column A ', ' Column B '], dtype='object')
In [12]: df.columns.str.lower()
```

```
     column_a     column_b
   0 -1.425575 -1.336299
   1  0.740933  1.032121
   2 -1.585660  0.913812
```

These string methods can then be used to clean up the columns as needed. Here we are removing leading and trailing whitespaces, lowercasing all names, and replacing any remaining whitespaces with underscores:

```
In [13]: df.columns = df.columns.str.strip().str.lower().str.replace(' ', '_')
In [14]: df
```

```
   column_a     column_b
   0 -1.425575 -1.336299
   1  0.740933  1.032121
   2 -1.585660  0.913812
```

Note: If you have a Series where lots of elements are repeated (i.e. the number of unique elements in the Series is a lot smaller than the length of the Series), it can be faster to convert the original Series to one of type category and then use `.str.<method>` or `.dt.<property>` on that. The performance difference comes from the fact that, for Series of type category, the string operations are done on the .categories and not on
each element of the Series.

Please note that a Series of type category with string .categories has some limitations in comparison of Series of type string (e.g. you can’t add strings to each other: s + " " + s won’t work if s is a Series of type category). Also, .str methods which operate on elements of type list are not available on such a Series.

## 10.1 Splitting and Replacing Strings

Methods like split return a Series of lists:

```
In [15]: s2 = pd.Series(["a_b_c", 'c_d_e', np.nan, 'f_g_h'])

In [16]: s2.str.split('_')
Out[16]:
          0        1
0        a    b    c
1        c    d    e
2         NaN
3        f    g    h
```

Elements in the split lists can be accessed using get or [] notation:

```
In [17]: s2.str.split('_').str.get(1)
Out[17]:
0    b
1    d
2   NaN
3    g
```

```
In [18]: s2.str.split('_')[1]
Out[18]:
0    b
1    d
2   NaN
3    g
```

It is easy to expand this to return a DataFrame using expand.

```
In [19]: s2.str.split('_', expand=True)
Out[19]:
     0  1  2
0  a  b  c
1  c  d  e
2   NaN NaN NaN
3  f  g  h
```

It is also possible to limit the number of splits:

```
In [20]: s2.str.split('_', expand=True, n=1)
Out[20]:
     0  1
0  a  b_c
1  c  d_e
```

(continues on next page)
rsplit is similar to split except it works in the reverse direction, i.e., from the end of the string to the beginning of the string:

```python
In [21]: s2.str.rsplit('_', expand=True, n=1)
Out[21]:
   0  1
0  a_b  c
1  c_d  e
2  NaN NaN
3  f_g  h
```

replace by default replaces regular expressions:

```python
In [22]: s3 = pd.Series(['A', 'B', 'C', 'Aaba', 'Baca',
                     '', np.nan, 'CABA', 'dog', 'cat'])
In [23]: s3
Out[23]:
0    A
1    B
2    C
3  Aaba
4  Baca
5    
6  NaN
7  CABA
8    dog
9    cat
dtype: object
In [24]: s3.str.replace('^\.|dog', 'XX-XX ', case=False)
```

Some caution must be taken to keep regular expressions in mind! For example, the following code will cause trouble because of the regular expression meaning of $:

```python
# Consider the following badly formatted financial data
In [25]: dollars = pd.Series(['12', '-$10', '$10,000'])
# This does what you'd naively expect:
```
In [26]: dollars.str.replace('$', '')
Out[26]:
0  12
1 -10
2 10,000
dtype: object

# But this doesn't:
In [27]: dollars.str.replace('-$', '-')
Out[27]:
0  12
1 -$10
2 $10,000
dtype: object

# We need to escape the special character (for >1 len patterns)
In [28]: dollars.str.replace(r'-$', '-')
Out[28]:
0  12
1 -10
2 $10,000
dtype: object

New in version 0.23.0.

If you do want literal replacement of a string (equivalent to `str.replace()`), you can set the optional `regex` parameter to `False`, rather than escaping each character. In this case both `pat` and `repl` must be strings:

# These lines are equivalent
In [29]: dollars.str.replace(r'-\$', '-')
Out[29]:
0  12
1 -10
2 $10,000
dtype: object
In [30]: dollars.str.replace('-\$', '-', regex=False)
Out[30]:
0  12
1 -10
2 $10,000
dtype: object

New in version 0.20.0.

The `replace` method can also take a callable as replacement. It is called on every `pat` using `re.sub()`. The callable should expect one positional argument (a regex object) and return a string.

# Reverse every lowercase alphabetic word
In [31]: pat = r'[a-z]+'
In [32]: repl = lambda m: m.group(0)[::-1]
In [33]: pd.Series(['foo 123', 'bar baz', np.nan]).str.replace(pat, repl)
Out[33]:
0  oof 123

(continues on next page)
# Using regex groups

```
In [34]: pat = r"(?P<one>\w+) (?P<two>\w+) (?P<three>\w+)"

In [35]: repl = lambda m: m.group('two').swapcase()

In [36]: pd.Series(['Foo Bar Baz', np.nan]).str.replace(pat, repl)
Out[36]:
0  bAR
1  NaN
```

New in version 0.20.0.

The `replace` method also accepts a compiled regular expression object from `re.compile()` as a pattern. All flags should be included in the compiled regular expression object.

```
In [37]: import re

In [38]: regex_pat = re.compile(r'^.a|dog', flags=re.IGNORECASE)

In [39]: s3.str.replace(regex_pat, 'XX-XX ')
Out[39]:
0  A
1  B
2  C
3  XX-XX ba
4  XX-XX ca
5  NaN
6  XX-XX BA
7  XX-XX
8  XX-XX t
```

Including a `flags` argument when calling `replace` with a compiled regular expression object will raise a `ValueError`.

```
In [40]: s3.str.replace(regex_pat, 'XX-XX ', flags=re.IGNORECASE)
---------------------------------------------------------------------------
ValueError: case and flags cannot be set when pat is a compiled regex
```

## 10.2 Concatenation

There are several ways to concatenate a `Series` or `Index`, either with itself or others, all based on `cat()`, resp. `Index.str.cat`.

### 10.2.1 Concatenating a single Series into a string

The content of a `Series` (or `Index`) can be concatenated:
In [41]: s = pd.Series(['a', 'b', 'c', 'd'])

In [42]: s.str.cat(sep=',')
Out[42]: 'a,b,c,d'

If not specified, the keyword sep for the separator defaults to the empty string, sep='':

In [43]: s.str.cat()
Out[43]: 'abcd'

By default, missing values are ignored. Using na_rep, they can be given a representation:

In [44]: t = pd.Series(['a', 'b', np.nan, 'd'])

In [45]: t.str.cat(sep=',')
Out[45]: 'a,b,d'

In [46]: t.str.cat(sep=',', na_rep='-')
Out[46]: 'a,b,-,d'

10.2.2 Concatenating a Series and something list-like into a Series

The first argument to `cat()` can be a list-like object, provided that it matches the length of the calling Series (or Index).

In [47]: s.str.cat(['A', 'B', 'C', 'D'])
Out[47]:
0  aA
1  bB
2  cC
3  dD
dtype: object

Missing values on either side will result in missing values in the result as well, unless na_rep is specified:

In [48]: s.str.cat(t)
Out[48]:
0  aa
1  bb
2  NaN
3  dd
dtype: object

In [49]: s.str.cat(t, na_rep='-')
Out[49]:
0  aa
1  bb
2  c-
3  dd
dtype: object

10.2.3 Concatenating a Series and something array-like into a Series

New in version 0.23.0.
The parameter `others` can also be two-dimensional. In this case, the number or rows must match the lengths of the calling `Series` (or `Index`).

```python
In [50]: d = pd.concat([t, s], axis=1)
In [51]: s
Out[51]:
0  a
1  b
2  c
3  d
dtype: object
In [52]: d
Out[52]:
     0 1
0  a a
1  b b
2  NaN c
3  d d
```

In [53]: s.str.cat(d, na_rep='--')

```
0  a a
1  b b
2  -- c
3  d d
```

### 10.2.4 Concatenating a Series and an indexed object into a Series, with alignment

New in version 0.23.0.

For concatenation with a `Series` or `DataFrame`, it is possible to align the indexes before concatenation by setting the `join`-keyword.

```python
In [54]: u = pd.Series(['b', 'd', 'a', 'c'], index=[1, 3, 0, 2])
In [55]: s
Out[55]:
0  a
1  b
2  c
3  d
dtype: object
In [56]: u
Out[56]:
1  b
3  d
0  a
2  c
dtype: object
In [57]: s.str.cat(u)

```

(continues on next page)
Warning: If the join keyword is not passed, the method `cat()` will currently fall back to the behavior before version 0.23.0 (i.e. no alignment), but a `FutureWarning` will be raised if any of the involved indexes differ, since this default will change to `join='left'` in a future version.

The usual options are available for `join` (one of 'left', 'outer', 'inner', 'right'). In particular, alignment also means that the different lengths do not need to coincide anymore.

```
In [59]: v = pd.Series(['z', 'a', 'b', 'd', 'e'], index=[-1, 0, 1, 3, 4])

In [60]: s
Out[60]:
 0  a
 1  b
 2  c
 3  d
dtype: object

In [61]: v
Out[61]:
   -1  z
    0  a
    1  b
    3  d
    4  e
dtype: object

In [62]: s.str.cat(v, join='left', na_rep='-')
   →
    0  aa
    1  bb
    2  c-
    3  dd
dtype: object

In [63]: s.str.cat(v, join='outer', na_rep='-')
   →
     -1  -z
```
The same alignment can be used when `others` is a DataFrame:

```python
In [64]: f = d.loc[[3, 2, 1, 0], :]
In [65]: s
Out[65]:
   0  a
   1  b
   2  c
   3  d
   dtype: object
In [66]: f
Out[66]:
   0  1
   3  NaN
   2  c
   1  b
   0  a
   dtype: object
In [67]: s.str.cat(f, join='left', na_rep='-')
   →
   0  aaa
   1  bbb
   2  c-c
   3  ddd
   dtype: object
```

### 10.2.5 Concatenating a Series and many objects into a Series

All one-dimensional list-likes can be arbitrarily combined in a list-like container (including iterators, dict-views, etc.):

```python
In [68]: s
Out[68]:
   0  a
   1  b
   2  c
   3  d
   dtype: object
In [69]: u
Out[69]:
   1  b
   3  d
   0  a
   2  c
   dtype: object
```
All elements must match in length to the calling Series (or Index), except those having an index if join is not None:

```python
In [71]: v
Out[71]:
-1  z
  0  a
  1  b
  3  d
  4  e
dtype: object
```

```
In [72]: s.str.cat([u, v, ['A', 'B', 'C', 'D']], join='outer', na_rep='--')
```

```plaintext
-1 --z--
 0 aaaA
 1 bbbB
 2 cc-C
 3 dddD
 4 --e--
dtype: object
```

If using join='right' on a list of others that contains different indexes, the union of these indexes will be used as the basis for the final concatenation:

```python
In [73]: u.loc[[3]]
Out[73]:
3  d
dtype: object
```

```python
In [74]: v.loc[[-1, 0]]
Out[74]:
-1  z
 0  a
dtype: object
```

```
In [75]: s.str.cat([u.loc[[3]], v.loc[[-1, 0]], join='right', na_rep='--')
```

```plaintext
-1 --z--
 0 a-a
 3 d- d
dtype: object
```

10.3 Indexing with .str

You can use [ ] notation to directly index by position locations. If you index past the end of the string, the result will be a NaN.

In [76]: s = pd.Series(['A', 'B', 'C', 'Aaba', 'Baca', np.nan, 'CABA', 'dog', 'cat'])
.....:   
In [77]: s.str[0]
Out[77]:
0   A
1   B
2   C
3   A
4   B
5   NaN
6   C
7   d
8   c
dtype: object

In [78]: s.str[1]
Out[78]:
0   NaN
1   NaN
2   NaN
3   a
4   a
5   NaN
6   A
7   o
8   a
dtype: object

10.4 Extracting Substrings

10.4.1 Extract first match in each subject (extract)

Warning: In version 0.18.0, extract gained the expand argument. When expand=False it returns a Series, Index, or DataFrame, depending on the subject and regular expression pattern (same behavior as pre-0.18.0). When expand=True it always returns a DataFrame, which is more consistent and less confusing from the perspective of a user. expand=True is the default since version 0.23.0.

The extract method accepts a regular expression with at least one capture group.

Extracting a regular expression with more than one group returns a DataFrame with one column per group.

In [79]: pd.Series(['a1', 'b2', 'c3']).str.extract('([^ab])', expand=False)
Out[79]:
0   1
(continues on next page)
Elements that do not match return a row filled with NaN. Thus, a Series of messy strings can be “converted” into a like-indexed Series or DataFrame of cleaned-up or more useful strings, without necessitating `get()` to access tuples or `re.match` objects. The dtype of the result is always object, even if no match is found and the result only contains NaN.

Named groups like

```
In [80]: pd.Series(['a1', 'b2', 'c3']).str.extract('(?P<letter>[ab])(?P<digit>\d)', expand=False)
```

```
Out[80]:
   letter  digit
0     a     1
1     b     2
2    NaN    NaN
```

and optional groups like

```
In [81]: pd.Series(['a1', 'b2', '3']).str.extract('(?P<letter>[ab])?(?P<digit>\d)', expand=False)
```

```
Out[81]:
      0   1
0     a     1
1     b     2
2  NaN     3
```

can also be used. Note that any capture group names in the regular expression will be used for column names; otherwise capture group numbers will be used.

Extracting a regular expression with one group returns a DataFrame with one column if `expand=True`.

```
In [82]: pd.Series(['a1', 'b2', 'c3']).str.extract('(?P<letter>[ab])(?P<digit>\d)', expand=True)
```

```
Out[82]:
      0
0     1
1     2
2    NaN
```

It returns a Series if `expand=False`.

```
In [83]: pd.Series(['a1', 'b2', 'c3']).str.extract('(?P<letter>[ab])(?P<digit>\d)', expand=False)
```

```
Out[83]:
      0
0     1
1     2
2    NaN
dtype: object
```

Calling on an Index with a regex with exactly one capture group returns a DataFrame with one column if `expand=True`.

```
In [84]: s = pd.Series(['a1', 'b2', 'c3'], ['A11', 'B22', 'C33'])
In [85]: s
Out[85]:
     A11
0    a1
```

(continues on next page)
B22  b2
C33  c3
dtype: object

In [86]: s.index.str.extract("(?P<letter>[a-zA-Z])", expand=True)
Out[86]:

<table>
<thead>
<tr>
<th>letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

It returns an Index if expand=False.

In [87]: s.index.str.extract("(?P<letter>[a-zA-Z])", expand=False)
Out[87]: Index(['A', 'B', 'C'], dtype='object', name='letter')

Calling on an Index with a regex with more than one capture group returns a DataFrame if expand=True.

In [88]: s.index.str.extract("(?P<letter>[a-zA-Z])([0-9]+)", expand=True)
Out[88]:

<table>
<thead>
<tr>
<th>letter</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>A 11</td>
</tr>
<tr>
<td>1</td>
<td>B 22</td>
</tr>
<tr>
<td>2</td>
<td>C 33</td>
</tr>
</tbody>
</table>

It raises ValueError if expand=False.

```python
>>> s.index.str.extract("(?P<letter>[a-zA-Z])([0-9]+)", expand=False)
ValueError: only one regex group is supported with Index
```

The table below summarizes the behavior of extract (expand=False) (input subject in first column, number of groups in regex in first row)

<table>
<thead>
<tr>
<th></th>
<th>1 group</th>
<th>&gt;1 group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index</td>
<td>Index</td>
<td>ValueError</td>
</tr>
<tr>
<td>Series</td>
<td>Series</td>
<td>DataFrame</td>
</tr>
</tbody>
</table>

### 10.4.2 Extract all matches in each subject (extractall)

New in version 0.18.0.

Unlike extract (which returns only the first match),

```python
In [89]: s = pd.Series(["ala2", "b1", "c1"], index=["A", "B", "C"])
In [90]: s
Out[90]:
A  ala2
B  b1
C  c1
dtype: object
```

```python
In [91]: two_groups = '(?P<letter>[a-z])(?P<digit>[0-9])'
```
the `extractall` method returns every match. The result of `extractall` is always a DataFrame with a MultiIndex on its rows. The last level of the MultiIndex is named `match` and indicates the order in the subject.

```
In [93]: s.str.extractall(two_groups)
Out[93]:
    letter digit  match
  A    a 1       0
  1    a 2       1
  B    b 1       0
  C    c 1       0
```

When each subject string in the Series has exactly one match,

```
In [94]: s = pd.Series(['a3', 'b3', 'c2'])
In [95]: s
Out[95]:
0    a3
1    b3
2    c2
dtype: object
```

then `extractall(pat).xs(0, level='match')` gives the same result as `extract(pat)`.

```
In [96]: extract_result = s.str.extract(two_groups, expand=True)
In [97]: extract_result
Out[97]:
    letter digit
  0    a  3
  1    b  3
  2    c  2
In [98]: extractall_result = s.str.extractall(two_groups)
In [99]: extractall_result
Out[99]:
    letter digit  match
  0    a  3       0
  1    b  3       0
  2    c  2       0
```

```
In [100]: extractall_result.xs(0, level="match")
    letter digit
```

(continues on next page)
Index also supports `.str.extractall`. It returns a DataFrame which has the same result as a Series.str.extractall with a default index (starts from 0).

New in version 0.19.0.

```
In [101]: pd.Index(['a1a2', 'b1', 'c1']).str.extractall(two_groups)
Out[101]:
   letter digit
0    a    1
1    a    2
1    b    1
2    c    1
```

```
In [102]: pd.Series(['a1a2', 'b1', 'c1']).str.extractall(two_groups)
```

```
   letter digit
0    a    1
1    a    2
1    b    1
2    c    1
```

## 10.5 Testing for Strings that Match or Contain a Pattern

You can check whether elements contain a pattern:

```
In [103]: pattern = r'[0-9][a-z]'

In [104]: pd.Series(['1', '2', '3a', '3b', '03c']).str.contains(pattern)
Out[104]:
0   False
1   False
2    True
3    True
4    True
dtype: bool
```

Or whether elements match a pattern:

```
In [105]: pd.Series(['1', '2', '3a', '3b', '03c']).str.match(pattern)
Out[105]:
0   False
1   False
2    True
3    True
4   False
dtype: bool
```
The distinction between `match` and `contains` is strictness: `match` relies on strict `re.match`, while `contains` relies on `re.search`.

Methods like `match`, `contains`, `startswith`, and `endswith` take an extra `na` argument so missing values can be considered True or False:

```python
In [106]: s4 = pd.Series(['A', 'B', 'C', 'Aaba', 'Baca', np.nan, 'CABA', 'dog', 'cat'])
In [107]: s4.str.contains('A', na=False)
Out[107]:
0   True
1  False
2  False
3   True
4  False
5   True
6  False
7  False
8  False
dtype: bool
```

### 10.6 Creating Indicator Variables

You can extract dummy variables from string columns. For example if they are separated by a ' | ':

```python
In [108]: s = pd.Series(['a', 'a|b', np.nan, 'a|c'])
In [109]: s.str.get_dummies(sep='|')
```

String Index also supports `get_dummies` which returns a MultiIndex.

New in version 0.18.1.

```python
In [110]: idx = pd.Index(['a', 'a|b', np.nan, 'a|c'])
In [111]: idx.str.get_dummies(sep='|')
```

See also `get_dummies()`.

### 10.7 Method Summary
<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cat()</td>
<td>Concatenate strings</td>
</tr>
<tr>
<td>split()</td>
<td>Split strings on delimiter</td>
</tr>
<tr>
<td>rsplit()</td>
<td>Split strings on delimiter working from the end of the string</td>
</tr>
<tr>
<td>get()</td>
<td>Index into each element (retrieve i-th element)</td>
</tr>
<tr>
<td>join()</td>
<td>Join strings in each element of the Series with passed separator</td>
</tr>
<tr>
<td>get_dummies()</td>
<td>Split strings on the delimiter returning DataFrame of dummy variables</td>
</tr>
<tr>
<td>contains()</td>
<td>Return boolean array if each string contains pattern/regex</td>
</tr>
<tr>
<td>replace()</td>
<td>Replace occurrences of pattern/regex/string with some other string or the return value of a callable given the occurrence</td>
</tr>
<tr>
<td>repeat()</td>
<td>Duplicate values (s.str.repeat(3) equivalent to x * 3)</td>
</tr>
<tr>
<td>pad()</td>
<td>Add whitespace to left, right, or both sides of strings</td>
</tr>
<tr>
<td>center()</td>
<td>Equivalent to str.center</td>
</tr>
<tr>
<td>ljust()</td>
<td>Equivalent to str.ljust</td>
</tr>
<tr>
<td>rjust()</td>
<td>Equivalent to str.rjust</td>
</tr>
<tr>
<td>zfill()</td>
<td>Equivalent to str.zfill</td>
</tr>
<tr>
<td>wrap()</td>
<td>Split long strings into lines with length less than a given width</td>
</tr>
<tr>
<td>slice()</td>
<td>Slice each string in the Series</td>
</tr>
<tr>
<td>slice_replace()</td>
<td>Replace slice in each string with passed value</td>
</tr>
<tr>
<td>count()</td>
<td>Count occurrences of pattern</td>
</tr>
<tr>
<td>startswith()</td>
<td>Equivalent to str.startswith(pat) for each element</td>
</tr>
<tr>
<td>endswith()</td>
<td>Equivalent to str.endswith(pat) for each element</td>
</tr>
<tr>
<td>findall()</td>
<td>Compute list of all occurrences of pattern/regex for each string</td>
</tr>
<tr>
<td>match()</td>
<td>Call re.match on each element, returning matched groups as list</td>
</tr>
<tr>
<td>extract()</td>
<td>Call re.search on each element, returning DataFrame with one row for each element and one column for each regex capture group</td>
</tr>
<tr>
<td>extractall()</td>
<td>Call re.findall on each element, returning DataFrame with one row for each match and one column for each regex capture group</td>
</tr>
<tr>
<td>len()</td>
<td>Compute string lengths</td>
</tr>
<tr>
<td>strip()</td>
<td>Equivalent to str.strip</td>
</tr>
<tr>
<td>rstrip()</td>
<td>Equivalent to str.rstrip</td>
</tr>
<tr>
<td>lstrip()</td>
<td>Equivalent to str.lstrip</td>
</tr>
<tr>
<td>partition()</td>
<td>Equivalent to str.partition</td>
</tr>
<tr>
<td>rpartition()</td>
<td>Equivalent to str.rpartition</td>
</tr>
<tr>
<td>lower()</td>
<td>Equivalent to str.lower</td>
</tr>
<tr>
<td>upper()</td>
<td>Equivalent to str.upper</td>
</tr>
<tr>
<td>find()</td>
<td>Equivalent to str.find</td>
</tr>
<tr>
<td>rfind()</td>
<td>Equivalent to str.rfind</td>
</tr>
<tr>
<td>index()</td>
<td>Equivalent to str.index</td>
</tr>
<tr>
<td>rindex()</td>
<td>Equivalent to str.rindex</td>
</tr>
<tr>
<td>capitalize()</td>
<td>Equivalent to str.capitalize</td>
</tr>
<tr>
<td>swapcase()</td>
<td>Equivalent to str.swapcase</td>
</tr>
<tr>
<td>normalize()</td>
<td>Return Unicode normal form. Equivalent to unicodedata.normalize</td>
</tr>
<tr>
<td>translate()</td>
<td>Equivalent to str.translate</td>
</tr>
<tr>
<td>isalnum()</td>
<td>Equivalent to str.isalnum</td>
</tr>
<tr>
<td>isalpha()</td>
<td>Equivalent to str.isalpha</td>
</tr>
<tr>
<td>isdigit()</td>
<td>Equivalent to str.isdigit</td>
</tr>
<tr>
<td>isspace()</td>
<td>Equivalent to str.isspace</td>
</tr>
<tr>
<td>islower()</td>
<td>Equivalent to str.islower</td>
</tr>
<tr>
<td>isupper()</td>
<td>Equivalent to str.isupper</td>
</tr>
<tr>
<td>istitle()</td>
<td>Equivalent to str.istitle</td>
</tr>
</tbody>
</table>

Continued on next page
Table 1 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>isnumeric()</code></td>
<td>Equivalent to <code>str.isnumeric</code></td>
</tr>
<tr>
<td><code>isdecimal()</code></td>
<td>Equivalent to <code>str.isdecimal</code></td>
</tr>
</tbody>
</table>
11.1 Overview

pandas has an options system that lets you customize some aspects of its behaviour, display-related options being those the user is most likely to adjust.

Options have a full “dotted-style”, case-insensitive name (e.g. display.max_rows). You can get/set options directly as attributes of the top-level options attribute:

```python
In [1]: import pandas as pd
In [2]: pd.options.display.max_rows
Out[2]: 15
In [3]: pd.options.display.max_rows = 999
In [4]: pd.options.display.max_rows
Out[4]: 999
```

The API is composed of 5 relevant functions, available directly from the pandas namespace:

- `get_option()` / `set_option()` - get/set the value of a single option.
- `reset_option()` - reset one or more options to their default value.
- `describe_option()` - print the descriptions of one or more options.
- `option_context()` - execute a codeblock with a set of options that revert to prior settings after execution.

Note: Developers can check out pandas/core/config.py for more information.

All of the functions above accept a regexp pattern (re.search style) as an argument, and so passing in a substring will work - as long as it is unambiguous:

```python
In [5]: pd.get_option("display.max_rows")
Out[5]: 999
In [6]: pd.set_option("display.max_rows",101)
In [7]: pd.get_option("display.max_rows")
Out[7]: 101
In [8]: pd.set_option("max_r",102)
In [9]: pd.get_option("display.max_rows")
Out[9]: 102
```
The following will **not work** because it matches multiple option names, e.g. `display.max_colwidth`, `display.max_rows`, `display.max_columns`:

```python
In [10]: try:
   ....:     pd.get_option("column")
   ....:     except KeyError as e:
   ....:         print(e)
   ....:
'Pattern matched multiple keys'
```

**Note:** Using this form of shorthand may cause your code to break if new options with similar names are added in future versions.

You can get a list of available options and their descriptions with `describe_option`. When called with no argument `describe_option` will print out the descriptions for all available options.

### 11.2 Getting and Setting Options

As described above, `get_option()` and `set_option()` are available from the pandas namespace. To change an option, call `set_option('option regex', new_value)`.

```python
In [11]: pd.get_option('mode.sim_interactive')
Out[11]: False

In [12]: pd.set_option('mode.sim_interactive', True)

In [13]: pd.get_option('mode.sim_interactive')
Out[13]: True
```

**Note:** The option ‘mode.sim_interactive’ is mostly used for debugging purposes.

All options also have a default value, and you can use `reset_option` to do just that:

```python
In [14]: pd.get_option("display.max_rows")
Out[14]: 60

In [15]: pd.set_option("display.max_rows", 999)

In [16]: pd.get_option("display.max_rows")
Out[16]: 999

In [17]: pd.reset_option("display.max_rows")

In [18]: pd.get_option("display.max_rows")
Out[18]: 60
```

It’s also possible to reset multiple options at once (using a regex):

```python
In [19]: pd.reset_option("^display")
```

`option_context` context manager has been exposed through the top-level API, allowing you to execute code with given option values. Option values are restored automatically when you exit the `with` block:

```python
In [20]: with pd.option_context("display.max_rows", 10,"display.max_columns", 5):
   ....:     print(pd.get_option("display.max_rows"))
   ....:     print(pd.get_option("display.max_columns"))
```

(continues on next page)
11.3 Setting Startup Options in python/ipython Environment

Using startup scripts for the python/ipython environment to import pandas and set options makes working with pandas more efficient. To do this, create a .py or .ipy script in the startup directory of the desired profile. An example where the startup folder is in a default ipython profile can be found at:

```
$IPYTHONDIR/profile_default/startup
```

More information can be found in the ipython documentation. An example startup script for pandas is displayed below:

```python
import pandas as pd
pd.set_option('display.max_rows', 999)
pd.set_option('precision', 5)
```

11.4 Frequently Used Options

The following is a walkthrough of the more frequently used display options.

`display.max_rows` and `display.max_columns` sets the maximum number of rows and columns displayed when a frame is pretty-printed. Truncated lines are replaced by an ellipsis.

```
In [23]: df = pd.DataFrame(np.random.randn(7,2))
In [24]: pd.set_option('max_rows', 7)
In [25]: df
Out[25]:
     0   1
0  0.469112 -0.282863
1 -1.509059 -1.135632
2  1.212112 -0.173215
3  0.119209 -1.044236
4 -0.861849 -2.104569
5 -0.494929  1.071804
6  0.721555 -0.706771
In [26]: pd.set_option('max_rows', 5)
In [27]: df
```

(continues on next page)
0 1
0 0.469112 -0.282863
1 -1.509059 -1.135632
... ...
5 -0.494929 1.071804
6 0.721555 -0.706771
[7 rows x 2 columns]

In [28]: pd.reset_option('max_rows')

display.expand_frame_repr allows for the representation of dataframes to stretch across pages, wrapped over the full column vs row-wise.

In [29]: df = pd.DataFrame(np.random.randn(5,10))

In [30]: pd.set_option('expand_frame_repr', True)

In [31]: df

Out[31]:
0 1 2 3 4 5 6 7 8 9
0 -1.039575 0.271860 -0.424972 0.567020 0.276232 -1.087401 -0.673690 0.113648 -1.478427 0.524988
1 0.404705 0.577046 -1.715002 -1.039268 -0.370647 -1.157892 -1.344312 0.844885 0.075770 -0.109050
2 1.643563 -1.469388 0.357021 -0.674600 -1.776904 -0.968914 -1.294524 0.413738 0.276662 -0.472035
3 -0.013960 -0.362543 -0.006154 -0.923061 0.895717 0.805244 -1.206412 0.413256 1.340309
4 -1.170299 -0.226169 0.410835 0.813850 0.132003 -0.827317 -0.076467 -1.187678 1.30127 -1.436737

In [32]: pd.set_option('expand_frame_repr', False)

In [33]: df

Out[33]:
0 1 2 3 4 5 6 7 8 9
0 -1.039575 0.271860 -0.424972 0.567020 0.276232 -1.087401 -0.673690 0.113648 -1.478427 0.524988
1 0.404705 0.577046 -1.715002 -1.039268 -0.370647 -1.157892 -1.344312 0.844885 0.075770 -0.109050
2 1.643563 -1.469388 0.357021 -0.674600 -1.776904 -0.968914 -1.294524 0.413738 0.276662 -0.472035
3 -0.013960 -0.362543 -0.006154 -0.923061 0.895717 0.805244 -1.206412 0.413256 1.340309
4 -1.170299 -0.226169 0.410835 0.813850 0.132003 -0.827317 -0.076467 -1.187678 1.30127 -1.436737

In [34]: pd.reset_option('expand_frame_repr')

display.large_repr lets you select whether to display dataframes that exceed max_columns or max_rows as a truncated frame, or as a summary.

In [35]: df = pd.DataFrame(np.random.randn(10,10))

(continues on next page)
In [36]: pd.set_option('max_rows', 5)
In [37]: pd.set_option('large_repr', 'truncate')
In [38]: df
Out[38]:
    0   1   2   3   4   5   6   7  
  0  8.413681 1.607920 1.024180 0.569605 0.875906 -2.211372 0.974466 -2.006747
    ...          ...          ...          ...          ...          ...          ...        
  8 -2.484478 -0.281461 0.030711 0.109121 1.126203 1.126203 -0.977349 1.474071
  9 -1.071357 0.441153 2.353925 0.583787 0.221471 -0.744471 0.758527 1.729689
[10 rows x 10 columns]
In [39]: pd.set_option('large_repr', 'info')
In [40]: df
Out[40]:
<class 'pandas.core.frame.DataFrame'>
Index: 10 entries, 0 to 9
Data columns (total 10 columns):
0 10 non-null float64
1 10 non-null float64
2 10 non-null float64
3 10 non-null float64
4 10 non-null float64
5 10 non-null float64
6 10 non-null float64
7 10 non-null float64
8 10 non-null float64
9 10 non-null float64
dtypes: float64(10)
memory usage: 880.0 bytes
In [41]: pd.reset_option('large_repr')
In [42]: pd.reset_option('max_rows')

`display.max_colwidth` sets the maximum width of columns. Cells of this length or longer will be truncated with an ellipsis.

In [43]: df = pd.DataFrame(np.array([['foo', 'bar', 'bim', 'uncomfortably long string --'], ['horse', 'cow', 'banana', 'apple']]))
In [44]: pd.set_option('max_colwidth', 40)

(continues on next page)
In [45]: df
Out[45]:
   0   1   2   3
0  foo  bar  bim  uncomfortably long string
1  horse  cow  banana  apple

In [46]: pd.set_option('max_colwidth', 6)

In [47]: df
Out[47]:
   0   1   2   3
0  foo  bar  bim  un...
1  horse  cow  ba...  apple

In [48]: pd.reset_option('max_colwidth')

display.max_info_columns sets a threshold for when by-column info will be given.

In [49]: df = pd.DataFrame(np.random.randn(10,10))

In [50]: pd.set_option('max_info_columns', 11)

In [51]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10 entries, 0 to 9
Data columns (total 10 columns):
0 10 non-null float64
1 10 non-null float64
2 10 non-null float64
3 10 non-null float64
4 10 non-null float64
5 10 non-null float64
6 10 non-null float64
7 10 non-null float64
8 10 non-null float64
9 10 non-null float64
dtypes: float64(10)
memory usage: 880.0 bytes

In [52]: pd.set_option('max_info_columns', 5)

In [53]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10 entries, 0 to 9
Columns: 10 entries, 0 to 9
dtypes: float64(10)
memory usage: 880.0 bytes

In [54]: pd.reset_option('max_info_columns')

display.max_info_rows: df.info() will usually show null-counts for each column. For large frames this can be quite slow. max_info_rows and max_info_cols limit this null check only to frames with smaller dimensions then specified. Note that you can specify the option df.info(null_counts=True) to override on showing a particular frame.

In [55]: df = pd.DataFrame(np.random.choice([0,1,np.nan], size=(10,10)))
In [56]: df

Out[56]:
      0    1    2    3    4    5    6    7    8    9
0  0.0  1.0  1.0  0.0  1.0  0.0  NaN  1.0  NaN  NaN
1  1.0  NaN  NaN  1.0  1.0  NaN  1.0  0.0  1.0  NaN
2  NaN  NaN  NaN  1.0  1.0  0.0  NaN  0.0  1.0  NaN
3  0.0  1.0  1.0  NaN  1.0  NaN  NaN  NaN  NaN  NaN
4  0.0  1.0  NaN  NaN  1.0  NaN  NaN  NaN  NaN  NaN
5  NaN  NaN  NaN  1.0  1.0  NaN  NaN  NaN  NaN  NaN
6  0.0  1.0  0.0  0.0  1.0  0.0  NaN  NaN  0.0  NaN
7  0.0  1.0  1.0  NaN  1.0  1.0  1.0  1.0  1.0  NaN
8  0.0  0.0  NaN  0.0  NaN  1.0  0.0  0.0  NaN  NaN
9  NaN  NaN  0.0  NaN  NaN  0.0  1.0  1.0  1.0  NaN

In [57]: pd.set_option('max_info_rows', 11)

In [58]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10 entries, 0 to 9
Data columns (total 10 columns):
0 float64
1 float64
2 float64
3 float64
4 float64
5 float64
6 float64
7 float64
8 float64
9 float64
dtypes: float64(10)
memory usage: 880.0 bytes

In [59]: pd.set_option('max_info_rows', 5)

In [60]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10 entries, 0 to 9
Data columns (total 10 columns):
0    float64
1    float64
2    float64
3    float64
4    float64
5    float64
6    float64
7    float64
8    float64
9    float64
dtypes: float64(10)
memory usage: 880.0 bytes

In [61]: pd.reset_option('max_info_rows')

display.precision sets the output display precision in terms of decimal places. This is only a suggestion.
In [62]: df = pd.DataFrame(np.random.randn(5,5))

In [63]: pd.set_option('precision',7)

In [64]: df
Out[64]:
       0    1    2    3    4
0 -2.0490  2.8466 -1.2080 -0.4504  2.4239
1  0.1211  0.2669  0.8438 -0.2225  2.0219
2 -0.7168 -2.2245 -1.0611 -0.2328  0.4308
3 -0.6655  1.8298 -1.4065  1.0782  0.3227
4  0.2003  0.8900  0.1948  0.3516  0.4488

In [65]: pd.set_option('precision',4)

In [66]: df
Out[66]:
       0    1    2    3    4
0 -2.05   2.85   -1.21  -0.45   2.42
1  0.12   0.27   0.84  -0.22   2.02
2 -0.72   -2.22  -1.06  -0.23   0.43
3 -0.67   1.83  -1.41  1.08   0.32
4  0.20   0.89   0.19   0.35   0.45

display.chop_threshold sets at what level pandas rounds to zero when it displays a Series of DataFrame. This setting does not change the precision at which the number is stored.

In [67]: df = pd.DataFrame(np.random.randn(6,6))

In [68]: pd.set_option('chop_threshold', 0)

In [69]: df
Out[69]:
       0    1    2    3    4    5
0 -0.1979  0.9657 -1.5229 -0.1166  0.2956 -1.0477
1  1.6406  1.9058  2.7721  0.0888 -1.1442 -0.6334
2  0.9254 -0.0064 -0.8204 -0.6009 -1.0393  0.8248
3 -0.8241 -0.3377 -0.9278 -0.8401  0.2485 -0.1093
4  0.4320 -0.4607  0.3365 -3.2076 -1.5359  0.4098
5 -0.6731 -0.7411 -0.1109 -2.6729  0.8645  0.0609

In [70]: pd.set_option('chop_threshold', .5)

In [71]: df
Out[71]:
       0    1    2    3    4    5
0  0.0000  0.9657 -1.5229  0.0000  0.0000 -1.0477
1  1.6406  1.9058  2.7721  0.0000 -1.1442 -0.6334
2  0.9254  0.0000 -0.8204 -0.6009 -1.0393  0.8248
3 -0.8241  0.0000 -0.9278 -0.8401  0.0000  0.0000
4  0.4320  0.0000  0.3365 -3.2076 -1.5359  0.0000
5 -0.6731 -0.7411  0.0000 -2.6729  0.8645  0.0000

In [72]: pd.reset_option('chop_threshold')

display.colheader_justify controls the justification of the headers. The options are 'right', and 'left'.
In [73]: df = pd.DataFrame(np.array([np.random.randn(6), np.random.randint(1,9,6)*.1, np.zeros(6)]).T, columns=['A', 'B', 'C'], dtype='float')

In [74]: pd.set_option('colheader_justify', 'right')

In [75]: df
Out[75]:
   A      B  C
0  0.9331  0.3  0.0
1  0.2888  0.2  0.0
2  1.3250  0.2  0.0
3  0.5892  0.7  0.0
4  0.5314  0.1  0.0
5 -1.1987  0.7  0.0

In [76]: pd.set_option('colheader_justify', 'left')

In [77]: df
Out[77]:
   A      B  C
0  0.9331  0.3  0.0
1  0.2888  0.2  0.0
2  1.3250  0.2  0.0
3  0.5892  0.7  0.0
4  0.5314  0.1  0.0
5 -1.1987  0.7  0.0

In [78]: pd.reset_option('colheader_justify')

11.5 Available Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Default</th>
<th>Function</th>
</tr>
</thead>
</table>
| display.chop_threshold  | None    | If set to a float value, all float values smaller then the given threshold will be displayed as exactly 0.
| display.colheader_justify | right  | Controls the justification of column headers. used by DataFrameFormatter.  |
| display.column_space    | 12      | No description available.                                                |
| display.date_dayfirst   | False   | When True, prints and parses dates with the day first, eg 20/01/2005     |
| display.date_yearfirst  | False   | When True, prints and parses dates with the year first, eg 2005/01/20    |
| display.encoding        | UTF-8   | Defaults to the detected encoding of the console. Specifies the encoding to be used. |
| display.expand_frame_repr | True   | Whether to print out the full DataFrame repr for wide DataFrames across multiple lines. |
| display.float_format    | None    | The callable should accept a floating point number and return a string with the desired format.
| display.large_repr      | truncate| For DataFrames exceeding max_rows/max_cols, the repr (and HTML repr) can become very wide. |
| display.latex.repr      | False   | Whether to produce a latex DataFrame representation for jupyter frontends that support it. |
| display.latex.escape    | True    | Escapes special characters in DataFrames, when using the to_latex method. |
| display.latex.longtable | False   | Specifies if the to_latex method of a DataFrame uses the longtable format. |
| display.latex.multicolumn | True  | Combines columns when using a MultiIndex. |
| display.latex.multicolumn_format | 'l'   | Alignment of multicoloumn labels. |
| display.latex.multirow  | False   | Combines rows when using a MultiIndex. Centered instead of top-aligned, separated by a line. |
| display.max_columns     | 0 or 20 | max_rows and max_columns are used in __repr__() methods to decide if to_string() or info() is used to render an object to a string. |
| display.max_colwidth    | 50      | The maximum width in characters of a column in the repr of a pandas data structure. |
pandas: powerful Python data analysis toolkit, Release 0.23.2

### Table 1 – continued from previous page

<table>
<thead>
<tr>
<th>Option</th>
<th>Default</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>display.max_info_columns</code></td>
<td>100</td>
<td><code>max_info_columns</code> is used in DataFrame.info method to decide if per column information will be printed.</td>
</tr>
<tr>
<td><code>display.max_info_rows</code></td>
<td>1690754</td>
<td><code>df.info()</code> will usually show null-counts for each column. For large frames this can be quite slow.</td>
</tr>
<tr>
<td><code>display.max_rows</code></td>
<td>60</td>
<td>This sets the maximum number of rows pandas should output when printing out a DataFrame.</td>
</tr>
<tr>
<td><code>display.max_seq_items</code></td>
<td>100</td>
<td>When pretty-printing a long sequence, no more than <code>max_seq_items</code> items will be printed.</td>
</tr>
<tr>
<td><code>display.memory_usage</code></td>
<td>True</td>
<td><code>memory_usage</code> specifies if the memory usage of a DataFrame should be displayed when the <code>df.info()</code> method is invoked.</td>
</tr>
<tr>
<td><code>display.multi_sparse</code></td>
<td>True</td>
<td>“Sparsify” MultiIndex display (don’t display repeated elements in outer levels when printing).</td>
</tr>
<tr>
<td><code>display.notebook_repr_html</code></td>
<td>True</td>
<td>When True, IPython notebook will use html representation for pandas objects (if available).</td>
</tr>
<tr>
<td><code>display.pprint_nest_depth</code></td>
<td>3</td>
<td>Controls the number of nested levels to process when pretty-printing.</td>
</tr>
<tr>
<td><code>display.precision</code></td>
<td>6</td>
<td>Floating point output precision in terms of number of places after the decimal, for regular formatting as well as scientific notation.</td>
</tr>
<tr>
<td><code>display.show_dimensions</code></td>
<td>truncate</td>
<td>Whether to print out dimensions at the end of DataFrame repr. If 'truncate' is specified, only print dimensions if the frame is truncated.</td>
</tr>
<tr>
<td><code>display.width</code></td>
<td>80</td>
<td>Width of the display in characters. In case python/IPython is running in a terminal, this option controls the display width.</td>
</tr>
<tr>
<td><code>display.html.table_schema</code></td>
<td>False</td>
<td>Whether to publish a Table Schema representation for frontends that support it.</td>
</tr>
<tr>
<td><code>io.excel.xls.writer</code></td>
<td>xlwt</td>
<td>The default Excel writer engine for ‘xls’ files.</td>
</tr>
<tr>
<td><code>io.parquet.engine</code></td>
<td>None</td>
<td>The engine to use as a default for parquet reading and writing. If None then try ‘pyarrow’ and ‘fastparquet’.</td>
</tr>
<tr>
<td><code>mode.chained_assignment</code></td>
<td>warn</td>
<td>Controls <code>SettingWithCopyWarning</code>: ‘raise’, ‘warn’, or None. Raise an exception if trying to use chained assignment.</td>
</tr>
<tr>
<td><code>mode.sim_interactive</code></td>
<td>False</td>
<td>Whether to simulate interactive mode for purposes of testing.</td>
</tr>
<tr>
<td><code>mode.use_inf_as_na</code></td>
<td>False</td>
<td>True means treat None, NaN, -INF, INF as NA (old way), False means None and NaN are null, but INF, -INF are not NA (new way). Raising an exception on use can be controlled by setting the warning level.</td>
</tr>
<tr>
<td><code>compute.use_bottleneck</code></td>
<td>True</td>
<td>Use the bottleneck library to accelerate computation if it is installed.</td>
</tr>
<tr>
<td><code>compute.use_numexpr</code></td>
<td>True</td>
<td>Use the numexpr library to accelerate computation if it is installed.</td>
</tr>
<tr>
<td><code>plotting.matplotlib.register_converters</code></td>
<td>True</td>
<td>Register custom converters with matplotlib. Set to False to de-register.</td>
</tr>
</tbody>
</table>

11.6 Number Formatting

pandas also allows you to set how numbers are displayed in the console. This option is not set through the `set_options` API.

Use the `set_eng_float_format` function to alter the floating-point formatting of pandas objects to produce a particular format.

For instance:

```python
In [79]: import numpy as np

In [80]: pd.set_eng_float_format(accuracy=3, use_eng_prefix=True)

In [81]: s = pd.Series(np.random.randn(5), index=['a', 'b', 'c', 'd', 'e'])

In [82]: s/1.e3
Out[82]:
   a   -236.866u
   b    846.974u
   c   -685.597u
   d    609.099u
   e   -303.961u
dtype: float64
```

(continues on next page)
To round floats on a case-by-case basis, you can also use `round()` and `round()`.  

### 11.7 Unicode Formatting

**Warning:** Enabling this option will affect the performance for printing of DataFrame and Series (about 2 times slower). Use only when it is actually required.

Some East Asian countries use Unicode characters whose width corresponds to two Latin characters. If a DataFrame or Series contains these characters, the default output mode may not align them properly.

**Note:** Screen captures are attached for each output to show the actual results.

```
In [84]: df = pd.DataFrame({u'': ['UK', u''], u'': ['Alice', u'']})
```

```
In [85]: df;
```

```
Out[85]

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>'名前'</td>
<td>'国籍'</td>
</tr>
<tr>
<td>Alice</td>
<td>UK</td>
</tr>
<tr>
<td>1</td>
<td>しのぶ</td>
</tr>
</tbody>
</table>
```

Enabling `display.unicode.east_asian_width` allows pandas to check each character’s “East Asian Width” property. These characters can be aligned properly by setting this option to `True`. However, this will result in longer render times than the standard `len` function.

```
In [86]: pd.set_option('display.unicode.east_asian_width', True)
```

```
In [87]: df;
```

```
Out[87]

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>'名前'</td>
<td>'国籍'</td>
</tr>
<tr>
<td>Alice</td>
<td>UK</td>
</tr>
<tr>
<td>1</td>
<td>しのぶ</td>
</tr>
</tbody>
</table>
```

In addition, Unicode characters whose width is “Ambiguous” can either be 1 or 2 characters wide depending on the terminal setting or encoding. The option `display.unicode.ambiguous_as_wide` can be used to handle the ambiguity.
By default, an “Ambiguous” character’s width, such as “¡” (inverted exclamation) in the example below, is taken to be 1.

```python
In [88]: df = pd.DataFrame({'a': ['xxx', u'¡¡'], 'b': ['yyy', u'¡¡']})
In [89]: df;
```

```python
In [90]: pd.set_option('display.unicode.ambiguous_as_wide', True)
In [91]: df;
```

Enabling `display.unicode.ambiguous_as_wide` makes pandas interpret these characters’ widths to be 2. (Note that this option will only be effective when `display.unicode.east_asian_width` is enabled.) However, setting this option incorrectly for your terminal will cause these characters to be aligned incorrectly:

```python
In [90]: pd.set_option('display.unicode.ambiguous_as_wide', True)
In [91]: df;
```

11.8 Table Schema Display

New in version 0.20.0.

`DataFrame` and `Series` will publish a Table Schema representation by default. False by default, this can be enabled globally with the `display.html.table_schema` option:

```python
In [92]: pd.set_option('display.html.table_schema', True)
```

Only ‘display.max_rows’ are serialized and published.
INDEXING AND SELECTING DATA

The axis labeling information in pandas objects serves many purposes:

- Identifies data (i.e. provides metadata) using known indicators, important for analysis, visualization, and interactive console display.
- Enables automatic and explicit data alignment.
- Allows intuitive getting and setting of subsets of the data set.

In this section, we will focus on the final point: namely, how to slice, dice, and generally get and set subsets of pandas objects. The primary focus will be on Series and DataFrame as they have received more development attention in this area.

**Note:** The Python and NumPy indexing operators [] and attribute operator . provide quick and easy access to pandas data structures across a wide range of use cases. This makes interactive work intuitive, as there’s little new to learn if you already know how to deal with Python dictionaries and NumPy arrays. However, since the type of the data to be accessed isn’t known in advance, directly using standard operators has some optimization limits. For production code, we recommended that you take advantage of the optimized pandas data access methods exposed in this chapter.

**Warning:** Whether a copy or a reference is returned for a setting operation, may depend on the context. This is sometimes called chained assignment and should be avoided. See Returning a View versus Copy.

**Warning:** Indexing on an integer-based Index with floats has been clarified in 0.18.0, for a summary of the changes, see here.

See the MultiIndex / Advanced Indexing for MultiIndex and more advanced indexing documentation.

See the cookbook for some advanced strategies.

### 12.1 Different Choices for Indexing

Object selection has had a number of user-requested additions in order to support more explicit location based indexing. Pandas now supports three types of multi-axis indexing.

- .loc is primarily label based, but may also be used with a boolean array. .loc will raise KeyError when the items are not found. Allowed inputs are:
A single label, e.g. 5 or 'a' (Note that 5 is interpreted as a label of the index. This use is not an integer position along the index.).

- A list or array of labels ['a', 'b', 'c'].
- A slice object with labels 'a':'f' (Note that contrary to usual python slices, both the start and the stop are included, when present in the index! See Slicing with labels.).
- A boolean array
- A callable function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above).

New in version 0.18.1.

See more at Selection by Label.

• .iloc is primarily integer position based (from 0 to length-1 of the axis), but may also be used with a boolean array. .iloc will raise IndexError if a requested indexer is out-of-bounds, except slice indexers which allow out-of-bounds indexing. (this conforms with Python/NumPy slice semantics). Allowed inputs are:
  - An integer e.g. 5.
  - A list or array of integers [4, 3, 0].
  - A slice object with ints 1:7.
  - A boolean array.
  - A callable function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above).

New in version 0.18.1.

See more at Selection by Position, Advanced Indexing and Advanced Hierarchical.

• .loc, .iloc, and also [] indexing can accept a callable as indexer. See more at Selection By Callable.

Getting values from an object with multi-axes selection uses the following notation (using .loc as an example, but the following applies to .iloc as well). Any of the axes accessors may be the null slice :. Axes left out of the specification are assumed to be :.e.g. p.loc['a'] is equivalent to p.loc['a', :, :].

<table>
<thead>
<tr>
<th>Object Type</th>
<th>Indexers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series</td>
<td>s.loc[indexer]</td>
</tr>
<tr>
<td>DataFrame</td>
<td>df.loc[row_indexer, column_indexer]</td>
</tr>
<tr>
<td>Panel</td>
<td>p.loc[item_indexer, major_indexer, minor_indexer]</td>
</tr>
</tbody>
</table>

### 12.2 Basics

As mentioned when introducing the data structures in the last section, the primary function of indexing with [] (a.k.a. __getitem__ for those familiar with implementing class behavior in Python) is selecting out lower-dimensional slices. The following table shows return type values when indexing pandas objects with []:

<table>
<thead>
<tr>
<th>Object Type</th>
<th>Selection</th>
<th>Return Value Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series</td>
<td>series[label]</td>
<td>scalar value</td>
</tr>
<tr>
<td>DataFrame</td>
<td>frame[colname]</td>
<td>Series corresponding to colname</td>
</tr>
<tr>
<td>Panel</td>
<td>panel[itemname]</td>
<td>DataFrame corresponding to the itemname</td>
</tr>
</tbody>
</table>
Here we construct a simple time series data set to use for illustrating the indexing functionality:

```python
In [1]: dates = pd.date_range('1/1/2000', periods=8)
In [2]: df = pd.DataFrame(np.random.randn(8, 4), index=dates, columns=['A', 'B', 'C', 'D'])
In [3]: df
Out[3]:
        A          B          C          D
2000-01-01  0.469112  -0.282863  -1.509059  -1.135632
2000-01-02  1.212112   0.173215   0.119209  -1.044236
2000-01-03  -0.861849  -2.104569  -0.494929   1.071804
2000-01-04   0.721555  -0.706771  -1.039575   0.271860
2000-01-05  -0.424972   0.567020   0.276232  -1.087401
2000-01-06  -0.673690   0.113648  -1.478427   0.524988
2000-01-07   0.404705   0.577046   1.715002  -1.039268
2000-01-08  -0.370647  -1.157892  -1.344312   0.844885
```

```python
In [4]: panel = pd.Panel({'one' : df, 'two' : df - df.mean()})
In [5]: panel
Out[5]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 8 (major_axis) x 4 (minor_axis)
Items axis: one to two
Major_axis axis: 2000-01-01 00:00:00 to 2000-01-08 00:00:00
Minor_axis axis: A to D
```

**Note:** None of the indexing functionality is time series specific unless specifically stated.

Thus, as per above, we have the most basic indexing using []:

```python
In [6]: s = df['A']
In [7]: s[dates[5]]
Out[7]: -0.67368970808837059
```

```python
In [8]: panel['two']
```

You can pass a list of columns to [] to select columns in that order. If a column is not contained in the DataFrame, an exception will be raised. Multiple columns can also be set in this manner:

```python
In [9]: df
Out[9]:
        A          B          C          D
2000-01-01  0.409571   0.113086  -0.610826  -0.936507
2000-01-02   1.152571   0.227235   0.107442  -0.845111
2000-01-03  -0.921390  -1.708620   0.403304   1.270929
2000-01-04   0.662014  -0.310822  -0.141342   0.470985
2000-01-05  -0.484513   0.962970   1.174465  -0.888276
2000-01-06  -0.733231   0.509598  -0.580194   0.724113
2000-01-07   0.345164   0.972995  -0.816769  -0.840143
2000-01-08  -0.430188  -0.761943  -0.446079   1.044010
```

(continues on next page)
In [10]: df[['B', 'A']] = df[['A', 'B']]  

In [11]: df
Out[11]:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-01</td>
<td>-0.282863</td>
<td>0.469112</td>
<td>-1.509059</td>
<td>-1.135632</td>
</tr>
<tr>
<td>2000-01-02</td>
<td>-0.173215</td>
<td>1.212112</td>
<td>0.119209</td>
<td>-1.044236</td>
</tr>
<tr>
<td>2000-01-03</td>
<td>-2.104569</td>
<td>-0.861849</td>
<td>-0.494929</td>
<td>1.071804</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>-0.706771</td>
<td>0.721555</td>
<td>0.271860</td>
<td>-1.087401</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>0.567020</td>
<td>-0.424972</td>
<td>0.276232</td>
<td>-1.478427</td>
</tr>
<tr>
<td>2000-01-06</td>
<td>0.113648</td>
<td>-0.673690</td>
<td>-0.706771</td>
<td>0.524988</td>
</tr>
<tr>
<td>2000-01-07</td>
<td>0.577046</td>
<td>-0.370647</td>
<td>-1.715002</td>
<td>-1.344312</td>
</tr>
<tr>
<td>2000-01-08</td>
<td>-1.157892</td>
<td>0.404705</td>
<td>-1.344312</td>
<td>0.844885</td>
</tr>
</tbody>
</table>

You may find this useful for applying a transform (in-place) to a subset of the columns.

**Warning:** pandas aligns all AXES when setting Series and DataFrame from .loc, and .iloc.  
This will **not** modify df because the column alignment is before value assignment.

In [12]: df[['A', 'B']]  

Out[12]:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-01</td>
<td>-0.282863</td>
<td>0.469112</td>
</tr>
<tr>
<td>2000-01-02</td>
<td>-0.173215</td>
<td>1.212112</td>
</tr>
<tr>
<td>2000-01-03</td>
<td>-2.104569</td>
<td>-0.861849</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>-0.706771</td>
<td>0.721555</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>0.567020</td>
<td>-0.424972</td>
</tr>
<tr>
<td>2000-01-06</td>
<td>0.113648</td>
<td>-0.673690</td>
</tr>
<tr>
<td>2000-01-07</td>
<td>0.577046</td>
<td>-0.370647</td>
</tr>
<tr>
<td>2000-01-08</td>
<td>-1.157892</td>
<td>0.404705</td>
</tr>
</tbody>
</table>

In [13]: df.loc[:,['B', 'A']] = df[['A', 'B']]  

In [14]: df[['A', 'B']]  

Out[14]:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-01</td>
<td>-0.282863</td>
<td>0.469112</td>
</tr>
<tr>
<td>2000-01-02</td>
<td>-0.173215</td>
<td>1.212112</td>
</tr>
<tr>
<td>2000-01-03</td>
<td>-2.104569</td>
<td>-0.861849</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>-0.706771</td>
<td>0.721555</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>0.567020</td>
<td>-0.424972</td>
</tr>
<tr>
<td>2000-01-06</td>
<td>0.113648</td>
<td>-0.673690</td>
</tr>
<tr>
<td>2000-01-07</td>
<td>0.577046</td>
<td>-0.370647</td>
</tr>
<tr>
<td>2000-01-08</td>
<td>-1.157892</td>
<td>0.404705</td>
</tr>
</tbody>
</table>

The correct way to swap column values is by using raw values:
In [15]: df.loc[:,['B', 'A']] = df[['A', 'B']].values

In [16]: df[['A', 'B']]
Out[16]:
          A          B
2000-01-01  0.469112 -0.282863
2000-01-02  1.212112 -0.173215
2000-01-03 -0.861849 -2.104569
2000-01-04  0.721555 -0.706771
2000-01-05 -0.424972  0.567020
2000-01-06 -0.673690  0.113648
2000-01-07  0.404705  0.577046
2000-01-08 -0.370647 -1.157892

12.3 Attribute Access

You may access an index on a Series, column on a DataFrame, and an item on a Panel directly as an attribute:

In [17]: sa = pd.Series([1,2,3],index=list('abc'))

In [18]: dfa = df.copy()

In [19]: sa.b
Out[19]:
2

In [20]: dfa.A
Out[20]:
          A
2000-01-01  0.469112
2000-01-02  1.212112
2000-01-03 -0.861849
2000-01-04  0.721555
2000-01-05 -0.424972
2000-01-06 -0.673690
2000-01-07  0.404705
2000-01-08 -0.370647
Freq: D, Name: A, dtype: float64

In [21]: panel.one

In [22]: sa.a = 5

In [23]: sa
Warning:

- You can use this access only if the index element is a valid Python identifier, e.g. s.1 is not allowed. See here for an explanation of valid identifiers.
- The attribute will not be available if it conflicts with an existing method name, e.g. s.min is not allowed.
- Similarly, the attribute will not be available if it conflicts with any of the following list: index, major_axis, minor_axis, items.
- In any of these cases, standard indexing will still work, e.g. s['1'], s['min'], and s['index'] will access the corresponding element or column.

If you are using the IPython environment, you may also use tab-completion to see these accessible attributes.

You can also assign a dict to a row of a DataFrame:

```
In [28]: x = pd.DataFrame({'x': [1, 2, 3], 'y': [3, 4, 5]})
In [29]: x.iloc[1] = dict(x=9, y=99)
```
You can use attribute access to modify an existing element of a Series or column of a DataFrame, but be careful; if you try to use attribute access to create a new column, it creates a new attribute rather than a new column. In 0.21.0 and later, this will raise a `UserWarning`:

```python
In[1]: df = pd.DataFrame({'one': [1., 2., 3.]})
In[2]: df.two = [4, 5, 6]
UserWarning: Pandas doesn't allow Series to be assigned into nonexistent columns - see https://pandas.pydata.org/pandas-docs/stable/indexing.html#attribute_access
In[3]: df
Out[3]:
one
0 1.0
1 2.0
2 3.0
```

## 12.4 Slicing ranges

The most robust and consistent way of slicing ranges along arbitrary axes is described in the *Selection by Position* section detailing the `.iloc` method. For now, we explain the semantics of slicing using the `[]` operator.

With Series, the syntax works exactly as with an ndarray, returning a slice of the values and the corresponding labels:

```python
In[31]: s[:5]
Out[31]:
2000-01-01 0.469112
2000-01-02 1.212112
2000-01-03 -0.861849
2000-01-04 0.721555
2000-01-05 -0.424972
Freq: D, Name: A, dtype: float64
```

```python
In[32]: s[::2]
   →
2000-01-01 0.469112
2000-01-03 -0.861849
2000-01-05 -0.424972
Freq: 2D, Name: A, dtype: float64
```

```python
In[33]: s[::-1]
   →
2000-01-08 -0.370647
2000-01-07 0.404705
2000-01-06 -0.673690
2000-01-05 -0.424972
```

(continues on next page)
Note that setting works as well:

```
In [34]: s2 = s.copy()
In [35]: s2[:5] = 0
In [36]: s2
Out[36]:
2000-01-01 0.000000
2000-01-02 0.000000
2000-01-03 0.000000
2000-01-04 0.000000
2000-01-05 0.000000
2000-01-06 -0.673690
2000-01-07 0.404705
2000-01-08 -0.370647
Freq: D, Name: A, dtype: float64
```

With DataFrame, slicing inside of [] slices the rows. This is provided largely as a convenience since it is such a common operation.

```
In [37]: df[:3]
Out[37]:
   A      B      C      D
2000-01-01 0.469112 -0.282863 -1.509059 -1.135632
2000-01-02 1.212112 -0.173215  0.119209 -1.044236
2000-01-03 -0.861849 -2.104569 -0.494929  1.071804
```

```
In [38]: df[::-1]
```

```
   A      B      C      D
2000-01-08 -0.370647 -1.157892 -1.344312  0.844885
2000-01-07  0.404705  0.577046 -1.715002 -1.039268
2000-01-06 -0.673690  0.113648 -1.478427  0.524988
2000-01-05 -0.424972  0.567020  0.276232 -1.087401
2000-01-04  0.721555 -0.706771 -1.039575  0.271860
2000-01-03 -0.861849 -2.104569 -0.494929  1.071804
2000-01-02  1.212112 -0.173215  0.119209 -1.044236
2000-01-01  0.469112 -0.282863 -1.509059 -1.135632
```

### 12.5 Selection By Label

**Warning:** Whether a copy or a reference is returned for a setting operation, may depend on the context. This is sometimes called chained assignment and should be avoided. See *Returning a View versus Copy.*
pandas: powerful Python data analysis toolkit, Release 0.23.2

Warning:
.loc is strict when you present slicers that are not compatible (or convertible) with the index type.
For example using integers in a DatetimeIndex. These will raise a TypeError.

```
In [39]: df1 = pd.DataFrame(np.random.randn(5,4), columns=list('ABCD'), index=pd.date_range('20130101',periods=5))
In [40]: df1.loc[2:3]
```

TypeError: cannot do slice indexing on <class 'pandas.tseries.index.DatetimeIndex'> with these indexers [2] of <type 'int'>

String likes in slicing can be convertible to the type of the index and lead to natural slicing.

```
In [41]: df1.loc['20130102':'20130104']
```

```
A   B   C   D
2013-01-02 0.357021 -0.674600 -1.776904 -0.968914
2013-01-03 -1.294524  0.413738  0.276662 -0.472035
2013-01-04 -0.013960 -0.362543 -0.006154 -0.923061
```

Warning: Starting in 0.21.0, pandas will show a FutureWarning if indexing with a list with missing labels. In the future this will raise a KeyError. See list-like Using loc with missing keys in a list is Deprecated.

pandas provides a suite of methods in order to have purely label based indexing. This is a strict inclusion based protocol. Every label asked for must be in the index, or a KeyError will be raised. When slicing, both the start bound AND the stop bound are included, if present in the index. Integers are valid labels, but they refer to the label and not the position.

The .loc attribute is the primary access method. The following are valid inputs:

- A single label, e.g. 5 or 'a' (Note that 5 is interpreted as a label of the index. This use is not an integer position along the index.).
- A list or array of labels ['a', 'b', 'c'].
- A slice object with labels 'a':'f' (Note that contrary to usual python slices, both the start and the stop are included, when present in the index! See Slicing with labels.).
- A boolean array.
- A callable, see Selection By Callable.

```
In [42]: s1 = pd.Series(np.random.randn(6),index=list('abcdef'))
In [43]: s1
```

```
a  1.431256
```

(continues on next page)
b 1.340309
c -1.170299
d -0.226169
e 0.410835
f 0.813850
dtype: float64

In [44]: s1.loc['c':]
   →
c -1.170299
d -0.226169
e 0.410835
f 0.813850
dtype: float64

In [45]: s1.loc['b']
   →
1.3403088497993827

Note that setting works as well:

In [46]: s1.loc['c'] = 0

In [47]: s1
Out[47]:
a 1.431256
b 1.340309
c 0.000000
d 0.000000
e 0.000000
f 0.000000
dtype: float64

With a DataFrame:

In [48]: df1 = pd.DataFrame(np.random.randn(6,4),
                         index=list('abcdef'),
                         columns=list('ABCD'))

In [49]: df1
Out[49]:
   A      B      C      D
a 0.132003 -0.827317 -0.076467 -1.187678
b 1.130127 -1.436737 -1.413681  1.607920
c 1.024180  0.569605  0.875906 -2.211372
d 0.974466 -2.006747 -0.410001  0.078638
e 0.545952 -1.219217 -1.226825  0.769804
f -1.281247 -0.727707 -0.121306 -0.097883

In [50]: df1.loc[['a', 'b', 'd'], :]
   →
      A      B      C      D
a 0.132003 -0.827317 -0.076467 -1.187678
b 1.130127 -1.436737 -1.413681  1.607920

Accessing via label slices:

```
In [51]: df1.loc['d':, 'A':'C']
Out[51]:
A   B   C
d  0.974466 -2.006747 -0.410001
e  0.545952 -1.219217 -1.226825
f -1.281247 -0.727707  0.121306
```

For getting a cross section using a label (equivalent to `df.xs('a')`):

```
In [52]: df1.loc['a']
Out[52]:
A   0.132003
B  -0.827317
C  -0.076467
D  -1.187678
Name: a, dtype: float64
```

For getting values with a boolean array:

```
In [53]: df1.loc['a'] > 0
Out[53]:
A   True
B   False
C   False
D   False
Name: a, dtype: bool
```

```
In [54]: df1.loc[:, df1.loc['a'] > 0]
```

For getting a value explicitly (equivalent to deprecated `df.get_value('a','A')`):

```
# this is also equivalent to ```df1.at['a','A']```
In [55]: df1.loc['a', 'A']
Out[55]: 0.13200317033032932
```

### 12.5.1 Slicing with labels

When using `.loc` with slices, if both the start and the stop labels are present in the index, then elements *located* between the two (including them) are returned:

```
In [56]: s = pd.Series(list('abcde'), index=[0,3,2,5,4])
In [57]: s.loc[3:5]
```

---

**12.5. Selection By Label**

---
If at least one of the two is absent, but the index is sorted, and can be compared against start and stop labels, then slicing will still work as expected, by selecting labels which rank between the two:

```
In [58]: s.sort_index()
Out[58]:
0  a
1  c
2  b
3  e
4  d
dtype: object
```

```
In [59]: s.sort_index().loc[1:6]
Out[59]:
2  c
3  b
4  e
5  d
dtype: object
```

However, if at least one of the two is absent and the index is not sorted, an error will be raised (since doing otherwise would be computationally expensive, as well as potentially ambiguous for mixed type indexes). For instance, in the above example, `s.loc[1:6]` would raise `KeyError`.

### 12.6 Selection By Position

**Warning:** Whether a copy or a reference is returned for a setting operation, may depend on the context. This is sometimes called *chained assignment* and should be avoided. See *Returning a View versus Copy*.

Pandas provides a suite of methods in order to get purely integer based indexing. The semantics follow closely Python and NumPy slicing. These are 0-based indexing. When slicing, the start bounds is included, while the upper bound is excluded. Trying to use a non-integer, even a valid label will raise an `IndexError`.

The `.iloc` attribute is the primary access method. The following are valid inputs:

- An integer e.g. 5.
- A list or array of integers `[4, 3, 0]`.
- A slice object with ints `1:7`.
- A boolean array.
- A callable, see *Selection By Callable*.

```
In [60]: s1 = pd.Series(np.random.randn(5), index=list(range(0,10,2)))
In [61]: s1
```
Out[61]:
0   0.695775
2   0.341734
4   0.959726
6  -1.110336
8  -0.619976
dtype: float64

In [62]: s1.iloc[:3]
Out[62]:
0   0.695775
2   0.341734
4   0.959726
dtype: float64

In [63]: s1.iloc[3]
→ -1.1103361028911669

Note that setting works as well:

In [64]: s1.iloc[3] = 0

In [65]: s1
Out[65]:
0   0.000000
2   0.000000
4   0.000000
6  -1.110336
8  -0.619976
dtype: float64

With a DataFrame:

In [66]: df1 = pd.DataFrame(np.random.randn(6,4),
    index=list(range(0,12,2)),
    columns=list(range(0,8,2)))

In [67]: df1
Out[67]:
     0   2   4   6
0  0.149748 -0.732339  0.687738  0.176444
2  0.403310 -0.154951  0.301624 -2.179861
4 -1.369849 -0.954208  1.462696 -1.743161
6 -0.826591 -0.345352  1.314232  0.690579
8  0.995761  2.396780  0.014871  3.357427
10 -0.317441 -1.236269  0.896171 -0.487602

Select via integer slicing:

In [68]: df1.iloc[:3]
Out[68]:
     0   2   4   6
0  0.149748 -0.732339  0.687738  0.176444
2  0.403310 -0.154951  0.301624 -2.179861
4 -1.369849 -0.954208  1.462696 -1.743161

(continues on next page)
4 -1.369849 -0.954208 1.462696 -1.743161

**In [69]:** df1.iloc[1:5, 2:4]

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>-0.154951</td>
<td>6.179861</td>
</tr>
<tr>
<td>4</td>
<td>0.301624</td>
<td>-2.179861</td>
</tr>
<tr>
<td>6</td>
<td>1.314232</td>
<td>0.690579</td>
</tr>
<tr>
<td>8</td>
<td>0.014871</td>
<td>3.357427</td>
</tr>
</tbody>
</table>

Select via integer list:

**In [70]:** df1.iloc[[1, 3, 5], [1, 3]]

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>-0.154951</td>
<td>0.690579</td>
</tr>
<tr>
<td>4</td>
<td>-0.345352</td>
<td>1.743161</td>
</tr>
</tbody>
</table>

**In [71]:** df1.iloc[1:3, :]

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.403310</td>
<td>0.687738</td>
</tr>
<tr>
<td>2</td>
<td>-0.154951</td>
<td>0.301624</td>
</tr>
<tr>
<td>4</td>
<td>-0.954208</td>
<td>1.462696</td>
</tr>
<tr>
<td>6</td>
<td>-0.345352</td>
<td>1.314232</td>
</tr>
<tr>
<td>8</td>
<td>2.396780</td>
<td>0.014871</td>
</tr>
<tr>
<td>10</td>
<td>-1.236269</td>
<td>0.896171</td>
</tr>
</tbody>
</table>

# this is also equivalent to `df1.iat[1,1]`

**In [73]:** df1.iloc[1, 1]

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-0.732339</td>
<td>0.687738</td>
</tr>
<tr>
<td>2</td>
<td>-0.154951</td>
<td>0.301624</td>
</tr>
<tr>
<td>4</td>
<td>-0.954208</td>
<td>1.462696</td>
</tr>
<tr>
<td>6</td>
<td>-0.345352</td>
<td>1.314232</td>
</tr>
<tr>
<td>8</td>
<td>2.396780</td>
<td>0.014871</td>
</tr>
<tr>
<td>10</td>
<td>-1.236269</td>
<td>0.896171</td>
</tr>
</tbody>
</table>

For getting a cross section using an integer position (equiv to df.xs(1)):

**In [74]:** df1.iloc[1]

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.403310</td>
<td>0.687738</td>
</tr>
<tr>
<td>2</td>
<td>-0.154951</td>
<td>0.301624</td>
</tr>
<tr>
<td>4</td>
<td>0.301624</td>
<td>1.462696</td>
</tr>
<tr>
<td>6</td>
<td>2.179861</td>
<td>0.014871</td>
</tr>
</tbody>
</table>

Out of range slice indexes are handled gracefully just as in Python/Numpy.

# these are allowed in python/numpy.

**In [75]:** x = list('abcdef')
```python
In [76]: x
Out[76]: ['a', 'b', 'c', 'd', 'e', 'f']

In [77]: x[4:10]
Out[77]: ['e', 'f']

In [78]: x[8:10]
Out[78]: []

In [79]: s = pd.Series(x)

In [80]: s
Out[80]:
   0 a
   1 b
   2 c
   3 d
   4 e
   5 f
dtype: object

In [81]: s.iloc[4:10]
Out[81]:
   e
   f
dtype: object

In [82]: s.iloc[8:10]
→Series([], dtype: object)
```

Note that using slices that go out of bounds can result in an empty axis (e.g. an empty DataFrame being returned).

```python
In [83]: dfl = pd.DataFrame(np.random.randn(5,2), columns=list('AB'))

In [84]: dfl
Out[84]:
   A   B
0 -0.082240 -2.182937
1  0.380396  0.084844
2  0.432390  1.519970
3 -0.493662  0.600178
4  0.274230  0.132885

In [85]: dfl.iloc[:, 2:3]
→Empty DataFrame
   Columns: []
   Index: [0, 1, 2, 3, 4]

In [86]: dfl.iloc[:, 1:3]
→    B
    0 -2.182937
    1  0.084844
```

12.6. Selection By Position 705
In [87]: df.iloc[4:6]

   A  B
4 0.27423 0.132885

A single indexer that is out of bounds will raise an IndexError. A list of indexers where any element is out of bounds will raise an IndexError.

dfl.iloc[[4, 5, 6]]
IndexError: positional indexers are out-of-bounds
dfl.iloc[:, 4]
IndexError: single positional indexer is out-of-bounds

### 12.7 Selection By Callable

New in version 0.18.1.

.loc, .iloc, and also [] indexing can accept a callable as indexer. The callable must be a function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing.

In [88]: df1 = pd.DataFrame(np.random.randn(6, 4),
                   index=list('abcdef'),
                   columns=list('ABCD'))

In [89]: df1

Out[89]:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>-0.023688</td>
<td>2.410179</td>
<td>1.450520</td>
<td>0.206053</td>
</tr>
<tr>
<td>b</td>
<td>-0.251905</td>
<td>-2.213588</td>
<td>1.063327</td>
<td>1.266143</td>
</tr>
<tr>
<td>c</td>
<td>0.299368</td>
<td>-0.863838</td>
<td>0.408204</td>
<td>-1.048089</td>
</tr>
<tr>
<td>d</td>
<td>-0.025747</td>
<td>-0.988387</td>
<td>0.094055</td>
<td>1.262731</td>
</tr>
<tr>
<td>e</td>
<td>1.289997</td>
<td>0.082423</td>
<td>-0.055758</td>
<td>0.536580</td>
</tr>
<tr>
<td>f</td>
<td>-0.489682</td>
<td>0.369374</td>
<td>-0.034571</td>
<td>-2.484478</td>
</tr>
</tbody>
</table>

In [90]: df1.loc[lambda df: df.A > 0, :]

   A  B
|   |     |     |  |     |
| c | 0.299368 | -0.863838 | 0.408204 | -1.048089 |
| e | 1.289997 | 0.082423  | -0.055758 | 0.536580 |

In [91]: df1.loc[:, lambda df: ['A', 'B']]

   A  B
|   |     |     |
| a | -0.023688 | 2.410179 |
| b | -0.251905 | -2.213588 |
You can use callable indexing in Series.

```python
In [94]: df1.A.loc[lambda s: s > 0]
```

```
Out[94]:
     c  0.299368
     e  1.289997
```

Using these methods/indexers, you can chain data selection operations without using temporary variable.

```python
In [95]: bb = pd.read_csv('data/baseball.csv', index_col='id')

In [96]: (bb.groupby(['year', 'team']).sum()
          .loc[lambda df: df.r > 100])
```

```
Out[96]:
     stint g  ab  r  h  X2b  X3b  hr  rbi  sb  cs  bb  so
  year team
  2007 CIN  6  379  745 101 203  35  2 36 125.0  10.0  105 127.0  14.
  2007 DET  5  301 1062 162 283  54  4 37 144.0  24.0   7.0  97 176.0  3.
  2007 HOU  4  311  926 109 218  47  6 14  77.0  10.0   4.0  60 212.0  3.
  2007 LAC  9  318  904 101 229  38  7 14  87.0  10.0   4.0  60 212.0  3.
  2007 NNY 11  413 1021 153 293  61  3 36 154.0   7.0  5.0 114 141.0  8.
  2007 KLY  9  331  972 107 245  38  7 14  87.0  10.0   4.0  60 212.0  3.
12.8 IX Indexer is Deprecated

**Warning:** Starting in 0.20.0, the `.ix` indexer is deprecated, in favor of the more strict `.iloc` and `.loc` indexers.

`.ix` offers a lot of magic on the inference of what the user wants to do. To wit, `.ix` can decide to index *positionally* OR via *labels* depending on the data type of the index. This has caused quite a bit of user confusion over the years.

The recommended methods of indexing are:

- `.loc` if you want to *label* index.
- `.iloc` if you want to *positionally* index.

```python
In [97]: dfd = pd.DataFrame({
                      'A': [1, 2, 3],
                      'B': [4, 5, 6]},
                      index=list('abc'))
```

Previous behavior, where you wish to get the 0th and the 2nd elements from the index in the ‘A’ column.

```python
In [3]: dfd.ix[[0, 2], 'A']
Out[3]:
    A
a 1
b 2
c 3
Name: A, dtype: int64
```

Using `.loc`. Here we will select the appropriate indexes from the index, then use *label* indexing.

```python
In [99]: dfd.loc[dfd.index[[0, 2]], 'A']
Out[99]:
    A
a 1
b 2
c 3
Name: A, dtype: int64
```

This can also be expressed using `.iloc`, by explicitly getting locations on the indexers, and using *positional* indexing to select things.

```python
In [100]: dfd.iloc[[0, 2], dfd.columns.get_loc('A')]
Out[100]:
```

(continues on next page)
For getting *multiple* indexers, using `.get_indexer`:

```python
In [101]: dfd.iloc[[0, 2], dfd.columns.get_indexer(['A', 'B'])]
Out[101]:
   A   B
a  1  4
c  3  6
```

## 12.9 Indexing with list with missing labels is Deprecated

**Warning:** Starting in 0.21.0, using `.loc` or `[]` with a list with one or more missing labels, is deprecated, in favor of `.reindex`.

In prior versions, using `.loc[list-of-labels]` would work as long as at least 1 of the keys was found (otherwise it would raise a `KeyError`). This behavior is deprecated and will show a warning message pointing to this section. The recommended alternative is to use `.reindex()`.

For example.

```python
In [102]: s = pd.Series([1, 2, 3])
In [103]: s
Out[103]:
0  1
1  2
2  3
dtype: int64
```

Selection with all keys found is unchanged.

```python
In [104]: s.loc[[1, 2]]
Out[104]:
1  2
2  3
dtype: int64
```

### Previous Behavior

```python
In [4]: s.loc[[1, 2, 3]]
Out[4]:
1  2.0
2  3.0
3  NaN
dtype: float64
```

### Current Behavior

12.9. Indexing with list with missing labels is Deprecated
In [4]: s.loc[[1, 2, 3]]
Passing list-likes to .loc with any non-matching elements will raise
KeyError in the future, you can use .reindex() as an alternative.

See the documentation here:
http://pandas.pydata.org/pandas-docs/stable/indexing.html#deprecate-loc-reindex-
˓listlike

Out[4]:
1 2.0
2 3.0
3 NaN
dtype: float64

12.9.1 Reindexing

The idiomatic way to achieve selecting potentially not-found elements is via .reindex(). See also the section on
reindexing.

In [105]: s.reindex([1, 2, 3])
Out[105]:
1 2.0
2 3.0
3 NaN
dtype: float64

Alternatively, if you want to select only valid keys, the following is idiomatic and efficient; it is guaranteed to preserve
the dtype of the selection.

In [106]: labels = [1, 2, 3]
In [107]: s.loc[s.index.intersection(labels)]
Out[107]:
1 2
2 3
dtype: int64

Having a duplicated index will raise for a .reindex():

In [108]: s = pd.Series(np.arange(4), index=['a', 'a', 'b', 'c'])
In [109]: labels = ['c', 'd']

In [17]: s.reindex(labels)
ValueError: cannot reindex from a duplicate axis

Generally, you can intersect the desired labels with the current axis, and then reindex.

In [110]: s.loc[s.index.intersection(labels)].reindex(labels)
Out[110]:
c 3.0
d NaN
dtype: float64

However, this would still raise if your resulting index is duplicated.
In [41]: labels = ['a', 'd']

In [42]: s.loc[s.index.intersection(labels)].reindex(labels)
ValueError: cannot reindex from a duplicate axis

12.10 Selecting Random Samples

A random selection of rows or columns from a Series, DataFrame, or Panel with the `sample()` method. The method will sample rows by default, and accepts a specific number of rows/columns to return, or a fraction of rows.

In [111]: s = pd.Series([0,1,2,3,4,5])

# When no arguments are passed, returns 1 row.
In [112]: s.sample()
Out[112]:
   0
   4
dtype: int64

# One may specify either a number of rows:
In [113]: s.sample(n=3)
Out[113]:
   0
   4
   1
dtype: int64

# Or a fraction of the rows:
In [114]: s.sample(frac=0.5)
Out[114]:
   5
   3
   1
dtype: int64

By default, `sample` will return each row at most once, but one can also sample with replacement using the `replace` option:

In [115]: s = pd.Series([0,1,2,3,4,5])

# Without replacement (default):
In [116]: s.sample(n=6, replace=False)
Out[116]:
   0
   4
   5
   3
   2
   4
   dtype: int64

# With replacement:
In [117]: s.sample(n=6, replace=True)
Out[117]:
   0
   4
(continues on next page)
By default, each row has an equal probability of being selected, but if you want rows to have different probabilities, you can pass the `sample` function sampling weights as `weights`. These weights can be a list, a NumPy array, or a Series, but they must be of the same length as the object you are sampling. Missing values will be treated as a weight of zero, and inf values are not allowed. If weights do not sum to 1, they will be re-normalized by dividing all weights by the sum of the weights. For example:

```
In [118]: s = pd.Series([0,1,2,3,4,5])
In [119]: example_weights = [0, 0, 0.2, 0.2, 0.2, 0.4]
In [120]: s.sample(n=3, weights=example_weights)
Out[120]:
3 3
2 2
4 4
dtype: int64
```

```
# Weights will be re-normalized automatically
In [121]: example_weights2 = [0.5, 0, 0, 0, 0, 0]
In [122]: s.sample(n=1, weights=example_weights2)
Out[122]:
0 0
dtype: int64
```

When applied to a DataFrame, you can use a column of the DataFrame as sampling weights (provided you are sampling rows and not columns) by simply passing the name of the column as a string.

```
In [123]: df2 = pd.DataFrame({'col1':[9,8,7,6], 'weight_column':[0.5, 0.4, 0.1, 0]})
In [124]: df2.sample(n = 3, weights = 'weight_column')
Out[124]:
   col1  weight_column
0     9             0.4
1     8             0.4
2     7             0.1
```

`sample` also allows users to sample columns instead of rows using the `axis` argument.

```
In [125]: df3 = pd.DataFrame({'col1':[1,2,3], 'col2':[2,3,4]})
In [126]: df3.sample(n=1, axis=1)
Out[126]:
   col1
0     1
1     2
2     3
```

Finally, one can also set a seed for `sample`'s random number generator using the `random_state` argument, which will accept either an integer (as a seed) or a NumPy RandomState object.
12.11 Setting With Enlargement

The .loc[] operations can perform enlargement when setting a non-existent key for that axis. In the Series case this is effectively an appending operation.

A DataFrame can be enlarged on either axis via .loc.
This is like an *append* operation on the DataFrame.

```
In [138]: dfi.loc[3] = 5
```

```
In [139]: dfi
Out[139]:
     A  B  C
0   0  1  0
1   2  3  2
2   4  5  4
3   5  5  5
```

### 12.12 Fast scalar value getting and setting

Since indexing with `[]` must handle a lot of cases (single-label access, slicing, boolean indexing, etc.), it has a bit of overhead in order to figure out what you’re asking for. If you only want to access a scalar value, the fastest way is to use the *at* and *iat* methods, which are implemented on all of the data structures.

Similarly to *loc*, *at* provides *label* based scalar lookups, while, *iat* provides *integer* based lookups analogously to *iloc*

```
In [140]: s.iat[5]
Out[140]: 5
```

```
In [141]: df.at[dates[5], 'A']
Out[141]: -0.67368970808837059
```

```
In [142]: df.iat[3, 0]
Out[142]: 0.72155516224436689
```

You can also set using these same indexers.

```
In [143]: df.at[dates[5], 'E'] = 7
```

```
In [144]: df.iat[3, 0] = 7
```

*at* may enlarge the object in-place as above if the indexer is missing.

```
In [145]: df.at[dates[-1]+1, 0] = 7
```

```
In [146]: df
Out[146]:
     A   B   C   D   E   0
0 2000-01-01 0.469112 -0.282863 -1.509059 -1.135632 NaN NaN
1 2000-01-02 1.212112 -0.173215 0.119209 -1.044236 NaN NaN
2 2000-01-03 -0.861849 -2.104569 -0.494929 1.071804 NaN NaN
3 2000-01-04 7.000000 -0.706771 -1.039575 0.271860 NaN NaN
```

(continues on next page)
Another common operation is the use of boolean vectors to filter the data. The operators are: \( \lor \) for or, \& for and, and \( \neg \) for not. These must be grouped by using parentheses, since by default Python will evaluate an expression such as \( \text{df.A} > 2 \ \& \ \text{df.B} < 3 \) as \( \text{df.A} > (2 \ \& \ \text{df.B}) < 3 \), while the desired evaluation order is \((\text{df.A} > 2) \ \& \ (\text{df.B} < 3)\).

Using a boolean vector to index a Series works exactly as in a NumPy ndarray:

In [147]: s = pd.Series(range(-3, 4))

In [148]: s
Out[148]:
0   -3
1   -2
2   -1
3    0
4    1
5    2
6    3
dtype: int64

In [149]: s[s > 0]
Out[149]:
4    1
5    2
6    3
dtype: int64

In [150]: s[(s < -1) | (s > 0.5)]
→
0   -3
1   -2
4    1
5    2
6    3
dtype: int64

In [151]: s[~(s < 0)]
→
3    0
4    1
5    2
6    3
dtype: int64

You may select rows from a DataFrame using a boolean vector the same length as the DataFrame’s index (for example,
something derived from one of the columns of the DataFrame):

```
In [152]: df[df['A'] > 0]
Out[152]:
   A      B      C      D      E
0 0.469112 -0.282863 -1.509059 -1.135632 NaN
1 1.212112 -0.173215  0.119209 -1.044236 NaN
2 7.000000 -0.706771 -1.039575  0.271860 NaN
3 0.404705  0.577046 -1.715002 -1.039268 NaN

List comprehensions and map method of Series can also be used to produce more complex criteria:

```
In [153]: df2 = pd.DataFrame({'a' : ['one', 'one', 'two', 'three', 'two', 'one', 'six
˓→'],
   .....
   'b' : ['x', 'y', 'y', 'x', 'y', 'x', 'x'],
   .....
   'c' : np.random.randn(7))
   .....

# only want 'two' or 'three'
In [154]: criterion = df2['a'].map(lambda x: x.startswith('t'))
In [155]: df2[criterion]
Out[155]:
   a  b  c
2 two y  0.041290
3 three x  0.361719
4 two y -0.238075

# equivalent but slower
In [156]: df2[[x.startswith('t') for x in df2['a']]]
Out[156]:
   a  b  c
2 two y  0.041290
3 three x  0.361719
4 two y -0.238075

# Multiple criteria
In [157]: df2[criterion & (df2['b'] == 'x')]
Out[157]:
   a  b  c
2 two y  0.041290
3 three x  0.361719

With the choice methods Selection by Label, Selection by Position, and Advanced Indexing you may select along more than one axis using boolean vectors combined with other indexing expressions.

```
In [158]: df2.loc[criterion & (df2['b'] == 'x'),'b':'c']
Out[158]:
   b  c
2 y 0.041290
3 x 0.361719

12.14 Indexing with isin

Consider the isin() method of Series, which returns a boolean vector that is true wherever the Series elements exist in the passed list. This allows you to select rows where one or more columns have values you want:

```
In [159]: df2.isin([0, 'x'])
Out[159]:
   a  b  c
2 False True
3   True False
4   True False

In [160]: df2.loc[df2['b'].isin(['x', 'y'])]
Out[160]:
   a  b  c
2 two y  0.041290
3 three x  0.361719
4 two y -0.238075
```
The same method is available for Index objects and is useful for the cases when you don’t know which of the sought labels are in fact present:

```
In [163]: s[s.index.isin([2, 4, 6])]
Out[163]:
4  0
2  2
dtype: int64
```

# compare it to the following
```
In [164]: s.reindex([2, 4, 6])
Out[164]:
2  2.0
4  0.0
6  NaN
dtype: float64
```

In addition to that, MultiIndex allows selecting a separate level to use in the membership check:

```
In [159]: s = pd.Series(np.arange(5), index=np.arange(5)[::-1], dtype='int64')
In [160]: s
Out[160]:
4  0
3  1
2  2
1  3
0  4
dtype: int64
In [161]: s.isin([2, 4, 6])
Out[161]:
4  False
3  False
2  True
1  False
0  True
dtype: bool
In [162]: s[s.isin([2, 4, 6])]
```

(continues on next page)
DataFrame also has an `isin()` method. When calling `isin`, pass a set of values as either an array or dict. If values is an array, `isin` returns a DataFrame of booleans that is the same shape as the original DataFrame, with True wherever the element is in the sequence of values.

```python
df.isin(values)
```

Oftentimes you’ll want to match certain values with certain columns. Just make values a `dict` where the key is the column, and the value is a list of items you want to check for.

```python
df.isin(values)
```

Combine DataFrame’s `isin` with the `any()` and `all()` methods to quickly select subsets of your data that meet a given criteria. To select a row where each column meets its own criterion:

```python
df.isin(values)
```

(continues on next page)
In [175]: row_mask = df.isin(values).all(1)

In [176]: df[row_mask]
Out[176]:
   vals ids ids2
0    1   a   a
1  12.15 The

where() Method and Masking

Selecting values from a Series with a boolean vector generally returns a subset of the data. To guarantee that selection output has the same shape as the original data, you can use the `where` method in `Series` and `DataFrame`.

To return only the selected rows:

In [177]: s[s > 0]
Out[177]:
   3  1
   2  2
   1  3
   0  4

dtype: int64

To return a Series of the same shape as the original:

In [178]: s.where(s > 0)
Out[178]:
   4  NaN
   3  1.0
   2  2.0
   1  3.0
   0  4.0

dtype: float64

Selecting values from a DataFrame with a boolean criterion now also preserves input data shape. `where` is used under the hood as the implementation. The code below is equivalent to `df.where(df < 0)`.

In [179]: df[df < 0]
Out[179]:
   A   B    C   D
2000-01-01 -2.104139 -1.309525 NaN NaN
2000-01-02 -0.352480 NaN -1.192319 NaN
2000-01-03 -0.864883 NaN -0.227870 NaN
2000-01-04 NaN -1.222082 NaN -1.233203
2000-01-05 NaN -0.605656 -1.169184 NaN
2000-01-06 NaN -0.948458 NaN -0.684718
2000-01-07 -2.670153 -0.114722 NaN -0.048048
2000-01-08 NaN NaN -0.048788 -0.808838

In addition, `where` takes an optional `other` argument for replacement of values where the condition is False, in the returned copy.

In [180]: df.where(df < 0, -df)
Out[180]:
   A   B    C   D
2000-01-01 -2.104139 -1.309525 NaN NaN
2000-01-02 -0.352480 NaN -1.192319 NaN
2000-01-03 -0.864883 NaN -0.227870 NaN
2000-01-04 NaN -1.222082 NaN -1.233203
2000-01-05 NaN -0.605656 -1.169184 NaN
2000-01-06 NaN -0.948458 NaN -0.684718
2000-01-07 -2.670153 -0.114722 NaN -0.048048
2000-01-08 NaN NaN -0.048788 -0.808838

(continues on next page)
You may wish to set values based on some boolean criteria. This can be done intuitively like so:

```
In [181]: s2 = s.copy()
In [182]: s2[s2 < 0] = 0
In [183]: s2
Out[183]:
        0  1  2  3
0  0  0  0  0
1  0  0  0  0
dtype: int64
```

```
In [184]: df2 = df.copy()
In [185]: df2[df2 < 0] = 0
In [186]: df2
Out[186]:
   A     B      C      D
0 0.000000 0.000000 0.485855 0.245166
1 0.000000 0.390389 0.000000 1.655824
2 0.000000 0.299674 0.000000 0.281059
3 0.846958 0.000000 0.600705 0.000000
4 0.669692 0.000000 0.000000 0.342416
5 0.868584 0.948458 2.297780 0.684718
6 0.000000 0.000000 0.168904 0.000000
7 0.801196 1.392071 0.000000 0.000000
```

By default, `where` returns a modified copy of the data. There is an optional parameter `inplace` so that the original data can be modified without creating a copy:

```
In [187]: df_orig = df.copy()
In [188]: df_orig.where(df > 0, -df, inplace=True);
In [189]: df_orig
Out[189]:
   A     B      C      D
0 2.104139 1.309525 0.485855 0.245166
1 0.352480 0.390389 1.192319 1.655824
2 0.864883 0.299674 0.227870 0.281059
3 0.846958 1.220822 0.600705 1.233203
4 0.669692 0.605656 1.169184 0.342416
5 0.868584 0.948458 2.297780 0.684718
6 0.000000 0.000000 0.168904 0.000000
7 0.801196 1.392071 0.000000 0.000000
```

(continues on next page)
2000-01-07  2.670153  0.114722  0.168904  0.048048
2000-01-08  0.801196  1.392071  0.048788  0.808838

Note: The signature for `DataFrame.where()` differs from `numpy.where()`. Roughly `df1.where(m, df2)` is equivalent to `np.where(m, df1, df2).

```python
In [190]: df.where(df < 0, -df) == np.where(df < 0, df, -df)
Out[190]:
     A      B      C      D
2000-01-01   True   True   True   True
2000-01-02   True   True   True   True
2000-01-03   True   True   True   True
2000-01-04   True   True   True   True
2000-01-05   True   True   True   True
2000-01-06   True   True   True   True
2000-01-07   True   True   True   True
2000-01-08   True   True   True   True
```

alignment
Furthermore, `where` aligns the input boolean condition (ndarray or DataFrame), such that partial selection with setting is possible. This is analogous to partial setting via `.loc` (but on the contents rather than the axis labels).

```python
In [191]: df2 = df.copy()
In [192]: df2[df2[1:4] > 0] = 3
In [193]: df2
Out[193]:
     A      B      C      D
2000-01-01 -2.104139 -2.104139  0.485855  0.245166
2000-01-02 -0.352480  0.390389 -0.352480  1.655824
2000-01-03 -0.864883  0.299674 -0.864883  0.281059
2000-01-04  0.846958  0.846958  0.600705  0.846958
2000-01-05  0.669692  0.669692  0.669692  0.342416
2000-01-06  0.868584  0.948458  2.297780 -0.684718
2000-01-07 -2.670153 -0.114722  0.168904 -2.670153
2000-01-08  0.801196  1.392071  0.801196  0.801196
```

Where can also accept `axis` and `level` parameters to align the input when performing the `where`.

```python
In [194]: df2 = df.copy()
In [195]: df2.where(df2>0,df2['A'],axis='index')
Out[195]:
     A      B      C      D
2000-01-01 -2.104139 -2.104139  0.485855  0.245166
2000-01-02 -0.352480  0.390389 -0.352480  1.655824
2000-01-03 -0.864883  0.299674 -0.864883  0.281059
2000-01-04  0.846958  0.846958  0.600705  0.846958
2000-01-05  0.669692  0.669692  0.669692  0.342416
2000-01-06  0.868584  0.868584  2.297780 -0.684718
2000-01-07 -2.670153 -0.114722  0.168904 -2.670153
2000-01-08  0.801196  1.392071  0.801196  0.801196
```

12.15. The `where()` Method and Masking
This is equivalent to (but faster than) the following.

```
In [196]: df2 = df.copy()

In [197]: df.apply(lambda x, y: x.where(x>0,y), y=df['A'])
Out[197]:
         A          B          C          D
2000-01-01 -2.104139 -2.104139  0.485855  0.245166
2000-01-02 -0.352480  0.390389 -0.352480  1.655824
2000-01-03 -0.864883  0.299674 -0.864883  0.281059
2000-01-04  0.846958  0.846958  0.600705  0.846958
2000-01-05  0.669692  0.669692  0.669692  0.342416
2000-01-06  0.868584  0.868584  2.297780  0.868584
2000-01-07 -2.670153 -2.670153  0.168904 -2.670153
2000-01-08  0.801196  1.392071  0.801196  0.801196
```

New in version 0.18.1.

Where can accept a callable as condition and other arguments. The function must be with one argument (the calling Series or DataFrame) and that returns valid output as condition and other argument.

```
In [198]: df3 = pd.DataFrame({'A': [1, 2, 3],
                      'B': [4, 5, 6],
                      'C': [7, 8, 9]})

In [199]: df3.where(lamda x: x > 4, lamda x: x + 10)
```

```
In [200]: s.mask(s >= 0)
Out[200]:
   0  11  14  7
   1  12  5  8
   2  13  6  9

12.15.1 Mask

mask() is the inverse boolean operation of where.

```
In [201]: df.mask(df >= 0)
Out[201]:
   2000-01-01 -2.104139 -1.309525   NaN   NaN
   2000-01-02 -0.352480   NaN -1.192319   NaN
   2000-01-03 -0.864883   NaN  -0.227870   NaN
   2000-01-04   NaN -1.222082   NaN -1.233203
   2000-01-05   NaN  -0.605656 -1.169184   NaN
   2000-01-06   NaN -0.948458   NaN -0.684718
   2000-01-07 -2.670153  -0.114722   NaN -0.048788
   2000-01-08   NaN  -0.048788 -0.808838
```
DataFrame objects have a `query()` method that allows selection using an expression.

You can get the value of the frame where column `b` has values between the values of columns `a` and `c`. For example:

```python
In [202]: n = 10
In [203]: df = pd.DataFrame(np.random.rand(n, 3), columns=list('abc'))
In [204]: df
Out[204]:
    a   b    c
0  0.438921  0.118680  0.863670
1  0.138138  0.577363  0.686602
2  0.595307  0.564592  0.520630
3  0.913052  0.926075  0.616184
4  0.078718  0.854477  0.898725
5  0.076404  0.523211  0.591538
6  0.792342  0.216974  0.564056
7  0.397890  0.454131  0.915716
8  0.074315  0.437913  0.019794
9  0.559209  0.502065  0.026437

# pure python
In [205]: df[(df.a < df.b) & (df.b < df.c)]
  ...:
   a   b    c
1  0.138138  0.577363  0.686602
4  0.078718  0.854477  0.898725
5  0.076404  0.523211  0.591538
7  0.397890  0.454131  0.915716

# query
In [206]: df.query('(a < b) & (b < c)')
  ...:
   a   b    c
1  0.138138  0.577363  0.686602
4  0.078718  0.854477  0.898725
5  0.076404  0.523211  0.591538
7  0.397890  0.454131  0.915716

Do the same thing but fall back on a named index if there is no column with the name `a`.

```
In [207]: df = pd.DataFrame(np.random.randint(n / 2, size=(n, 2)), columns=list('bc'))
In [208]: df.index.name = 'a'

In [209]: df
Out[209]:
    b    c
a 0 0 4
1 0 1
2 3 4
```

(continues on next page)
In [210]: df.query('a < b and b < c')

Out[210]:
    b  c
2  3  4

If instead you don’t want to or cannot name your index, you can use the name `index` in your query expression:

In [211]: df = pd.DataFrame(np.random.randint(n, size=(n, 2)), columns=list('bc'))

In [212]: df
Out[212]:
    b  c
0  3  1
1  3  0
2  5  6
3  5  2
4  7  4
5  0  1
6  2  5
7  0  1
8  6  0
9  7  9

In [213]: df.query('index < b < c')

Out[213]:
    b  c
2  5  6

**Note:** If the name of your index overlaps with a column name, the column name is given precedence. For example,

In [214]: df = pd.DataFrame({'a': np.random.randint(5, size=5)})

In [215]: df.index.name = 'a'

In [216]: df.query('a > 2')  # uses the column 'a', not the index
Out[216]:
    a
0  3
1  3

You can still use the index in a query expression by using the special identifier `index`:

In [217]: df.query('index > 2')

(continues on next page)
If for some reason you have a column named `index`, then you can refer to the index as `ilevel_0` as well, but at this point you should consider renaming your columns to something less ambiguous.

### 12.16.1 MultiIndex `query()` Syntax

You can also use the levels of a `DataFrame` with a `MultiIndex` as if they were columns in the frame:

```python
In [218]: n = 10
In [219]: colors = np.random.choice(['red', 'green'], size=n)
In [220]: foods = np.random.choice(['eggs', 'ham'], size=n)
In [221]: colors
Out[221]: array(['red', 'red', 'red', 'green', 'green', 'green', 'green', 'green', 'green', 'green'], dtype='<U5')
In [222]: foods
Out[222]: array(['ham', 'ham', 'eggs', 'eggs', 'eggs', 'ham', 'ham', 'eggs', 'eggs', 'eggs'], dtype='<U4')
In [223]: index = pd.MultiIndex.from_arrays([colors, foods], names=['color', 'food'])
In [224]: df = pd.DataFrame(np.random.randn(n, 2), index=index)
In [225]: df
Out[225]:     0     1
color food
red  ham  0.194889 -0.381994
   ham  0.318587  2.089075
   eggs -0.728293 -0.090255
green eggs -0.748199  1.318931
          eggs -2.029766  0.792652
          ham  0.461007 -0.542749
          ham -0.305384 -0.479195
          eggs  0.095031 -0.270099
          eggs -0.707140 -0.773882
          eggs  0.229453  0.304418
In [226]: df.query('color == "red"')
```

(continues on next page)
If the levels of the MultiIndex are unnamed, you can refer to them using special names:

```
In [227]: df.index.names = [None, None]

In [228]: df
Out[228]:
\n                   0       1
  red   ham  0.194889 -0.381994
  ham    0.318587  2.089075
  eggs  -0.728293 -0.090255
  green eggs -0.748199  1.318931
  eggs    2.029766  0.792652
  ham    0.461007 -0.542749
  ham   -0.305384 -0.479195
  eggs   0.095031 -0.270099
  eggs  -0.707140 -0.773882
  eggs   0.229453  0.304418

In [229]: df.query('ilevel_0 == "red"')
```

The convention is ilevel_0, which means “index level 0” for the 0th level of the index.

### 12.16.2 query() Use Cases

A use case for `query()` is when you have a collection of `DataFrame` objects that have a subset of column names (or index levels/names) in common. You can pass the same query to both frames without having to specify which frame you’re interested in querying.

```
In [230]: df = pd.DataFrame(np.random.rand(n, 3), columns=list('abc'))

In [231]: df
Out[231]:
\n                   a       b       c
  0  0.224283  0.736107  0.139168
  1  0.302827  0.657803  0.713897
  2  0.611185  0.136624  0.984960
  3  0.195246  0.123436  0.627712
  4  0.618673  0.371660  0.047902
  5  0.480088  0.062993  0.185760
  6  0.568018  0.483467  0.445289
  7  0.309040  0.274580  0.587101
  8  0.258993  0.477769  0.370255
  9  0.550459  0.840870  0.304611
```

(continues on next page)
In [232]: df2 = pd.DataFrame(np.random.rand(n + 2, 3), columns=df.columns)
In [233]: df2
Out[233]:
   a      b      c
0  0.357579  0.229800  0.596001
1  0.309059  0.957923  0.965663
2  0.123102  0.336914  0.318616
3  0.526506  0.323321  0.860813
4  0.518736  0.486514  0.384724
5  0.190804  0.505723  0.614533
6  0.891939  0.623977  0.676639
7  0.480559  0.378528  0.460858
8  0.420223  0.136404  0.141295
9  0.732206  0.419540  0.604675
10 0.604466  0.848974  0.896165
11 0.589168  0.920046  0.732716

In [234]: expr = '0.0 <= a <= c <= 0.5'

In [235]: map(lambda frame: frame.query(expr), [df, df2])
Out[235]: <map at 0x1c2b11f5f8>

12.16.3 query() Python versus pandas Syntax Comparison

Full numpy-like syntax:

In [236]: df = pd.DataFrame(np.random.randint(n, size=(n, 3)), columns=list('abc'))
In [237]: df
Out[237]:
   a  b  c
0  7  8  9
1  1  0  7
2  2  7  2
3  6  2  2
4  2  6  3
5  3  8  2
6  1  7  2
7  5  1  5
8  9  8  0
9  1  5  0

In [238]: df.query('(a < b) & (b < c)')
→   a  b  c
0  7  8  9

In [239]: df[(df.a < df.b) & (df.b < df.c)]
→   a  b  c
0  7  8  9

12.16. The query() Method
Slightly nicer by removing the parentheses (by binding making comparison operators bind tighter than & and |).

In [240]: df.query('a < b & b < c')
Out[240]:
    a  b  c
0  7  8  9

Use English instead of symbols:

In [241]: df.query('a < b and b < c')
Out[241]:
    a  b  c
0  7  8  9

Pretty close to how you might write it on paper:

In [242]: df.query('a < b < c')
Out[242]:
    a  b  c
0  7  8  9

12.16.4 The in and not in operators

query() also supports special use of Python’s in and not in comparison operators, providing a succinct syntax for calling the isin method of a Series or DataFrame.

# get all rows where columns "a" and "b" have overlapping values
In [243]: df = pd.DataFrame({'a': list('aabbccddeeff'), 'b': list('aaaabbbbcccc'),
                      ....:             'c': np.random.randint(5, size=12),
                      ....:             'd': np.random.randint(9, size=12)})

In [244]: df
Out[244]:
    a  b  c  d
0  a  a  2  6
1  a  a  4  7
2  b  a  1  6
3  b  a  2  1
4  c  b  3  6
5  c  b  0  2
6  d  b  3  3
7  d  b  2  1
8  e  c  4  3
9  e  c  2  0
10 f  c  0  6
11 f  c  1  2

In [245]: df.query('a in b')
Out[245]:
    a  b  c  d
0  a  a  2  6
1  a  a  4  7
2  b  a  1  6
3  b  a  2  1

(continues on next page)
# How you'd do it in pure Python

```python
In [246]: df[df.a.isin(df.b)]
```

```
<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>a</td>
<td>a</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>a</td>
<td>a</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>b</td>
<td>a</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>b</td>
<td>a</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>c</td>
<td>b</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>c</td>
<td>b</td>
<td>0</td>
</tr>
</tbody>
</table>
```

```python
Out[246]:
```

```python
In [247]: df.query('a not in b')
```

```
<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>d</td>
<td>b</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>d</td>
<td>b</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>e</td>
<td>c</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>e</td>
<td>c</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>f</td>
<td>c</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>f</td>
<td>c</td>
<td>1</td>
</tr>
</tbody>
</table>
```

# pure Python

```python
In [248]: df[~df.a.isin(df.b)]
```

```
<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>d</td>
<td>b</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>d</td>
<td>b</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>e</td>
<td>c</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>e</td>
<td>c</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>f</td>
<td>c</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>f</td>
<td>c</td>
<td>1</td>
</tr>
</tbody>
</table>
```

You can combine this with other expressions for very succinct queries:

```python
# rows where cols a and b have overlapping values and col c's values are less than col d's
```

```python
In [249]: df.query('a in b and c < d')
```

```
<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>a</td>
<td>a</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>a</td>
<td>a</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>b</td>
<td>a</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>c</td>
<td>b</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>c</td>
<td>b</td>
<td>0</td>
</tr>
</tbody>
</table>
```

# pure Python

```python
In [250]: df[df.b.isin(df.a) & (df.c < df.d)]
```

```
<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>a</td>
<td>a</td>
<td>2</td>
</tr>
</tbody>
</table>
| 12.16. The query() Method
Note: Note that `in` and `not in` are evaluated in Python, since `numexpr` has no equivalent of this operation. However, only the `in/not in` expression itself is evaluated in vanilla Python. For example, in the expression

```python
df.query('a in b + c + d')
```

`(b + c + d)` is evaluated by `numexpr` and then the `in` operation is evaluated in plain Python. In general, any operations that can be evaluated using `numexpr` will be.

### 12.16.5 Special use of the `==` operator with `list` objects

Comparing a list of values to a column using `==`/`!=` works similarly to `in/not in`.

```python
In [251]: df.query('b == ["a", "b", "c"]')
Out[251]:
   a  b  c  d
0  a  a  2  6
1  a  a  4  7
2  b  a  1  6
3  b  a  2  1
4  c  b  3  6
5  c  b  0  2
6  d  b  3  3
7  d  b  2  1
8  e  c  4  3
9  e  c  2  0
10 f  c  0  6
11 f  c  1  2
```

# pure Python

```python
In [252]: df[df.b.isin(["a", "b", "c")]
```

(continues on next page)
In [253]: df.query('c == [1, 2]

\rightarrow
da
0 a a 2 6
2 b a 1 6
3 b a 2 1
7 d b 2 1
9 e c 2 0
11 f c 1 2

In [254]: df.query('c != [1, 2]

\rightarrow
da
1 a a 4 7
4 c b 3 6
5 c b 0 2
6 d b 3 3
8 e c 4 3
10 f c 0 6

# using in/not in
In [255]: df.query('[1, 2] in c

\rightarrow
da
0 a a 2 6
2 b a 1 6
3 b a 2 1
7 d b 2 1
9 e c 2 0
11 f c 1 2

In [256]: df.query('[1, 2] not in c

\rightarrow
da
1 a a 4 7
4 c b 3 6
5 c b 0 2
6 d b 3 3
8 e c 4 3
10 f c 0 6

# pure Python
In [257]: df[df.c.isin([1, 2])]

\rightarrow
da
0 a a 2 6
2 b a 1 6
3 b a 2 1
7 d b 2 1
9 e c 2 0
11 f c 1 2

12.16. The `query()` Method
12.16.6 Boolean Operators

You can negate boolean expressions with the word `not` or the ~ operator.

```
In [258]: df = pd.DataFrame(np.random.rand(n, 3), columns=list('abc'))
In [259]: df['bools'] = np.random.rand(len(df)) > 0.5
In [260]: df.query('~bools')
Out[260]:
   a    b    c  bools
2  0.697753  0.212799  0.329209    False
7  0.275396  0.691034  0.826619    False
8  0.190649  0.558748  0.262467    False
```

```
In [261]: df.query('not bools')
Out[261]:
   a    b    c  bools
2  0.697753  0.212799  0.329209    False
7  0.275396  0.691034  0.826619    False
8  0.190649  0.558748  0.262467    False
```

Of course, expressions can be arbitrarily complex too:

```
# short query syntax
In [263]: shorter = df.query('a < b < c and (not bools) or bools > 2')

# equivalent in pure Python
In [264]: longer = df[(df.a < df.b) & (df.b < df.c) & (~df.bools) | (df.bools > 2)]

In [265]: shorter
Out[265]:
   a    b    c  bools
2  0.697753  0.212799  0.329209    False
7  0.275396  0.691034  0.826619    False
8  0.190649  0.558748  0.262467    False

In [266]: longer
Out[266]:
   a    b    c  bools
2  0.697753  0.212799  0.329209    False
7  0.275396  0.691034  0.826619    False
8  0.190649  0.558748  0.262467    False
```

```
In [267]: shorter == longer
Out[267]:
   a    b    c  bools
2  True  True  True  True
7  True  True  True  True
8  True  True  True  True
```
12.16.7 Performance of `query()`

`DataFrame.query()` using `numexpr` is slightly faster than Python for large frames.

![Graph showing performance comparison between `python` and `numexpr` for `DataFrame.query()`](image)

**Note:** You will only see the performance benefits of using the `numexpr` engine with `DataFrame.query()` if your frame has more than approximately 200,000 rows.

This plot was created using a `DataFrame` with 3 columns each containing floating point values generated using `numpy.random.randn()`.

12.17 Duplicate Data

If you want to identify and remove duplicate rows in a `DataFrame`, there are two methods that will help: `duplicated` and `drop_duplicates`. Each takes as an argument the columns to use to identify duplicated rows.
• duplicated returns a boolean vector whose length is the number of rows, and which indicates whether a row is duplicated.
• drop_duplicates removes duplicate rows.

By default, the first observed row of a duplicate set is considered unique, but each method has a keep parameter to specify targets to be kept.

• keep='first' (default): mark / drop duplicates except for the first occurrence.
• keep='last': mark / drop duplicates except for the last occurrence.
• keep=False: mark / drop all duplicates.

```
In[268]: df2 = pd.DataFrame({'a': ['one', 'one', 'two', 'two', 'two', 'three', 'four'],
                        'b': ['x', 'y', 'x', 'y', 'x', 'x', 'x'],
                        'c': np.random.randn(7))

In[269]: df2
Out[269]:
   a    b         c
0  one  x -1.067137
1  one  y  0.309500
2  two  x -0.211056
3  two  y -1.842023
4  two  x -0.390820
5  three  x -1.964475
6   four  x  1.298329

In[270]: df2.duplicated('a')
Out[270]:
0  False
1   True
2  False
3   True
4   True
5  False
6  False
dtype: bool

In[271]: df2.duplicated('a', keep='last')
Out[271]:
0   True
1  False
2   True
3   True
4  False
5  False
6  False
dtype: bool

In[272]: df2.duplicated('a', keep=False)
Out[272]:
0   True
1   True
```

(continues on next page)
In [273]: df2.drop_duplicates('a')

\[\rightarrow\]

\[
\begin{array}{ccc}
 0 & one & x -1.067137 \\
 2 & two & x -0.211056 \\
 5 & three & x -1.964475 \\
 6 & four & x 1.298329 \\
\end{array}
\]

In [274]: df2.drop_duplicates('a', keep='last')

\[\rightarrow\]

\[
\begin{array}{ccc}
 1 & one & y 0.309500 \\
 4 & two & x -0.390820 \\
 5 & three & x -1.964475 \\
 6 & four & x 1.298329 \\
\end{array}
\]

In [275]: df2.drop_duplicates('a', keep=False)

\[\rightarrow\]

\[
\begin{array}{ccc}
 5 & three & x -1.964475 \\
 6 & four & x 1.298329 \\
\end{array}
\]

Also, you can pass a list of columns to identify duplications.

In [276]: df2.duplicated(['a', 'b'])

Out[276]:

\[
\begin{array}{cccc}
 0 & False \\
 1 & False \\
 2 & False \\
 3 & False \\
 4 & True \\
 5 & False \\
 6 & False \\
\end{array}
\]

dtype: bool

In [277]: df2.drop_duplicates(['a', 'b'])

\[\rightarrow\]

\[
\begin{array}{ccc}
 0 & one & x -1.067137 \\
 1 & one & y 0.309500 \\
 2 & two & x -0.211056 \\
 3 & two & y -1.842023 \\
 5 & three & x -1.964475 \\
 6 & four & x 1.298329 \\
\end{array}
\]

To drop duplicates by index value, use `Index.duplicated` then perform slicing. The same set of options are
available for the `keep` parameter.

```python
In [278]: df3 = pd.DataFrame(
               {'a': np.arange(6),
               'b': np.random.randn(6)},
               index=['a', 'a', 'b', 'c', 'b', 'a'])

In [279]: df3
Out[279]:
      a   b
a 0  1.4405
a 1  2.45609
b 2  1.0384
b 3  0.6835
b 4  3.0828
a 5  3.0828

In [280]: df3.index.duplicated()
\[\rightarrow\]
array([False, True, False, False, True, True], dtype=bool)

In [281]: df3[~df3.index.duplicated()]
\[\rightarrow\]
      a   b
a 0  1.4405
b 2  1.0384
b 3  0.6835
a 5  3.0828

In [282]: df3[~df3.index.duplicated(keep='last')]
\[\rightarrow\]
      a   b
b 3  0.6835
b 4  0.6835
a 5  3.0828

In [283]: df3[~df3.index.duplicated(keep=False)]
\[\rightarrow\]
      a   b
b 3  0.6835
```

### 12.18 Dictionary-like `get()` method

Each of Series, DataFrame, and Panel have a `get` method which can return a default value.

```python
In [284]: s = pd.Series([1,2,3], index=['a','b','c'])

In [285]: s.get('a')                      # equivalent to s['a']
Out[285]: 1

In [286]: s.get('x', default=-1)
\[\rightarrow\]
Out[286]: -1
```
12.19 The `lookup()` Method

Sometimes you want to extract a set of values given a sequence of row labels and column labels, and the `lookup` method allows for this and returns a NumPy array. For instance:

```python
In [287]: dflookup = pd.DataFrame(np.random.rand(20,4), columns=['A','B','C','D'])
In [288]: dflookup.lookup(list(range(0,10,2)), ['B','C','A','B','D'])
```

Out[288]:
```
array([ 0.3506, 0.4779, 0.4825, 0.9197, 0.5019])
```

12.20 Index objects

The pandas `Index` class and its subclasses can be viewed as implementing an *ordered multiset*. Duplicates are allowed. However, if you try to convert an `Index` object with duplicate entries into a `set`, an exception will be raised.

`Index` also provides the infrastructure necessary for lookups, data alignment, and reindexing. The easiest way to create an `Index` directly is to pass a list or other sequence to `Index`:

```python
In [289]: index = pd.Index(['e', 'd', 'a', 'b'])
In [290]: index
```

Out[290]:
```
Index(['e', 'd', 'a', 'b'], dtype='object')
```

You can also pass a name to be stored in the index:

```python
In [292]: index = pd.Index(['e', 'd', 'a', 'b'], name='something')
In [293]: index.name
```

Out[293]:
```
'something'
```

The name, if set, will be shown in the console display:

```python
In [294]: index = pd.Index(list(range(5)), name='rows')
In [295]: columns = pd.Index(['A', 'B', 'C'], name='cols')
In [296]: df = pd.DataFrame(np.random.randn(5, 3), index=index, columns=columns)
In [297]: df
```

Out[297]:
```
   A     B     C
rows  
0  1.295989  0.185778  0.436259
1  0.678101  0.311369 -0.528378
2 -0.674808 -1.103529 -0.656157
3  1.889957  2.076651 -1.102192
4 -1.211795 -0.791746  0.634724
```

(continues on next page)
12.20.1 Setting metadata

Indexes are “mostly immutable”, but it is possible to set and change their metadata, like the index name (or, for MultiIndex, levels and labels).

You can use the rename, set_names, set_levels, and set_labels to set these attributes directly. They default to returning a copy; however, you can specify inplace=True to have the data change in place.

See Advanced Indexing for usage of MultiIndexes.

```python
In [299]: ind = pd.Index([1, 2, 3])
In [300]: ind.rename("apple")
Out[300]: Int64Index([1, 2, 3], dtype='int64', name='apple')

In [301]: ind
Out[301]: Int64Index([1, 2, 3], dtype='int64')

In [302]: ind.set_names(['apple'], inplace=True)
In [303]: ind.name = "bob"
In [304]: ind
Out[304]: Int64Index([1, 2, 3], dtype='int64', name='bob')
```

set_names, set_levels, and set_labels also take an optional level' argument

```python
In [305]: index = pd.MultiIndex.from_product([range(3), ['one', 'two']], names=['first', 'second'])
In [306]: index
Out[306]: MultiIndex(levels=[[0, 1, 2], ['one', 'two']],
               labels=[[0, 0, 1, 1, 2, 2], [0, 1, 0, 1, 0, 1]],
               names=['first', 'second'])

In [307]: index.levels[1]
Index(['one', 'two'], dtype='object', name='second')

In [308]: index.set_levels(['a', 'b'], level=1)
MultiIndex(levels=[[0, 1, 2], ['a', 'b']],
           labels=[[0, 0, 1, 1, 2, 2], [0, 1, 0, 1, 0, 1]],
           names=['first', 'second'])
```
12.20.2 Set operations on Index objects

The two main operations are `union (|)` and `intersection (&)`. These can be directly called as instance methods or used via overloaded operators. Difference is provided via the `.difference()` method.

```python
In [309]: a = pd.Index(['c', 'b', 'a'])
In [310]: b = pd.Index(['c', 'e', 'd'])
In [311]: a | b
Out[311]: Index(['a', 'b', 'c', 'd', 'e'], dtype='object')

In [312]: a & b
Out[312]: Index(['c'], dtype='object')

In [313]: a.difference(b)
Out[313]: Index(['a', 'b'], dtype='object')
```

Also available is the `symmetric_difference (^)` operation, which returns elements that appear in either `idx1` or `idx2`, but not in both. This is equivalent to the Index created by `idx1.difference(idx2).union(idx2.difference(idx1))`, with duplicates dropped.

```python
In [314]: idx1 = pd.Index([1, 2, 3, 4])
In [315]: idx2 = pd.Index([2, 3, 4, 5])
In [316]: idx1.symmetric_difference(idx2)
Out[316]: Int64Index([1, 5], dtype='int64')

In [317]: idx1 ^ idx2
Out[317]: Int64Index([1, 5], dtype='int64')
```

**Note:** The resulting index from a set operation will be sorted in ascending order.

12.20.3 Missing values

**Important:** Even though `Index` can hold missing values (`NaN`), it should be avoided if you do not want any unexpected results. For example, some operations exclude missing values implicitly.

`Index.fillna` fills missing values with specified scalar value.

```python
In [318]: idx1 = pd.Index([1, np.nan, 3, 4])
In [319]: idx1
Out[319]: Float64Index([1.0, nan, 3.0, 4.0], dtype='float64')

In [320]: idx1.fillna(2)
Out[320]: Float64Index([1.0, 2.0, 3.0, 4.0], dtype='float64')
```

(continues on next page)

In [322]: idx2
Out[322]: DatetimeIndex(['2011-01-01', 'NaT', '2011-01-03'], dtype='datetime64[ns]', freq=None)

In [323]: idx2.fillna(pd.Timestamp('2011-01-02'))
Out[323]: DatetimeIndex(['2011-01-01', '2011-01-02', '2011-01-03'], dtype='datetime64[ns]', freq=None)

12.21 Set / Reset Index

Occasionally you will load or create a data set into a DataFrame and want to add an index after you’ve already done so. There are a couple of different ways.

12.21.1 Set an index

DataFrame has a set_index() method which takes a column name (for a regular Index) or a list of column names (for a MultiIndex). To create a new, re-indexed DataFrame:

In [324]: data
Out[324]:
   a   b   c   d
0  bar  one  z  1.0
1  bar  two  y  2.0
2  foo  one  x  3.0
3  foo  two  w  4.0

In [325]: indexed1 = data.set_index('c')

In [326]: indexed1
Out[326]:
   b   d
   c
  z  bar  one  1.0
  y  bar  two  2.0
  x  foo  one  3.0
  w  foo  two  4.0

In [327]: indexed2 = data.set_index(['a', 'b'])

In [328]: indexed2
Out[328]:
   c   d
   a
   bar  one  z  1.0
         two  y  2.0
         two  w  4.0
The `append` keyword option allow you to keep the existing index and append the given columns to a MultiIndex:

```python
In [329]: frame = data.set_index('c', drop=False)
In [330]: frame = frame.set_index(['a', 'b'], append=True)
In [331]: frame
Out[331]:
   c  d
   a b
   z bar one z 1.0
   y bar two y 2.0
   x foo one x 3.0
   w foo two w 4.0
```

Other options in `set_index` allow you not drop the index columns or to add the index in-place (without creating a new object):

```python
In [332]: data.set_index('c', drop=False)
Out[332]:
   a  b  c  d
   c
   z bar one z 1.0
   y bar two y 2.0
   x foo one x 3.0
   w foo two w 4.0
In [333]: data.set_index(['a', 'b'], inplace=True)
In [334]: data
Out[334]:
   c  d
   a b
   bar one z 1.0
   two y 2.0
   foo one x 3.0
   two w 4.0
```

### 12.21.2 Reset the index

As a convenience, there is a new function on DataFrame called `reset_index()` which transfers the index values into the DataFrame’s columns and sets a simple integer index. This is the inverse operation of `set_index()`.

```python
In [335]: data
Out[335]:
   c  d
   a b
   bar one z 1.0
   two y 2.0
   foo one x 3.0
   two w 4.0
In [336]: data.reset_index()
```

(continues on next page)
The output is more similar to a SQL table or a record array. The names for the columns derived from the index are the ones stored in the names attribute.

You can use the level keyword to remove only a portion of the index:

```python
In [337]: frame
Out[337]:
   c  d
   a  b
z bar one  z  1.0
y bar two  y  2.0
x foo one   x  3.0
w foo two   w  4.0
```

```
In [338]: frame.reset_index(level=1)
```

reset_index takes an optional parameter drop which if true simply discards the index, instead of putting index values in the DataFrame’s columns.

### 12.21.3 Adding an ad hoc index

If you create an index yourself, you can just assign it to the index field:

```python
data.index = index
```

### 12.22 Returning a view versus a copy

When setting values in a pandas object, care must be taken to avoid what is called chained indexing. Here is an example.

```python
In [339]: dfmi = pd.DataFrame([[list('abcd'),
                        list('efgh'),
                        list('ijkl'),
                        list('mnop')],
                       columns=pd.MultiIndex.from_product([[ 'one','two'],
                                                ['first','second']],
                                              level=['one','two']))
```

```
In [340]: dfmi
```
Compare these two access methods:

```
In [341]: dfmi['one']['second']
Out[341]:
   0  b
   1  f
   2  j
   3  n
Name: second, dtype: object
```

```
In [342]: dfmi.loc[:,('one','second')]
Out[342]:
   0  b
   1  f
   2  j
   3  n
Name: (one, second), dtype: object
```

These both yield the same results, so which should you use? It is instructive to understand the order of operations on these and why method 2 (`.loc`) is much preferred over method 1 (chained `.[]`).

dfmi['one'] selects the first level of the columns and returns a DataFrame that is singly-indexed. Then another Python operation dfmi_with_one['second'] selects the series indexed by 'second'. This is indicated by the variable dfmi_with_one because pandas sees these operations as separate events. e.g. separate calls to `__getitem__`, so it has to treat them as linear operations, they happen one after another.

Contrast this to df.loc[:,('one','second')] which passes a nested tuple of (slice(None),('one','second')) to a single call to `__getitem__`. This allows pandas to deal with this as a single entity. Furthermore this order of operations can be significantly faster, and allows one to index both axes if so desired.

### 12.22.1 Why does assignment fail when using chained indexing?

The problem in the previous section is just a performance issue. What’s up with the `SettingWithCopy` warning? We don’t usually throw warnings around when you do something that might cost a few extra milliseconds!

But it turns out that assigning to the product of chained indexing has inherently unpredictable results. To see this, think about how the Python interpreter executes this code:

```
dfmi.loc[:,('one','second')] = value
# becomes
dfmi.loc.__setitem__((slice(None), ('one', 'second')), value)
```

But this code is handled differently:

```
dfmi['one']['second'] = value
# becomes
dfmi.__getitem__('one').__setitem__('second', value)
```

### 12.22. Returning a view versus a copy
See that __getitem__ in there? Outside of simple cases, it’s very hard to predict whether it will return a view or a copy (it depends on the memory layout of the array, about which pandas makes no guarantees), and therefore whether the __setitem__ will modify dfmi or a temporary object that gets thrown out immediately afterward. That’s what SettingWithCopy is warning you about!

**Note:** You may be wondering whether we should be concerned about the loc property in the first example. But dfmi.loc is guaranteed to be dfmi itself with modified indexing behavior, so dfmi.loc.__getitem__/dfmi.loc.__setitem__ operate on dfmi directly. Of course, dfmi.loc.__getitem__(idx) may be a view or a copy of dfmi.

Sometimes a SettingWithCopy warning will arise at times when there’s no obvious chained indexing going on. These are the bugs that SettingWithCopy is designed to catch! Pandas is probably trying to warn you that you’ve done this:

```python
def do_something(df):
    foo = df[['bar', 'baz']]
    # Is foo a view? A copy? Nobody knows!
    # ... many lines here ...
    foo['quux'] = value
    # We don’t know whether this will modify df or not!
    return foo
```

Yikes!

### 12.22.2 Evaluation order matters

When you use chained indexing, the order and type of the indexing operation partially determine whether the result is a slice into the original object, or a copy of the slice.

Pandas has the SettingWithCopyWarning because assigning to a copy of a slice is frequently not intentional, but a mistake caused by chained indexing returning a copy where a slice was expected.

If you would like pandas to be more or less trusting about assignment to a chained indexing expression, you can set the option mode.chained_assignment to one of these values:

- 'warn', the default, means a SettingWithCopyWarning is printed.
- 'raise' means pandas will raise a SettingWithCopyException you have to deal with.
- None will suppress the warnings entirely.

```python
In [343]: dfb = pd.DataFrame({'a' : ['one', 'one', 'two', 'three', 'two', 'one', 'six'],
                        'c' : np.arange(7)})
                        
# This will show the SettingWithCopyWarning
# but the frame values will be set
In [344]: dfb['c'][dfb.a.str.startswith('o')] = 42
```

This however is operating on a copy and will not work.

```python
>>> pd.set_option('mode.chained_assignment', 'warn')
>>> dfb[dfb.a.str.startswith('o')]['c'] = 42
Traceback (most recent call last)
... SettingWithCopyWarning:
```

(continues on next page)
A chained assignment can also crop up in setting in a mixed dtype frame.

**Note:** These setting rules apply to all of `.loc/.iloc`.

This is the correct access method:

```python
In [345]: dfc = pd.DataFrame({'A':['aaa','bbb','ccc'],'B':[1,2,3]})
In [346]: dfc.loc[0,'A'] = 11
In [347]: dfc
Out[347]:
   A  B
0  11  1
1  bbb  2
2   ccc  3
```

This *can* work at times, but it is not guaranteed to, and therefore should be avoided:

```python
In [348]: dfc = dfc.copy()
In [349]: dfc['A'][0] = 111
In [350]: dfc
Out[350]:
   A  B
0  111  1
1  bbb  2
2   ccc  3
```

This will **not** work at all, and so should be avoided:

```python
>>> pd.set_option('mode.chained_assignment','raise')
>>> dfc.loc[0]['A'] = 1111
Traceback (most recent call last)
  ... 
SettingWithCopyException:
    A value is trying to be set on a copy of a slice from a DataFrame.
    Try using .loc[row_index,col_indexer] = value instead
```

**Warning:** The chained assignment warnings / exceptions are aiming to inform the user of a possibly invalid assignment. There may be false positives; situations where a chained assignment is inadvertently reported.
This section covers indexing with a MultiIndex and more advanced indexing features.

See the Indexing and Selecting Data for general indexing documentation.

**Warning:** Whether a copy or a reference is returned for a setting operation, may depend on the context. This is sometimes called chained assignment and should be avoided. See Returning a View versus Copy.

See the cookbook for some advanced strategies.

### 13.1 Hierarchical indexing (MultiIndex)

Hierarchical / Multi-level indexing is very exciting as it opens the door to some quite sophisticated data analysis and manipulation, especially for working with higher dimensional data. In essence, it enables you to store and manipulate data with an arbitrary number of dimensions in lower dimensional data structures like Series (1d) and DataFrame (2d).

In this section, we will show what exactly we mean by “hierarchical” indexing and how it integrates with all of the pandas indexing functionality described above and in prior sections. Later, when discussing group by and pivoting and reshaping data, we’ll show non-trivial applications to illustrate how it aids in structuring data for analysis.

See the cookbook for some advanced strategies.

#### 13.1.1 Creating a MultiIndex (hierarchical index) object

The MultiIndex object is the hierarchical analogue of the standard Index object which typically stores the axis labels in pandas objects. You can think of MultiIndex as an array of tuples where each tuple is unique. A MultiIndex can be created from a list of arrays (using MultiIndex.from_arrays), an array of tuples (using MultiIndex.from_tuples), or a crossed set of iterables (using MultiIndex.from_product). The Index constructor will attempt to return a MultiIndex when it is passed a list of tuples. The following examples demonstrate different ways to initialize MultiIndexes.

```python
In [1]: arrays = [['bar', 'bar', 'baz', 'baz', 'foo', 'foo', 'qux', 'qux'],
               ...
               ['one', 'two', 'one', 'two', 'one', 'two', 'one', 'two']]

In [2]: tuples = list(zip(*arrays))

In [3]: tuples
Out[3]:
[('bar', 'one'),
  ('bar', 'two'),
  ('baz', 'one'),
  ('baz', 'two'),
  ...]
```

(continues on next page)
In [4]: index = pd.MultiIndex.from_tuples(tuples, names=['first', 'second'])

In [5]: index
Out[5]:
MultiIndex(levels=[['bar', 'baz', 'foo', 'qux'], ['one', 'two']],
labels=[[0, 0, 1, 1, 2, 2, 3, 3], [0, 1, 0, 1, 0, 1, 0, 1]],
names=['first', 'second'])

In [6]: s = pd.Series(np.random.randn(8), index=index)

In [7]: s
Out[7]:
first    second
bar one   0.469112
         two -0.282863
baz one   -1.509059
         two -1.135632
foo one   1.212112
         two -0.173215
qux one   0.119209
         two -1.044236

When you want every pairing of the elements in two iterables, it can be easier to use the MultiIndex.
from_product function:

In [8]: iterables = [['bar', 'baz', 'foo', 'qux'], ['one', 'two']]

In [9]: pd.MultiIndex.from_product(iterables, names=['first', 'second'])
Out[9]:
MultiIndex(levels=[['bar', 'baz', 'foo', 'qux'], ['one', 'two']],
labels=[[0, 0, 1, 1, 2, 2, 3, 3], [0, 1, 0, 1, 0, 1, 0, 1]],
names=['first', 'second'])

As a convenience, you can pass a list of arrays directly into Series or DataFrame to construct a MultiIndex automatically:

In [10]: arrays = [np.array( ['bar', 'bar', 'baz', 'baz', 'foo', 'foo', 'qux', 'qux'] ),
             np.array( ['one', 'two', 'one', 'two', 'one', 'two', 'one', 'two'] )]

In [11]: s = pd.Series(np.random.randn(8), index=arrays)

In [12]: s
Out[12]:
bar one   -0.861849
         two -2.104569
baz one   -0.494929

(continues on next page)
pandas: powerful Python data analysis toolkit, Release 0.23.2

(continued from previous page)

two 1.071804
foo one 0.721555
two -0.706771
qux one -1.039575
two 0.271860
dtype: float64

In [13]: df = pd.DataFrame(np.random.randn(8, 4), index=arrays)

In [14]: df
Out[14]:
     0   1   2   3
bar one -0.424972 0.567020 0.276232 -1.087401
two -0.673690 0.113648 -1.478427 0.524988
baz one 0.404705 0.577046 -1.715002 -1.039268
two -0.370647 -1.157892 -1.344312 0.844885
foo one 1.075770 -0.109050 1.643563 -1.469388
two 0.357021 -0.674600 -1.776904 -0.968914
qux one -1.294524 0.413738 0.276662 -0.472035
two -0.013960 -0.362543 -0.006154 -0.923061

All of the MultiIndex constructors accept a names argument which stores string names for the levels themselves. If no names are provided, None will be assigned:

In [15]: df.index.names
Out[15]: FrozenList([None, None])

This index can back any axis of a pandas object, and the number of levels of the index is up to you:

In [16]: df = pd.DataFrame(np.random.randn(3, 8), index=['A', 'B', 'C'],
                     columns=index)

In [17]: df
Out[17]:
   first  bar  baz  foo  qux
second one  two  one  two  one  two
A  0.895717  0.805244 -1.206412  2.565646  1.431256  1.340309 -1.170299 -0.226169
B  0.410835  0.813850  0.132003 -0.827317 -0.076467 -1.187678  1.130127 -1.436737
C -1.413681  1.607920  1.024180  0.569605  0.875906 -2.211372  0.974466 -2.006747

In [18]: pd.DataFrame(np.random.randn(6, 6), index=index[:6], columns=index[:6])

We’ve “sparsified” the higher levels of the indexes to make the console output a bit easier on the eyes. Note that how the index is displayed can be controlled using the multi_sparse option in pandas.set_options():

13.1. Hierarchical indexing (MultiIndex)
In [19]: with pd.option_context('display.multi_sparse', False):
    ....:  df
    ....:

It’s worth keeping in mind that there’s nothing preventing you from using tuples as atomic labels on an axis:

In [20]: pd.Series(np.random.randn(8), index=tuples)
Out[20]:
(bar, one) -1.236269
(bar, two)  0.896171
(baz, one) -0.487602
(baz, two) -0.082240
(foo, one) -2.182937
(foo, two)  0.380396
(qux, one)  0.084844
(qux, two)  0.432390
dtype: float64

The reason that the MultiIndex matters is that it can allow you to do grouping, selection, and reshaping operations as we will describe below and in subsequent areas of the documentation. As you will see in later sections, you can find yourself working with hierarchically-indexed data without creating a MultiIndex explicitly yourself. However, when loading data from a file, you may wish to generate your own MultiIndex when preparing the data set.

13.1.2 Reconstructing the level labels

The method `get_level_values` will return a vector of the labels for each location at a particular level:

In [21]: index.get_level_values(0)
Out[21]:
Index(['bar', 'bar', 'baz', 'baz', 'foo', 'foo', 'qux', 'qux'], dtype='object',
      name='first')

In [22]: index.get_level_values('second')

In [23]: df['bar']
Out[23]:
second one two
A  0.895717  0.805244
B  0.410835  0.813850
C -1.413681  1.607920

In [24]: df['bar', 'one']

(continues on next page)
C  -1.413681
Name: (bar, one), dtype: float64

In [25]: df['bar']['one']

→
A  0.895717
B  0.410835
C  -1.413681
Name: one, dtype: float64

In [26]: s['qux']

→
one  -1.039575
two  0.271860
dtype: float64

See Cross-section with hierarchical index for how to select on a deeper level.

13.1.4 Defined Levels

The repr of a MultiIndex shows all the defined levels of an index, even if they are not actually used. When slicing an index, you may notice this. For example:

In [27]: df.columns  # original MultiIndex
Out[27]:
MultiIndex(levels=['bar', 'baz', 'foo', 'qux'], ['one', 'two'],
labels=[[0, 0, 1, 1, 2, 2, 3, 3], [0, 1, 0, 1, 0, 1, 0, 1]],
names=['first', 'second'])

In [28]: df[['foo', 'qux']].columns  # sliced

→
MultiIndex(levels=['bar', 'baz', 'foo', 'qux'], ['one', 'two'],
labels=[[2, 2, 3, 3], [0, 1, 0, 1]],
names=['first', 'second'])

This is done to avoid a recomputation of the levels in order to make slicing highly performant. If you want to see only the used levels, you can use the MultiIndex.get_level_values() method.

In [29]: df[['foo', 'qux']].columns.values
Out[29]:
array([('foo', 'one'), ('foo', 'two'), ('qux', 'one'), ('qux', 'two')],
dtype=object)

# for a specific level
In [30]: df[['foo', 'qux']].columns.get_level_values(0)

→
Index([('foo', 'one'), ('foo', 'two'), ('qux', 'one'), ('qux', 'two')],
dtype=object, name='first')

To reconstruct the MultiIndex with only the used levels, the remove_unused_levels method may be used. New in version 0.20.0.
13.1.5 Data alignment and using `reindex`

Operations between differently-indexed objects having `MultiIndex` on the axes will work as you expect; data alignment will work the same as an Index of tuples:

```python
In [32]: s + s[:,-2]
Out[32]:
bar one  -1.723698
two   -4.209138
baz one  -0.989859
two   2.143608
foo one  1.443110
two  -1.413542
qux one   NaN
two   NaN
dtype: float64
```

```python
In [33]: s + s[::2]
```

```
bar one  -1.723698
two   NaN
baz one  -0.989859
two   NaN
foo one  1.443110
two   NaN
qux one  -2.079150
two   NaN
dtype: float64
```

`reindex` can be called with another `MultiIndex`, or even a list or array of tuples:

```python
In [34]: s.reindex(index[:3])
Out[34]:
first second
bar one   -0.861849
two  -2.104569
baz one   -0.494929
dtype: float64
```

```python
In [35]: s.reindex([('foo', 'two'), ('bar', 'one'), ('qux', 'one'), ('baz', 'one')])
```

```
foo two  -0.706771
bar one  -0.861849
qux one  -1.039575
baz one  -0.494929
dtype: float64
```
13.2 Advanced indexing with hierarchical index

Syntactically integrating MultiIndex in advanced indexing with .loc is a bit challenging, but we’ve made every effort to do so. In general, MultiIndex keys take the form of tuples. For example, the following works as you would expect:

```
In [36]: df = df.T

In [37]: df
Out[37]:
   A    B    C
first second
   bar  one  0.895717  0.410835 -1.413681
        two  0.805244  0.813850  1.607920
   baz  one -1.206412  0.132003  1.024180
        two  2.565646 -0.827317  0.569605
   foo  one  1.431256 -0.076467  0.875906
        two  1.340309 -1.187678 -2.211372
   qux  one -1.170299  1.130127  0.974466
        two -0.226169 -1.436737 -2.006747

In [38]: df.loc[('bar', 'two'),]

A  0.805244
B  0.813850
C  1.607920
Name: (bar, two), dtype: float64
```

Note that df.loc['bar', 'two'] would also work in this example, but this shorthand notation can lead to ambiguity in general.

If you also want to index a specific column with .loc, you must use a tuple like this:

```
In [39]: df.loc[('bar', 'two'), 'A']
Out[39]: 0.80524402538637851
```

You don’t have to specify all levels of the MultiIndex by passing only the first elements of the tuple. For example, you can use “partial” indexing to get all elements with bar in the first level as follows:

df.loc['bar']

This is a shortcut for the slightly more verbose notation df.loc[('bar',),] (equivalent to df.loc['bar',] in this example).

“Partial” slicing also works quite nicely.

```
In [40]: df.loc['baz':'foo']
Out[40]:
   A    B    C
first second
   baz  one -1.206412  0.132003  1.024180
        two  2.565646 -0.827317  0.569605
   foo  one  1.431256 -0.076467  0.875906
        two  1.340309 -1.187678 -2.211372
```

You can slice with a ‘range’ of values, by providing a slice of tuples.
In [41]: df.loc[('baz', 'two'):('qux', 'one')]
Out[41]:
   A     B    C
first second
baz two  2.565646 -0.827317  0.569605
foo one  1.431256 -0.076467  0.875906
two      1.340309 -1.187678 -2.211372
qux one  -1.170299  1.130127  0.974466

In [42]: df.loc[('baz', 'two'):'foo']
   ...
   ...
Out[42]:
   A     B    C
first second
baz two  2.565646 -0.827317  0.569605
foo one  1.431256 -0.076467  0.875906
two      1.340309 -1.187678 -2.211372

Passing a list of labels or tuples works similar to reindexing:

In [43]: df.loc[['bar', 'two'], ('qux', 'one')]
Out[43]:
   A     B    C
first second
bar two  0.805244  0.813850  1.607920
qux one  -1.170299  1.130127  0.974466

Note: It is important to note that tuples and lists are not treated identically in pandas when it comes to indexing. Whereas a tuple is interpreted as one multi-level key, a list is used to specify several keys. Or in other words, tuples go horizontally (traversing levels), lists go vertically (scanning levels).

Importantly, a list of tuples indexes several complete MultiIndex keys, whereas a tuple of lists refer to several values within a level:

In [44]: s = pd.Series([1, 2, 3, 4, 5, 6],
   index=pd.MultiIndex.from_product([['A', 'B'], ['c', 'd', 'e']]))

In [45]: s.loc[('A', 'c'), ('B', 'd')]  # list of tuples
Out[45]:
A c  1
B d  5
dtype: int64

In [46]: s.loc[['A', 'B'], ['c', 'd']]  # tuple of lists
Out[46]:
A c  1
d  2
B c  4
d  5
dtype: int64
13.2.1 Using slicers

You can slice a `MultiIndex` by providing multiple indexers.

You can provide any of the selectors as if you are indexing by label, see *Selection by Label*, including slices, lists of labels, labels, and boolean indexers.

You can use `slice(None)` to select all the contents of that level. You do not need to specify all the *deeper* levels, they will be implied as `slice(None)`.

As usual, both sides of the slicers are included as this is label indexing.

**Warning:** You should specify all axes in the `.loc` specifier, meaning the indexer for the *index* and for the *columns*. There are some ambiguous cases where the passed indexer could be mis-interpreted as indexing both axes, rather than into say the `MultiIndex` for the rows.

You should do this:

```python
df.loc[(slice('A1','A3'),.....), :]
```

You should not do this:

```python
df.loc[(slice('A1','A3'),.....)]
```

```python
In [47]: def mklbl(prefix,n):
    ....:     return ["%s%s" % (prefix,i) for i in range(n)]
    ....:

In [48]: miindex = pd.MultiIndex.from_product([mklbl('A',4),
                                 mklbl('B',2),
                                 mklbl('C',4),
                                 mklbl('D',2)])

In [49]: micolumns = pd.MultiIndex.from_tuples([('a','foo'),('a','bar'),
                                         ('b','foo'),('b','bah')],
                                         names=['lvl0', 'lvl1'])

In [50]: dfmi = pd.DataFrame(np.arange(len(miindex)*len(micolumns)).reshape((len(miindex),len(micolumns))),
                         index=miindex,
                         columns=micolumns).sort_index().sort_index(axis=1)

In [51]: dfmi
Out[51]:
<table>
<thead>
<tr>
<th>lvl0</th>
<th>lvl1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>A0</td>
<td>B0</td>
</tr>
<tr>
<td></td>
<td>C0</td>
</tr>
<tr>
<td></td>
<td>D0</td>
</tr>
<tr>
<td></td>
<td>D1</td>
</tr>
<tr>
<td></td>
<td>C1</td>
</tr>
<tr>
<td></td>
<td>D0</td>
</tr>
<tr>
<td></td>
<td>D1</td>
</tr>
<tr>
<td></td>
<td>C2</td>
</tr>
<tr>
<td></td>
<td>D0</td>
</tr>
<tr>
<td></td>
<td>D1</td>
</tr>
<tr>
<td></td>
<td>C3</td>
</tr>
<tr>
<td></td>
<td>D0</td>
</tr>
<tr>
<td></td>
<td>D1</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>A3</td>
<td>B1</td>
</tr>
<tr>
<td></td>
<td>C0</td>
</tr>
<tr>
<td></td>
<td>D1</td>
</tr>
</tbody>
</table>

(continues on next page)
Basic multi-index slicing using slices, lists, and labels.

Basic multi-index slicing using slices, lists, and labels.

<table>
<thead>
<tr>
<th>C1</th>
<th>D0</th>
<th>233</th>
<th>232</th>
<th>235</th>
<th>234</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>237</td>
<td>236</td>
<td>239</td>
<td>238</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>D0</td>
<td>241</td>
<td>240</td>
<td>243</td>
<td>242</td>
</tr>
<tr>
<td>D1</td>
<td>245</td>
<td>244</td>
<td>247</td>
<td>246</td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>D0</td>
<td>249</td>
<td>248</td>
<td>251</td>
<td>250</td>
</tr>
<tr>
<td>D1</td>
<td>253</td>
<td>252</td>
<td>255</td>
<td>254</td>
<td></td>
</tr>
</tbody>
</table>

[64 rows x 4 columns]

You can use `pandas.IndexSlice` to facilitate a more natural syntax using `:`, rather than using `slice(None)`.

You can use `pandas.IndexSlice` to facilitate a more natural syntax using `:`, rather than using `slice(None)`.

In [55]: dfmi.loc[(slice('A1','A3'), slice(None), ['C1', 'C3']), :]

Out[55]:

<table>
<thead>
<tr>
<th>lvl0</th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>lvl1</td>
<td>bar</td>
<td>foo</td>
</tr>
<tr>
<td>A1 B0 C1 D0</td>
<td>73</td>
<td>72</td>
</tr>
<tr>
<td>D1</td>
<td>77</td>
<td>76</td>
</tr>
<tr>
<td>C3 D0</td>
<td>89</td>
<td>88</td>
</tr>
<tr>
<td>D1</td>
<td>93</td>
<td>92</td>
</tr>
<tr>
<td>B1 C1 D0</td>
<td>105</td>
<td>104</td>
</tr>
<tr>
<td>D1</td>
<td>109</td>
<td>108</td>
</tr>
<tr>
<td>C3 D0</td>
<td>121</td>
<td>120</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>A3 B0 C1 D1</td>
<td>205</td>
<td>204</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>C3 D0</td>
<td>217</td>
<td>216</td>
</tr>
<tr>
<td>...</td>
<td>A3 B0 C1 D1</td>
<td>204</td>
</tr>
</tbody>
</table>

[24 rows x 4 columns]
It is possible to perform quite complicated selections using this method on multiple axes at the same time.

```
In [55]: dfmi.loc['A1', (slice(None), 'foo')]
Out[55]:
   lvl0   a   b
B0   C0   D0   64   66
     D1   68   70
C1   D0   72   74
     D1   76   78
C2   D0   80   82
     D1   84   86
C3   D0   88   90
...     ... ...
B1   C0   D1  100  102
     D1  108  110
C1   D0  112  114
     D1  116  118
C2   D0  120  122
     D1  124  126
[16 rows x 2 columns]
```

```
In [56]: dfmi.loc[idx[:, :, ['C1', 'C3']], idx[:, 'foo']]
```

```
lvl0   a   b
lvl1   foo  foo
A0   B0   C1   D0   8   10
     D1   12   14
     C3   D0  24   26
      D1   28   30
B1   C1   D0  40   42
     D1  44   46
     C3   D0  56   58
...     ... ...
A3   B0   C1   D1  204  206
     C3   D0  216  218
      D1  220  222
B1   C1   D0  232  234
     D1  236  238
     C3   D0  248  250
      D1  252  254
[32 rows x 2 columns]
```

Using a boolean indexer you can provide selection related to the values.

```
In [57]: mask = dfmi['a', 'foo'] > 200

In [58]: dfmi.loc[idx[mask, :, ['C1', 'C3']], idx[:, 'foo']]
Out[58]:
   lvl0   a   b
   lvl1   foo  foo
```

(continues on next page)
You can also specify the `axis` argument to `.loc` to interpret the passed slicers on a single axis.

```
In [59]: dfmi.loc(axis=0)[:, :, ['C1', 'C3']]
Out[59]:
     a    b
   lvl0
lvl1 bar  foo  bah  foo
   A0  9    8  11    10
   D0 13   12  15    14
   C0 25   24  27    26
   D0 29   28  31    30
   B1 41   40  43    42
   D0 45   44  47    46
   C0 57   56  59    58
   D0 ...
```

Furthermore you can set the values using the following methods.

```
In [60]: df2 = dfmi.copy()

In [61]: df2.loc(axis=0)[:, :, ['C1', 'C3']] = -10

In [62]: df2
Out[62]:
     a    b
   lvl0
   A0  1    0  3    2
   D0  5    4  7     6
   C0-10   -10 -10  -10
   D0-10   -10 -10  -10
   B1 17    16  19    18
   D0 21    20  23    22
   C0-10   -10 -10  -10
   D0 ...
```

(continues on next page)
You can use a right-hand-side of an alignable object as well.

```python
In [63]: df2 = dfmi.copy()
In [64]: df2.loc[idx[:, :, ['C1', 'C3']], :] = df2 * 1000
In [65]: df2
Out[65]:
    lvl0    a    b
   lvl1
A0  B0  C0  D0  1  0  3  2
   D1  5  4  7  6
   C1  D0  9000  8000  11000  10000
   D1  13000  12000  15000  14000
   C2  D0  17  16  19  18
   D1  21  20  23  22
   C3  D0  25000  24000  27000  26000
   D1  253000  252000  255000  254000
... ... ... ... ...
   A3  B1  C0  D1  229  228  231  230
   C1  D0  233000  232000  235000  234000
   D1  237000  236000  239000  238000
   C2  D0  241  240  243  242
   D1  245  244  247  246
   C3  D0  249000  248000  251000  250000
   D1  253000  252000  255000  254000
[64 rows x 4 columns]
```

### 13.2.2 Cross-section

The **xs** method of **DataFrame** additionally takes a level argument to make selecting data at a particular level of a **MultiIndex** easier.

```python
In [66]: df
Out[66]:
     A  B  C
first  bar 0.895717 0.410835 -1.413681
     baz -1.206412 0.132003  1.024180
     foo  1.431256 -0.076467  0.875906
     qux -1.170299  1.130127  0.974466
     baz  1.340309 -1.187678 -2.211372
     foo -0.226169 -1.436737 -2.006747

In [67]: df.xs('one', level='second')
```

```\------------------------
   A  B  C
first  bar 0.895717 0.410835 -1.413681
\------------------------```
You can also select on the columns with `xs()`, by providing the axis argument.

```
In [69]: df = df.T

In [70]: df.xs('one', level='second', axis=1)
Out[70]:
    first   bar   baz   foo   qux
A       0.895717 -1.206412 1.431256 -1.170299
B       0.410835  0.132003 0.076467  0.875906
C      -1.413681  1.024180  1.130127  0.974466
```

`xs()` also allows selection with multiple keys.

```
In [72]: df.xs(('one', 'bar'), level=('second', 'first'), axis=1)
Out[72]:
    first   bar
second
A       0.895717
B       0.410835
C      -1.413681
```

You can pass `drop_level=False` to `xs()` to retain the level that was selected.
In [74]: df.xs('one', level='second', axis=1, drop_level=False)
Out[74]:
first  bar  baz  foo  qux
second one  one  one  one
A  0.895717 -1.206412  1.431256 -1.170299
B  0.410835  0.132003 -0.076467  1.130127
C -1.413681  1.024180  0.875906  0.974466

Compare the above with the result using drop_level=True (the default value).

In [75]: df.xs('one', level='second', axis=1, drop_level=True)
Out[75]:
first  bar  baz  foo  qux
A  0.895717 -1.206412  1.431256 -1.170299
B  0.410835  0.132003 -0.076467  1.130127
C -1.413681  1.024180  0.875906  0.974466

13.2.3 Advanced reindexing and alignment

The parameter level has been added to the reindex and align methods of pandas objects. This is useful to broadcast values across a level. For instance:

In [76]: midx = pd.MultiIndex(levels=[['zero', 'one'], ['x','y']],
                   labels=[[1,1,0,0],[1,0,1,0]])

In [77]: df = pd.DataFrame(np.random.randn(4,2), index=midx)

In [78]: df
Out[78]:
   0   1
one y  1.519970 -0.493662
   x   0.600178  0.274230
zero y  0.132885 -0.023688
   x   2.410179  1.450520

In [79]: df2 = df.mean(level=0)

In [80]: df2
Out[80]:
   0   1
one  1.060074 -0.109716
zero  1.271532  0.713416

In [81]: df2.reindex(df.index, level=0)

# aligning
In [82]: df_aligned, df2_aligned = df.align(df2, level=0)

(continues on next page)
In [83]: df_aligned
Out[83]:
   0  1
one y 1.519970 -0.493662
   x 0.600178  0.274230
zero y 0.132885 -0.023688
   x 2.410179  1.450520

In [84]: df2_aligned

In [85]: df[:5]
Out[85]:
   0  1
one y 1.519970 -0.493662
   x 0.600178  0.274230
zero y 0.132885 -0.023688
   x 2.410179  1.450520

In [86]: df[:5].swaplevel(0, 1, axis=0)

In [87]: df[:5].reorder_levels([1,0], axis=0)

13.2.4 Swapping levels with swaplevel()

The swaplevel function can switch the order of two levels:

In [88]: df[:5]
Out[88]:
   0  1
one y 1.519970 -0.493662
   x 0.600178  0.274230
zero y 0.132885 -0.023688
   x 2.410179  1.450520

In [89]: df[:5].swaplevel(0, 1, axis=0)

13.2.5 Reordering levels with reorder_levels()

The reorder_levels function generalizes the swaplevel function, allowing you to permute the hierarchical index levels in one step:

In [90]: df[:5].reorder_levels([1,0], axis=0)
Out[90]:
   0  1
y one 1.519970 -0.493662
x one 0.600178  0.274230
y zero 0.132885 -0.023688
x zero 2.410179  1.450520
13.3 Sorting a MultiIndex

For MultiIndex-ed objects to be indexed and sliced effectively, they need to be sorted. As with any index, you can use `sort_index`.

```
In [88]: import random; random.shuffle(tuples)

In [89]: s = pd.Series(np.random.randn(8), index=pd.MultiIndex.from_tuples(tuples))

In [90]: s
Out[90]:
foo one 0.206053
qux one -0.251905
baz two -2.213588
bar two 1.063327
qux two 1.266143
foo two 0.299368
baz one -0.863838
bar one 0.408204
dtype: float64

In [91]: s.sort_index()
...
bar one 0.408204
two 1.063327
baz one -0.863838
two -2.213588
foo one 0.206053
two 0.299368
qux one -0.251905
two 1.266143
dtype: float64

In [92]: s.sort_index(level=0)
...
bar one 0.408204
two 1.063327
baz one -0.863838
two -2.213588
foo one 0.206053
two 0.299368
qux one -0.251905
two 1.266143
dtype: float64

In [93]: s.sort_index(level=1)
...
bar one 0.408204
baz one -0.863838
foo one 0.206053
qux one -0.251905
bar two 1.063327
baz two -2.213588
foo two 0.299368
```

(continues on next page)
You may also pass a level name to `sort_index` if the MultiIndex levels are named.

```
In [94]: s.index.set_names(['L1', 'L2'], inplace=True)

In [95]: s.sort_index(level='L1')
Out[95]:
   L1  L2
  bar one  0.408204
two  1.063327
  baz one -0.863838
two  2.213588
  foo one  0.206053
two  0.299368
  qux one -0.251905
two  1.266143
dtype: float64
```

```
In [96]: s.sort_index(level='L2')
   L1  L2
  bar one  0.408204
  baz one -0.863838
  foo one  0.206053
  qux one -0.251905
  bar two  1.063327
  baz two -2.213588
  foo two  0.299368
  qux two  1.266143
dtype: float64
```

On higher dimensional objects, you can sort any of the other axes by level if they have a `MultiIndex`:

```
In [97]: df.T.sort_index(level=1, axis=1)
Out[97]:
     one  zero  one  zero
       x     x     y     y
    0  0.600178  2.410179  1.519970  0.132885
   1  0.274230  1.450520 -0.493662  0.023688
```

Indexing will work even if the data are not sorted, but will be rather inefficient (and show a `PerformanceWarning`). It will also return a copy of the data rather than a view:

```
in [98]: dfm = pd.DataFrame({'jim': [0, 0, 1, 1],
                        'joe': ['x', 'x', 'z', 'y'],
                        'jolie': np.random.rand(4)})

in [99]: dfm = dfm.set_index(['jim', 'joe'])
```

```
in [100]: dfm
Out[100]:
    jolie
```

(continues on next page)
In [4]: dfm.loc[(1, 'z')]
PerformanceWarning: indexing past lexsort depth may impact performance.

Out[4]:
    jolie
  jim joe
1   z  0.64094

Furthermore if you try to index something that is not fully lexsorted, this can raise:

In [5]: dfm.loc[(0,'y'):(1, 'z')]
UnsortedIndexError: 'Key length (2) was greater than MultiIndex lexsort depth (1)'

The `is_lexsorted()` method on an Index show if the index is sorted, and the `lexsort_depth` property returns the sort depth:

In [101]: dfm.index.is_lexsorted()
Out[101]: False

In [102]: dfm.index.lexsort_depth
Out[102]: 1

In [103]: dfm = dfm.sort_index()

In [104]: dfm
Out[104]:
    jolie
  jim joe
0   x  0.490671
   x  0.120248
1   y  0.110968
   z  0.537020

In [105]: dfm.index.is_lexsorted()
Out[105]: True

In [106]: dfm.index.lexsort_depth
Out[106]: 2

And now selection works as expected.

In [107]: dfm.loc[(0,'y'):(1, 'z')]
Out[107]:
    jolie
  jim joe
1   y  0.110968
   z  0.537020
13.4 Take Methods

Similar to NumPy ndarrays, pandas Index, Series, and DataFrame also provides the `take` method that retrieves elements along a given axis at the given indices. The given indices must be either a list or an ndarray of integer index positions. `take` will also accept negative integers as relative positions to the end of the object.

```
In [108]: index = pd.Index(np.random.randint(0, 1000, 10))
In [109]: index
Out[109]: Int64Index([214, 502, 712, 567, 786, 175, 993, 133, 758, 329], dtype='int64')
In [110]: positions = [0, 9, 3]
In [111]: index[positions]
Out[111]: Int64Index([214, 329, 567], dtype='int64')
In [112]: index.take(positions)
Out[112]: Int64Index([214, 329, 567], dtype='int64')
```

```
In [113]: ser = pd.Series(np.random.randn(10))
In [114]: ser.iloc[positions]
Out[114]:
      0  -0.179666
      9   1.824375
      3   0.392149
      dtype: float64
In [115]: ser.take(positions)
Out[115]:
      0  -0.179666
      9   1.824375
      3   0.392149
      dtype: float64
```

For DataFrames, the given indices should be a 1d list or ndarray that specifies row or column positions.

```
In [116]: frm = pd.DataFrame(np.random.randn(5, 3))
In [117]: frm.take([1, 4, 3])
Out[117]:
     0       1       2
0 -1.237881  0.106854 -1.276829
1  0.629675 -1.425966  1.857704
2  0.979542 -1.633678  0.615855
In [118]: frm.take([0, 2], axis=1)
Out[118]:
     0       2
0  0.595974  0.601544
1 -1.237881 -1.276829
2 -0.767101  1.499591
3  0.979542  0.615855
4  0.629675  1.857704
```
It is important to note that the `take` method on pandas objects are not intended to work on boolean indices and may return unexpected results.

```
In [119]: arr = np.random.randn(10)
In [120]: arr.take([False, False, True, True])
Out[120]: array([-1.1935, -1.1935, 0.6775, 0.6775])
In [121]: arr[[0, 1]]
Out[121]: array([-1.1935, 0.6775])
In [122]: ser = pd.Series(np.random.randn(10))
In [123]: ser.take([False, False, True, True])
Out[123]:
   0   0.233141
   1  -0.223540
   dtype: float64
In [124]: ser.iloc[[0, 1]]
Out[124]:
   0   0.233141
   1  -0.223540
```

Finally, as a small note on performance, because the `take` method handles a narrower range of inputs, it can offer performance that is a good deal faster than fancy indexing.

### 13.5 Index Types

We have discussed `MultiIndex` in the previous sections pretty extensively. `DatetimeIndex` and `PeriodIndex` are shown here, and information about `TimedeltaIndex` is found [here](#).

In the following sub-sections we will highlight some other index types.

#### 13.5.1 CategoricalIndex

`CategoricalIndex` is a type of index that is useful for supporting indexing with duplicates. This is a container around a `Categorical` and allows efficient indexing and storage of an index with a large number of duplicated elements.

```
In [125]: from pandas.api.types import CategoricalDtype

In [126]: df = pd.DataFrame({'A': np.arange(6),
                       'B': list('aabbca'))

In [127]: df['B'] = df['B'].astype(CategoricalDtype(list('cab')))

In [128]: df
```

(continues on next page)
Setting the index will create a `CategoricalIndex`.

Indexing with `__getitem__/ .iloc/.loc` works similarly to an `Index` with duplicates. The indexers must be in the category or the operation will raise a `KeyError`.

The `CategoricalIndex` is preserved after indexing:

Sorting the index will sort by the order of the categories (recall that we created the index with `CategoricalDtype(list('cab'))`, so the sorted order is `cab`).
Groupby operations on the index will preserve the index nature as well.

```python
In [136]: df2.groupby(level=0).sum()
Out[136]:
   A  B
c  4
a  6
b  5
```

```
In [137]: df2.groupby(level=0).sum().index
Out[137]: CategoricalIndex(['c', 'a', 'b'], categories=['c', 'a', 'b'], ordered=False, name='B', dtype='category')
```

Reindexing operations will return a resulting index based on the type of the passed indexer. Passing a list will return a plain-old Index; indexing with a Categorical will return a CategoricalIndex, indexed according to the categories of the passed Categorical dtype. This allows one to arbitrarily index these even with values not in the categories, similarly to how you can reindex any pandas index.

```python
In [138]: df2.reindex(['a','e'])
Out[138]:
A   B
a  0.0
a  1.0
a  5.0
e  NaN
```

```python
In [139]: df2.reindex(['a','e']).index
Out[139]: Index(['a', 'a', 'a', 'e'], dtype='object', name='B')
```

```python
In [140]: df2.reindex(pd.Categorical(['a','e'],categories=list('abcde')))
```

```python
In [141]: df2.reindex(pd.Categorical(['a','e'],categories=list('abcde'))).index
```

**Warning:** Reshaping and Comparison operations on a CategoricalIndex must have the same categories or a TypeError will be raised.

```python
In [9]: df3 = pd.DataFrame({'A' : np.arange(6),
       'B' : pd.Series(list('aabbca')).astype('category')})
In [11]: df3 = df3.set_index('B')
```

```python
In [11]: df3.index
Out[11]: CategoricalIndex([u'a', u'a', u'b', u'b', u'c', u'a'], categories=[u'a', u'b', u'c'], ordered=False, name=u'B', dtype='category')
```

```
In [10]: pd.concat([df2, df3])
```
13.5.2 Int64Index and RangeIndex

**Warning:** Indexing on an integer-based Index with floats has been clarified in 0.18.0, for a summary of the changes, see here.

Int64Index is a fundamental basic index in pandas. This is an Immutable array implementing an ordered, sliceable set. Prior to 0.18.0, the Int64Index would provide the default index for all NDFrame objects.

RangeIndex is a sub-class of Int64Index added in version 0.18.0, now providing the default index for all NDFrame objects. RangeIndex is an optimized version of Int64Index that can represent a monotonic ordered set. These are analogous to Python range types.

13.5.3 Float64Index

By default a Float64Index will be automatically created when passing floating, or mixed-integer-floating values in index creation. This enables a pure label-based slicing paradigm that makes [], ix, loc for scalar indexing and slicing work exactly the same.

```
In [142]: indexf = pd.Index([1.5, 2, 3, 4.5, 5])
In [143]: indexf
Out[143]: Float64Index([1.5, 2.0, 3.0, 4.5, 5.0], dtype='float64')
In [144]: sf = pd.Series(range(5), index=indexf)
In [145]: sf
Out[145]:
  1.5  0
  2.0  1
  3.0  2
  4.5  3
  5.0  4
dtype: int64
```

Scalar selection for [], loc will always be label based. An integer will match an equal float index (e.g. 3 is equivalent to 3.0).

```
In [146]: sf[3]
Out[146]: 2
In [147]: sf[3.0]
Out[147]: 2
In [148]: sf.loc[3]
Out[148]: 2
In [149]: sf.loc[3.0]
Out[149]: 2
```

The only positional indexing is via iloc.
In [150]: sf.iloc[3]
Out[150]: 3

A scalar index that is not found will raise a `KeyError`. Slicing is primarily on the values of the index when using [], ix, loc, and always positional when using iloc. The exception is when the slice is boolean, in which case it will always be positional.

In [151]: sf[2:4]
Out[151]:
2.0  1
3.0  2
dtype: int64

In [152]: sf.loc[2:4]
2.0  1
3.0  2
dtype: int64

In [153]: sf.iloc[2:4]
3.0  2
4.5  3
dtype: int64

In float indexes, slicing using floats is allowed.

In [154]: sf[2.1:4.6]
Out[154]:
3.0  2
4.5  3
dtype: int64

In [155]: sf.loc[2.1:4.6]
3.0  2
4.5  3
dtype: int64

In non-float indexes, slicing using floats will raise a `TypeError`.

In [1]: pd.Series(range(5))[3.5]
TypeError: the label [3.5] is not a proper indexer for this index type (Int64Index)

In [1]: pd.Series(range(5))[3.5:4.5]
TypeError: the slice start [3.5] is not a proper indexer for this index type

Warning: Using a scalar float indexer for .iloc has been removed in 0.18.0, so the following will raise a `TypeError`:

In [3]: pd.Series(range(5)).iloc[3.0]
TypeError: cannot do positional indexing on <class 'pandas.indexes.range.RangeIndex'> with these indexers [3.0] of <type 'float'>

13.5. Index Types
Here is a typical use-case for using this type of indexing. Imagine that you have a somewhat irregular timedelta-like indexing scheme, but the data is recorded as floats. This could for example be millisecond offsets.

```python
In [156]: dfir = pd.concat([pd.DataFrame(np.random.randn(5,2),
                        index=np.arange(5) * 250.0, columns=list('AB')),
                        pd.DataFrame(np.random.randn(6,2),
                        index=np.arange(4,10) * 250.1, columns=list('AB'))])

In [157]: dfir
Out[157]:
   A    B
0  0.997289 -1.693316
250.0 -0.179129 -1.598062
500.0  0.936914  0.912560
750.0 -1.003401  1.632781
1000.0 -0.724626  0.178219
1000.4  0.310610 -0.108002
...

Selection operations then will always work on a value basis, for all selection operators.

```python
In [158]: dfir[0:1000.4]
Out[158]:
   A    B
0  0.997289 -1.693316
250.0 -0.179129 -1.598062
500.0  0.936914  0.912560
750.0 -1.003401  1.632781
1000.0 -0.724626  0.178219
1000.4  0.310610 -0.108002
...

In [159]: dfir.loc[0:1001,'A']
Out[159]:
   A
0  0.997289
250.0 -0.179129
500.0  0.936914
750.0 -1.003401
1000.0 -0.724626
1000.4  0.310610
Name: A, dtype: float64

In [160]: dfir.loc[1000.4]
Out[160]:
   A    B
0  0.997289 -1.693316
250.0 -0.179129 -1.598062
500.0  0.936914  0.912560
750.0 -1.003401  1.632781
1000.0 -0.724626  0.178219
1000.4  0.310610 -0.108002
Name: 1000.4, dtype: float64

You could retrieve the first 1 second (1000 ms) of data as such:
If you need integer based selection, you should use `iloc`:

```python
In [162]: dfir.iloc[0:5]
Out[162]:
   A     B
0  0.0  0.997289 -1.693316
250.0 -0.179129 -1.598062
500.0  0.936914  0.912560
750.0 -1.003401  1.632781
1000.0 -0.724626  0.178219
```

### 13.5.4 `IntervalIndex`

New in version 0.20.0.

`IntervalIndex` together with its own `dtype`, `interval` as well as the `Interval` scalar type, allow first-class support in pandas for interval notation.

The `IntervalIndex` allows some unique indexing and is also used as a return type for the categories in `cut()` and `qcut()`.

**Warning:** These indexing behaviors are provisional and may change in a future version of pandas.

An `IntervalIndex` can be used in `Series` and in `DataFrame` as the index.

```python
In [163]: df = pd.DataFrame({'A': [1, 2, 3, 4]},
                    index=pd.IntervalIndex.from_breaks([0, 1, 2, 3, 4]))
In [164]: df
Out[164]:
          A
(0, 1]     1
(1, 2]     2
(2, 3]     3
(3, 4]     4
```

Label based indexing via `.loc` along the edges of an interval works as you would expect, selecting that particular interval.

```python
In [165]: df.loc[2]
Out[165]:
          A
0 (1, 2]  2
Name: (1, 2], dtype: int64
```
If you select a label *contained* within an interval, this will also select the interval.

```python
In [167]: df.loc[2.5]
Out[167]:
A
(2, 3] 3
```

```
In [168]: df.loc[[2.5, 3.5]]
Out[168]:
A
(2, 3] 3
(3, 4] 4
```

*Interval* and *IntervalIndex* are used by *cut* and *qcut*:

```python
In [169]: c = pd.cut(range(4), bins=2)
In [170]: c
Out[170]:
[(-0.003, 1.5], (-0.003, 1.5], (1.5, 3.0], (1.5, 3.0]]
Categories (2, interval[float64]): [(-0.003, 1.5] < (1.5, 3.0]]
```

```python
In [171]: c.categories
Out[171]:
IntervalIndex([(-0.003, 1.5], (1.5, 3.0]
closed='right',
dtype='interval[float64]')
```

Furthermore, *IntervalIndex* allows one to bin *other* data with these same bins, with *NaN* representing a missing value similar to other dtypes.

```python
In [172]: pd.cut([0, 3, 5, 1], bins=c.categories)
Out[172]:
[(-0.003, 1.5], (1.5, 3.0], NaN, (-0.003, 1.5]]
Categories (2, interval[float64]): [(-0.003, 1.5] < (1.5, 3.0]]
```

### 13.5.4.1 Generating Ranges of Intervals

If we need intervals on a regular frequency, we can use the *interval_range()* function to create an *IntervalIndex* using various combinations of start, end, and periods. The default frequency for *interval_range* is a 1 for numeric intervals, and calendar day for datetime-like intervals:

```python
In [173]: pd.interval_range(start=0, end=5)
Out[173]:
IntervalIndex([(0, 1], (1, 2], (2, 3], (3, 4], (4, 5]]
closed='right',
dtype='interval[int64]')
```

(continues on next page)
In [174]: pd.interval_range(start=pd.Timestamp('2017-01-01'), periods=4)

Out[174]:
IntervalIndex([(2017-01-01, 2017-01-02],
               (2017-01-02, 2017-01-03],
               (2017-01-03, 2017-01-04],
               (2017-01-04, 2017-01-05]],
               closed='right',
               dtype='interval[datetime64[ns]]')

In [175]: pd.interval_range(end=pd.Timedelta('3 days'), periods=3)

Out[175]:
IntervalIndex([(0 days 00:00:00, 1 days 00:00:00],
               (1 days 00:00:00, 2 days 00:00:00],
               (2 days 00:00:00, 3 days 00:00:00]],
               closed='right',
               dtype='interval[timedelta64[ns]]')

The `freq` parameter can be used to specify non-default frequencies, and can utilize a variety of *frequency aliases* with datetime-like intervals:

In [176]: pd.interval_range(start=0, periods=5, freq=1.5)

Out[176]:
IntervalIndex([(0.0, 1.5],
               (1.5, 3.0],
               (3.0, 4.5],
               (4.5, 6.0],
               (6.0, 7.5]],
               closed='right',
               dtype='interval[float64]')

In [177]: pd.interval_range(start=pd.Timestamp('2017-01-01'), periods=4, freq='W')

Out[177]:
IntervalIndex([(2017-01-01, 2017-01-08],
               (2017-01-08, 2017-01-15],
               (2017-01-15, 2017-01-22],
               (2017-01-22, 2017-01-29]],
               closed='right',
               dtype='interval[datetime64[ns]]')

In [178]: pd.interval_range(start=pd.Timedelta('0 days'), periods=3, freq='9H')

Out[178]:
IntervalIndex([(0 days 00:00:00, 0 days 09:00:00],
               (0 days 09:00:00, 0 days 18:00:00],
               (0 days 18:00:00, 1 days 03:00:00]],
               closed='right',
               dtype='interval[timedelta64[ns]]')

Additionally, the `closed` parameter can be used to specify which side(s) the intervals are closed on. Intervals are closed on the right side by default.

In [179]: pd.interval_range(start=0, end=4, closed='both')

Out[179]:
IntervalIndex([[0, 1], [1, 2], [2, 3], [3, 4]],
               closed='both',
               dtype='interval[int64]')

In [180]: pd.interval_range(start=0, end=4, closed='neither')

Out[180]:
IntervalIndex([[0, 1], [1, 2], [2, 3], [3, 4]],
               closed='neither',
               dtype='interval[int64]')
New in version 0.23.0.

Specifying \texttt{start}, \texttt{end}, and \texttt{periods} will generate a range of evenly spaced intervals from \texttt{start} to \texttt{end} inclusively, with \texttt{periods} number of elements in the resulting \texttt{IntervalIndex}:

\begin{verbatim}
In [181]: pd.interval_range(start=0, end=6, periods=4)
Out[181]:
IntervalIndex([[(0.0, 1.5], (1.5, 3.0], (3.0, 4.5], (4.5, 6.0]],
             closed='right',
             dtype='interval[float64]')
In [182]: pd.interval_range(pd.Timestamp('2018-01-01'), pd.Timestamp('2018-02-28'),
                          periods=3)
Out[182]:
IntervalIndex([[(2018-01-01, 2018-01-20 08:00:00], (2018-01-20 08:00:00, 2018-02-08 16:00:00],
               (2018-02-08 16:00:00, 2018-02-28]],
             closed='right',
             dtype='interval[datetime64[ns]]')
\end{verbatim}

13.6 Miscellaneous indexing FAQ

13.6.1 Integer indexing

Label-based indexing with integer axis labels is a thorny topic. It has been discussed heavily on mailing lists and among various members of the scientific Python community. In pandas, our general viewpoint is that labels matter more than integer locations. Therefore, with an integer axis index only label-based indexing is possible with the standard tools like \texttt{.loc}. The following code will generate exceptions:

\begin{verbatim}
s = pd.Series(range(5))
s[-1]
df = pd.DataFrame(np.random.randn(5, 4))
df
df.loc[-2:]
\end{verbatim}

This deliberate decision was made to prevent ambiguities and subtle bugs (many users reported finding bugs when the API change was made to stop “falling back” on position-based indexing).

13.6.2 Non-monotonic indexes require exact matches

If the index of a \texttt{Series} or \texttt{DataFrame} is monotonically increasing or decreasing, then the bounds of a label-based slice can be outside the range of the index, much like slice indexing a normal Python list. Monotonicity of an index can be tested with the \texttt{is_monotonic_increasing} and \texttt{is_monotonic_decreasing} attributes.

\begin{verbatim}
In [183]: df = pd.DataFrame(index=[2,3,3,4,5], columns=['data'], data=list(range(5)))
In [184]: df.index.is_monotonic_increasing
Out[184]: True

# no rows 0 or 1, but still returns rows 2, 3 (both of them), and 4:
In [185]: df.loc[0:4, :]
Out[185]:
   data
(continues on next page)
On the other hand, if the index is not monotonic, then both slice bounds must be *unique* members of the index.

```python
In [187]: df = pd.DataFrame({'data': list(range(6))}, index=[2,3,1,4,3,5])
In [188]: df.index.is_monotonic_increasing
Out[188]: False

# OK because 2 and 4 are in the index
In [189]: df.loc[2:4, :]
```

```
   data
2    0
3    1
1    2
4    3
```

```
In [9]: df.loc[0:4, :]
KeyError: 0

# 3 is not a unique label
In [11]: df.loc[2:3, :]
KeyError: 'Cannot get right slice bound for non-unique label: 3'
```

`Index.is_monotonic_increasing()` and `Index.is_monotonic_decreasing()` only check that an index is weakly monotonic. To check for strict monotonicity, you can combine one of those with `Index.is_unique()`

```python
In [190]: weakly_monotonic = pd.Index(['a', 'b', 'c', 'c'])

In [191]: weakly_monotonic
Out[191]: Index(['a', 'b', 'c', 'c'], dtype='object')

In [192]: weakly_monotonic.is_monotonic_increasing
Out[192]: True

In [193]: weakly_monotonic.is_monotonic_increasing & weakly_monotonic.is_unique
Out[193]: False
```
13.6.3 Endpoints are inclusive

Compared with standard Python sequence slicing in which the slice endpoint is not inclusive, label-based slicing in pandas is inclusive. The primary reason for this is that it is often not possible to easily determine the “successor” or next element after a particular label in an index. For example, consider the following Series:

```
In [194]: s = pd.Series(np.random.randn(6), index=list('abcdef'))
```

```
Out[195]:
   a    0.112246
   b    0.871721
   c   -0.816064
   d   -0.784880
   e    1.030659
   f    0.187483
dtype: float64
```

Suppose we wished to slice from `c` to `e`, using integers this would be accomplished as such:

```
In [196]: s[2:5]
```

```
Out[196]:
   c   -0.816064
   d   -0.784880
   e    1.030659
```

However, if you only had `c` and `e`, determining the next element in the index can be somewhat complicated. For example, the following does not work:

```
s.loc['c':'e'+1]
```

A very common use case is to limit a time series to start and end at two specific dates. To enable this, we made the design to make label-based slicing include both endpoints:

```
In [197]: s.loc['c':'e']
```

```
Out[197]:
   c   -0.816064
   d   -0.784880
   e    1.030659
```

This is most definitely a “practicality beats purity” sort of thing, but it is something to watch out for if you expect label-based slicing to behave exactly in the way that standard Python integer slicing works.

13.6.4 Indexing potentially changes underlying Series dtype

The different indexing operation can potentially change the dtype of a Series.

```
In [198]: series1 = pd.Series([1, 2, 3])
```

```
In [199]: series1.dtype
Out[199]: dtype('int64')
```

```
In [200]: res = series1.reindex([0, 4])
```
In [201]: res.dtype
Out[201]: dtype('float64')

In [202]: res

Out[202]:
0   1.0
4   NaN
dtype: float64

In [203]: series2 = pd.Series([True])

In [204]: series2.dtype
Out[204]: dtype('bool')

In [205]: res = series2.reindex_like(series1)

In [206]: res.dtype
Out[206]: dtype('O')

In [207]: res

Out[207]:
0    True
1   NaN
2   NaN
dtype: object

This is because the (re)indexing operations above silently inserts NaNs and the dtype changes accordingly. This can cause some issues when using numpy ufuncs such as numpy.logical_and.

See the this old issue for a more detailed discussion.
14.1 Statistical Functions

14.1.1 Percent Change

Series, DataFrame, and Panel all have a method `pct_change()` to compute the percent change over a given number of periods (using `fill_method` to fill NA/null values before computing the percent change).

```
In [1]: ser = pd.Series(np.random.randn(8))
In [2]: ser.pct_change()
Out[2]:
   0     NaN
   1  -1.60298
   2   4.33494
   3  -0.24746
   4  -2.06735
   5  -1.14290
   6  -1.68821
   7  -9.75973
dtype: float64
```

```
In [3]: df = pd.DataFrame(np.random.randn(10, 4))
In [4]: df.pct_change(periods=3)
Out[4]:
     0     1      2      3
0  NaN  NaN  NaN  NaN
1  NaN  NaN  NaN  NaN
2  NaN  NaN  NaN  NaN
3  NaN  NaN  NaN  NaN
4  NaN  NaN  NaN  NaN
5  NaN  NaN  NaN  NaN
6  NaN  NaN  NaN  NaN
7  NaN  NaN  NaN  NaN
8  NaN  NaN  NaN  NaN
9  NaN  NaN  NaN  NaN
```

14.1.2 Covariance

Series.cov() can be used to compute covariance between series (excluding missing values).
Analogously, `DataFrame.cov()` to compute pairwise covariances among the series in the DataFrame, also excluding NA/null values.

**Note:** Assuming the missing data are missing at random this results in an estimate for the covariance matrix which is unbiased. However, for many applications this estimate may not be acceptable because the estimated covariance matrix is not guaranteed to be positive semi-definite. This could lead to estimated correlations having absolute values which are greater than one, and/or a non-invertible covariance matrix. See Estimation of covariance matrices for more details.

`DataFrame.cov` also supports an optional `min_periods` keyword that specifies the required minimum number of observations for each column pair in order to have a valid result.
14.1.3 Correlation

Correlation may be computed using the `corr()` method. Using the `method` parameter, several methods for computing correlations are provided:

<table>
<thead>
<tr>
<th>Method name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pearson</td>
<td>Standard correlation coefficient</td>
</tr>
<tr>
<td>kendall</td>
<td>Kendall Tau correlation coefficient</td>
</tr>
<tr>
<td>spearman</td>
<td>Spearman rank correlation coefficient</td>
</tr>
</tbody>
</table>

All of these are currently computed using pairwise complete observations. Wikipedia has articles covering the above correlation coefficients:

- Pearson correlation coefficient
- Kendall rank correlation coefficient
- Spearman’s rank correlation coefficient

**Note:** Please see the caveats associated with this method of calculating correlation matrices in the covariance section.

In [15]: frame = pd.DataFrame(np.random.randn(1000, 5), columns=['a', 'b', 'c', 'd', 'e'])

In [16]: frame.iloc[::2] = np.nan

# Series with Series
In [17]: frame['a'].corr(frame['b'])
Out[17]: 0.013479040400098794

In [18]: frame['a'].corr(frame['b'], method='spearman')
Out[18]: -0.0072898851595406371

# Pairwise correlation of DataFrame columns
In [19]: frame.corr()
Out[19]:

```
a           b          c            d           e
a  1.000000  0.013479 -0.049269 -0.042239 -0.028525
b  0.013479  1.000000 -0.020433 -0.011139  0.005654
c -0.049269 -0.020433  1.000000  0.018587 -0.054269
d -0.042239 -0.011139  0.018587  1.000000 -0.017060
e -0.028525  0.005654 -0.054269 -0.017060  1.000000
```

Note that non-numeric columns will be automatically excluded from the correlation calculation.

Like `cov, corr` also supports the optional `min_periods` keyword:

In [20]: frame = pd.DataFrame(np.random.randn(20, 3), columns=['a', 'b', 'c'])

In [21]: frame.loc[frame.index[:5], 'a'] = np.nan

In [22]: frame.loc[frame.index[5:10], 'b'] = np.nan

In [23]: frame.corr()
A related method `corrwith()` is implemented on DataFrame to compute the correlation between like-labeled Series contained in different DataFrame objects.

```python
In [25]: index = ['a', 'b', 'c', 'd', 'e']
In [26]: columns = ['one', 'two', 'three', 'four']
In [27]: df1 = pd.DataFrame(np.random.randn(5, 4), index=index, columns=columns)
In [28]: df2 = pd.DataFrame(np.random.randn(4, 4), index=index[:4], columns=columns)
In [29]: df1.corrwith(df2)
Out[29]:
one   -0.125501
two   -0.493244
three  0.344056
four   0.004183
dtype: float64
```

14.1.4 Data ranking

The `rank()` method produces a data ranking with ties being assigned the mean of the ranks (by default) for the group:

```python
In [31]: s = pd.Series(np.random.randn(5), index=list('abcde'))
In [32]: s['d'] = s['b']  # so there's a tie
In [33]: s.rank()
Out[33]:
a    5.0
b    2.5
c    1.0
d    2.5
```

(continues on next page)
rank() is also a DataFrame method and can rank either the rows (axis=0) or the columns (axis=1). NaN values are excluded from the ranking.

```python
In [34]: df = pd.DataFrame(np.random.randn(10, 6))
In [36]: df
Out[36]:
   0    1    2    3    4    5
0 -0.904948 -1.163537 -1.457187 0.135463 -1.457187 0.294650
1 -0.976288 -0.244652 -0.748406 -0.999601 -0.748406 -0.800809
2  0.401965  1.460840  1.256057  1.308127  1.256057  0.876004
3  0.205954  0.369552 -0.669304  0.383788 -0.669304  1.140296
4 -0.477586 -0.730705 -1.129149 -0.601463 -1.129149 -0.211196
5 -1.092970 -0.689246  0.908114  0.204848 NaN  0.463347
6  0.376892  0.959292  0.095572 -0.593740 NaN -0.069180
7 -1.002601  1.957794 -0.120708  0.094214 NaN -1.467422
8 -0.547231  0.664402 -0.519424 -0.073254 NaN -1.263544
9 -0.250277 -0.237428 -1.056443  0.419477 NaN  1.375064
In [37]: df.rank(1)
   0    1    2    3    4    5
0  4.0  3.0  1.5  5.0  1.5  6.0
1  2.0  6.0  4.5  1.0  4.5  3.0
2  1.0  6.0  3.5  5.0  3.5  2.0
3  4.0  5.0  1.5  3.0  1.5  6.0
4  5.0  3.0  1.5  4.0  1.5  6.0
5  1.0  2.0  5.0  3.0 NaN  4.0
6  4.0  5.0  3.0  1.0 NaN  2.0
7  2.0  5.0  3.0  4.0 NaN  1.0
8  2.0  5.0  3.0  4.0 NaN  1.0
9  2.0  3.0  1.0  4.0 NaN  5.0
```

rank optionally takes a parameter ascending which by default is true; when false, data is reverse-ranked, with larger values assigned a smaller rank.

rank supports different tie-breaking methods, specified with the method parameter:

- **average**: average rank of tied group
- **min**: lowest rank in the group
- **max**: highest rank in the group
- **first**: ranks assigned in the order they appear in the array

### 14.2 Window Functions

For working with data, a number of window functions are provided for computing common window or rolling statistics. Among these are count, sum, mean, median, correlation, variance, covariance, standard deviation, skewness, and
kurtosis.

The `rolling()` and `expanding()` functions can be used directly from DataFrameGroupBy objects, see the `groupby docs`.

**Note:** The API for window statistics is quite similar to the way one works with GroupBy objects, see the documentation here.

We work with `rolling`, `expanding` and `exponentially weighted` data through the corresponding objects, `Rolling`, `Expanding` and `EWM`.

```python
In [38]: s = pd.Series(np.random.randn(1000), index=pd.date_range('1/1/2000', period=1000))
In [39]: s = s.cumsum()
In [40]: r = s.rolling(window=60)
```

These are created from methods on `Series` and `DataFrame`.

```python
In [41]: r = s.rolling(window=60)
```

These object provide tab-completion of the available methods and properties.

```python
In [14]: r.
```

Generally these methods all have the same interface. They all accept the following arguments:

- `window`: size of moving window
- `min_periods`: threshold of non-null data points to require (otherwise result is NA)
- `center`: boolean, whether to set the labels at the center (default is False)

We can then call methods on these `rolling` objects. These return like-indexed objects:
In [43]: r.mean()
Out[43]:
2000-01-01    NaN
2000-01-02    NaN
2000-01-03    NaN
2000-01-04    NaN
2000-01-05    NaN
2000-01-06    NaN
2000-01-07    NaN
...
2002-09-20   -62.694135
2002-09-21   -62.812190
2002-09-22   -62.914971
2002-09-23   -63.061867
2002-09-24   -63.213876
2002-09-25   -63.375074
2002-09-26   -63.539734
Freq: D, Length: 1000, dtype: float64

In [44]: s.plot(style='k--')
Out[44]: <matplotlib.axes._subplots.AxesSubplot at 0x1a24661e80>

In [45]: r.mean().plot(style='k')
Out[45]: <matplotlib.axes._subplots.AxesSubplot at 0x1a24661e80>
They can also be applied to DataFrame objects. This is really just syntactic sugar for applying the moving window operator to all of the DataFrame’s columns:

```python
In [46]: df = pd.DataFrame(np.random.randn(1000, 4),
                      index=pd.date_range('1/1/2000', periods=1000),
                      columns=['A', 'B', 'C', 'D'])

In [47]: df = df.cumsum()

In [48]: df.rolling(window=60).sum().plot(subplots=True)
```

14.2.1 Method Summary

We provide a number of common statistical functions:
<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>count()</code></td>
<td>Number of non-null observations</td>
</tr>
<tr>
<td><code>sum()</code></td>
<td>Sum of values</td>
</tr>
<tr>
<td><code>mean()</code></td>
<td>Mean of values</td>
</tr>
<tr>
<td><code>median()</code></td>
<td>Arithmetic median of values</td>
</tr>
<tr>
<td><code>min()</code></td>
<td>Minimum</td>
</tr>
<tr>
<td><code>max()</code></td>
<td>Maximum</td>
</tr>
<tr>
<td><code>std()</code></td>
<td>Bessel-corrected sample standard deviation</td>
</tr>
<tr>
<td><code>var()</code></td>
<td>Unbiased variance</td>
</tr>
<tr>
<td><code>skew()</code></td>
<td>Sample skewness (3rd moment)</td>
</tr>
<tr>
<td><code>kurt()</code></td>
<td>Sample kurtosis (4th moment)</td>
</tr>
<tr>
<td><code>quantile()</code></td>
<td>Sample quantile (value at %)</td>
</tr>
<tr>
<td><code>apply()</code></td>
<td>Generic apply</td>
</tr>
<tr>
<td><code>cov()</code></td>
<td>Unbiased covariance (binary)</td>
</tr>
<tr>
<td><code>corr()</code></td>
<td>Correlation (binary)</td>
</tr>
</tbody>
</table>

The `apply()` function takes an extra `func` argument and performs generic rolling computations. The `func` argument should be a single function that produces a single value from an ndarray input. Suppose we wanted to compute the mean absolute deviation on a rolling basis:

```python
In [49]: mad = lambda x: np.fabs(x - x.mean()).mean()

In [50]: s.rolling(window=60).apply(mad, raw=True).plot(style='k')
Out[50]: <matplotlib.axes._subplots.AxesSubplot at 0x1a24b21630>
```
14.2.2 Rolling Windows

Passing `win_type` to `.rolling` generates a generic rolling window computation, that is weighted according the `win_type`. The following methods are available:

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>sum()</code></td>
<td>Sum of values</td>
</tr>
<tr>
<td><code>mean()</code></td>
<td>Mean of values</td>
</tr>
</tbody>
</table>

The weights used in the window are specified by the `win_type` keyword. The list of recognized types are the `scipy.signal` window functions:

- boxcar
- triang
- blackman
- hamming
- bartlett
- parzen
- bohman
- blackmanharris
- nuttall
- barthann
- kaiser (needs beta)
- gaussian (needs std)
- general_gaussian (needs power, width)
- slepian (needs width).

```python
In [51]: ser = pd.Series(np.random.randn(10), index=pd.date_range('1/1/2000', periods=10))
In [52]: ser.rolling(window=5, win_type='triang').mean()
Out[52]:
2000-01-01    NaN
2000-01-02    NaN
2000-01-03    NaN
2000-01-04    NaN
2000-01-05  -1.037870
2000-01-06  -0.767705
2000-01-07  -0.383197
2000-01-08  -0.395513
2000-01-09  -0.558440
2000-01-10  -0.672416
Freq: D, dtype: float64
```

Note that the boxcar window is equivalent to `mean()`.

```python
In [53]: ser.rolling(window=5, win_type='boxcar').mean()
Out[53]:
2000-01-01    NaN
2000-01-02    NaN
2000-01-03    NaN
2000-01-04    NaN
2000-01-05  -0.841164
2000-01-06  -0.779948
2000-01-07  -0.565487
2000-01-08  -0.502815
2000-01-09  -0.553755
2000-01-10  -0.472211
Freq: D, dtype: float64
```

```python
In [54]: ser.rolling(window=5).mean()
```

14.2. Window Functions
For some windowing functions, additional parameters must be specified:

```
In [55]: ser.rolling(window=5, win_type='gaussian').mean(std=0.1)
Out[55]:
2000-01-01    NaN
2000-01-02    NaN
2000-01-03    NaN
2000-01-04    NaN
2000-01-05  -1.309989
2000-01-06  -1.153000
2000-01-07   0.606382
2000-01-08  -0.681101
2000-01-09  -0.289724
2000-01-10  -0.996632
Freq: D, dtype: float64
```

Note: For .sum() with a win_type, there is no normalization done to the weights for the window. Passing custom weights of [1, 1, 1] will yield a different result than passing weights of [2, 2, 2], for example. When passing a win_type instead of explicitly specifying the weights, the weights are already normalized so that the largest weight is 1.

In contrast, the nature of the .mean() calculation is such that the weights are normalized with respect to each other. Weights of [1, 1, 1] and [2, 2, 2] yield the same result.

### 14.2.3 Time-aware Rolling

New in version 0.19.0.

New in version 0.19.0 are the ability to pass an offset (or convertible) to a .rolling() method and have it produce variable sized windows based on the passed time window. For each time point, this includes all preceding values occurring within the indicated time delta.

This can be particularly useful for a non-regular time frequency index.

```
In [56]: dft = pd.DataFrame({'B': [0, 1, 2, np.nan, 4]},
                       index=pd.date_range('20130101 09:00:00', periods=5, freq='s'))
```

```
In [57]: dft
Out[57]:
            B
2013-01-01 09:00:00  0.0
2013-01-01 09:00:01  1.0
2013-01-01 09:00:02  2.0
2013-01-01 09:00:03  NaN
2013-01-01 09:00:04  4.0
```

This is a regular frequency index. Using an integer window parameter works to roll along the window frequency.

```
In [58]: dft.rolling(2).sum()
Out[58]:
            B
2013-01-01 09:00:00  NaN
2013-01-01 09:00:01  1.0
```

(continues on next page)
Specifying an offset allows a more intuitive specification of the rolling frequency.

Using a non-regular, but still monotonic index, rolling with an integer window does not impart any special calculation.
Using the time-specification generates variable windows for this sparse data.

```python
In [64]: dft.rolling('2s').sum()
Out[64]:
     B
foo  
2013-01-01 09:00:00 0.0
2013-01-01 09:00:02 1.0
2013-01-01 09:00:03 3.0
2013-01-01 09:00:05 NaN
2013-01-01 09:00:06 4.0
```

Furthermore, we now allow an optional `on` parameter to specify a column (rather than the default of the index) in a DataFrame.

```python
In [65]: dft = dft.reset_index()
In [66]: dft
Out[66]:
     foo  B
0 2013-01-01 09:00:00 0.0
1 2013-01-01 09:00:02 1.0
2 2013-01-01 09:00:03 2.0
3 2013-01-01 09:00:05 NaN
4 2013-01-01 09:00:06 4.0
In [67]: dft.rolling('2s', on='foo').sum()
```

### 14.2.4 Rolling Window Endpoints

New in version 0.20.0.

The inclusion of the interval endpoints in rolling window calculations can be specified with the `closed` parameter:

<table>
<thead>
<tr>
<th><code>closed</code></th>
<th>Description</th>
<th>Default for</th>
</tr>
</thead>
<tbody>
<tr>
<td>right</td>
<td>close right endpoint</td>
<td>time-based windows</td>
</tr>
<tr>
<td>left</td>
<td>close left endpoint</td>
<td></td>
</tr>
<tr>
<td>both</td>
<td>close both endpoints</td>
<td>fixed windows</td>
</tr>
<tr>
<td>neither</td>
<td>open endpoints</td>
<td></td>
</tr>
</tbody>
</table>

For example, having the right endpoint open is useful in many problems that require that there is no contamination from present information back to past information. This allows the rolling window to compute statistics “up to that point in time”, but not including that point in time.

```python
In [68]: df = pd.DataFrame({'x': 1},
                      index = [pd.Timestamp('20130101 09:00:01'),
                      pd.Timestamp('20130101 09:00:02'))
```

(continues on next page)
In [69]: df["right"] = df.rolling('2s', closed='right').x.sum()  # default

In [70]: df["both"] = df.rolling('2s', closed='both').x.sum()

In [71]: df["left"] = df.rolling('2s', closed='left').x.sum()

In [72]: df["neither"] = df.rolling('2s', closed='neither').x.sum()

In [73]: df

Out[73]:
<table>
<thead>
<tr>
<th>x</th>
<th>right</th>
<th>both</th>
<th>left</th>
<th>neither</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-01-01 09:00:01</td>
<td>1.0</td>
<td>1.0</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>2013-01-01 09:00:02</td>
<td>2.0</td>
<td>2.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2013-01-01 09:00:03</td>
<td>2.0</td>
<td>3.0</td>
<td>2.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2013-01-01 09:00:04</td>
<td>2.0</td>
<td>3.0</td>
<td>2.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2013-01-01 09:00:06</td>
<td>1.0</td>
<td>2.0</td>
<td>1.0</td>
<td>NaN</td>
</tr>
</tbody>
</table>

Currently, this feature is only implemented for time-based windows. For fixed windows, the closed parameter cannot be set and the rolling window will always have both endpoints closed.

### 14.2.5 Time-aware Rolling vs. Resampling

Using `rolling()` with a time-based index is quite similar to `resampling`. They both operate and perform reductive operations on time-indexed pandas objects.

When using `rolling()` with an offset. The offset is a time-delta. Take a backwards-in-time looking window, and aggregate all of the values in that window (including the end-point, but not the start-point). This is the new value at that point in the result. These are variable sized windows in time-space for each point of the input. You will get a same sized result as the input.

When using `.resample()` with an offset. Construct a new index that is the frequency of the offset. For each frequency bin, aggregate points from the input within a backwards-in-time looking window that fall in that bin. The result of this aggregation is the output for that frequency point. The windows are fixed size in the frequency space. Your result will have the shape of a regular frequency between the min and the max of the original input object.

To summarize, `.rolling()` is a time-based window operation, while `.resample()` is a frequency-based window operation.

### 14.2.6 Centering Windows

By default the labels are set to the right edge of the window, but a `center` keyword is available so the labels can be set at the center.

In [74]: ser.rolling(window=5).mean()

Out[74]:
<table>
<thead>
<tr>
<th>x</th>
<th>NaN</th>
<th>NaN</th>
<th>NaN</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-01</td>
<td>NaN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000-01-02</td>
<td>NaN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000-01-03</td>
<td>NaN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000-01-04</td>
<td>NaN</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 14.2.7 Binary Window Functions

`cov()` and `corr()` can compute moving window statistics about two `Series` or any combination of `DataFrame/Series` or `DataFrame/DataFrame`. Here is the behavior in each case:

- **two `Series`**: compute the statistic for the pairing.
- **`DataFrame/Series`**: compute the statistics for each column of the `DataFrame` with the passed `Series`, thus returning a `DataFrame`.
- **`DataFrame/DataFrame`**: by default compute the statistic for matching column names, returning a `DataFrame`. If the keyword argument `pairwise=True` is passed then computes the statistic for each pair of columns, returning a MultiIndexed `DataFrame` whose index are the dates in question (see the next section).

For example:

```py
In [76]: df = pd.DataFrame(np.random.randn(1000, 4),
...:                    index=pd.date_range('1/1/2000', periods=1000),
...:                    columns=['A', 'B', 'C', 'D'])
...
...
In [77]: df = df.cumsum()
In [78]: df2 = df[:20]
In [79]: df2.rolling(window=5).corr(df2['B'])
Out[79]:
       A       B       C       D
2000-01-01 NaN  NaN  NaN  NaN
2000-01-02 NaN  NaN  NaN  NaN
2000-01-03 NaN  NaN  NaN  NaN
2000-01-04 NaN  NaN  NaN  NaN
...
```
In financial data analysis and other fields it’s common to compute covariance and correlation matrices for a collection of time series. Often one is also interested in moving-window covariance and correlation matrices. This can be done by passing the `pairwise` keyword argument, which in the case of `DataFrame` inputs will yield a MultiIndexed `DataFrame` whose index are the dates in question. In the case of a single `DataFrame` argument the `pairwise` argument can even be omitted:

**Note:** Missing values are ignored and each entry is computed using the pairwise complete observations. Please see the covariance section for caveats associated with this method of calculating covariance and correlation matrices.

```python
In [80]: covs = df[['B','C','D']].rolling(window=50).cov(df[['A','B','C']], pairwise=True)
```

```python
In [81]: covs.loc['2002-09-22':]
```

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002-09-22</td>
<td>1.367467</td>
<td>8.676734</td>
<td>-8.047366</td>
</tr>
<tr>
<td>2002-09-23</td>
<td>3.067315</td>
<td>0.865946</td>
<td>-1.052533</td>
</tr>
<tr>
<td>2002-09-24</td>
<td>0.910343</td>
<td>8.669065</td>
<td>-8.443062</td>
</tr>
<tr>
<td>2002-09-25</td>
<td>2.625456</td>
<td>0.565152</td>
<td>-0.907654</td>
</tr>
<tr>
<td>2002-09-26</td>
<td>0.565152</td>
<td>7.825521</td>
<td>-5.367526</td>
</tr>
</tbody>
</table>

14.2. Window Functions
In [82]: correls = df.rolling(window=50).corr()

In [83]: correls.loc['2002-09-22':]

Out[83]:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002-09-22</td>
<td>1.000000</td>
<td>0.186397</td>
<td>0.744551</td>
<td>-0.769767</td>
</tr>
<tr>
<td></td>
<td>0.186397</td>
<td>1.000000</td>
<td>0.177725</td>
<td>-0.240802</td>
</tr>
<tr>
<td></td>
<td>0.744551</td>
<td>0.177725</td>
<td>1.000000</td>
<td>-0.712051</td>
</tr>
<tr>
<td></td>
<td>-0.769767</td>
<td>-0.240802</td>
<td>-0.712051</td>
<td>1.000000</td>
</tr>
<tr>
<td>2002-09-23</td>
<td>1.000000</td>
<td>0.134723</td>
<td>0.743113</td>
<td>-0.758758</td>
</tr>
<tr>
<td></td>
<td>0.134723</td>
<td>1.000000</td>
<td>0.124683</td>
<td>-0.209934</td>
</tr>
<tr>
<td></td>
<td>0.743113</td>
<td>0.124683</td>
<td>1.000000</td>
<td>-0.719088</td>
</tr>
</tbody>
</table>

...  ...

| 2002-09-25 | 0.075157 | 1.000000 | 0.064399 | -0.164179 |
| 2002-09-26 | 1.000000 | 0.087756 | 0.727792 | -0.736562 |

[20 rows x 4 columns]

You can efficiently retrieve the time series of correlations between two columns by reshaping and indexing:

In [84]: correls.unstack(1)[('A', 'C')].plot()

Out[84]: <matplotlib.axes._subplots.AxesSubplot at 0x1c25247630>
### 14.3 Aggregation

Once the `Rolling`, `Expanding` or `EWM` objects have been created, several methods are available to perform multiple computations on the data. These operations are similar to the *aggregating API*, *groupby API*, and *resample API*.

In [85]:
   : dfa = pd.DataFrame(np.random.randn(1000, 3),
   ....:                   index=pd.date_range('1/1/2000', periods=1000),
   ....:                   columns=['A', 'B', 'C'])
   ....:

In [86]:
   r = dfa.rolling(window=60, min_periods=1)

In [87]:
   r
   Out[87]: Rolling [window=60, min_periods=1, center=False, axis=0]

We can aggregate by passing a function to the entire DataFrame, or select a Series (or multiple Series) via standard `__getitem__`.

In [88]:
   r.aggregate(np.sum)
   Out[88]:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>2000-01-01 -0.289838 -0.370545 -1.284206</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000-01-02 -0.216612 -1.675528 -1.169415</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(continues on next page)
In [89]: r['A'].aggregate(np.sum)

    2000-01-01 -0.289838
    2000-01-02 -0.216612
    2000-01-03  1.154661
    2000-01-04  2.969393
    2000-01-05  4.690630
    2000-01-06  3.880630
    2000-01-07  4.001957
    ...            ...
    2002-09-20  2.652493
    2002-09-21  0.844497
    2002-09-22  2.860036
    2002-09-23  3.510163
    2002-09-24  6.524983
    2002-09-25  6.409626
    2002-09-26  5.093787
Freq: D, Name: A, Length: 1000, dtype: float64

In [90]: r[['A','B']].aggregate(np.sum)

    A       B
    2000-01-01 -0.289838 -0.370545
    2000-01-02 -0.216612 -1.675528
    2000-01-03  1.154661 -1.634017
    2000-01-04  2.969393 -4.003274
    2000-01-05  4.690630 -4.682017
    2000-01-06  3.880630 -4.447700
    2000-01-07  4.001957 -2.884072
    ...            ...
    2002-09-20  2.652493 -10.528875
    2002-09-21  0.844497 -9.280944
    2002-09-22  2.860036 -9.270337
    2002-09-23  3.510163 -8.151439
    2002-09-24  6.524983 -10.168078
    2002-09-25  6.409626 -9.956226
    2002-09-26  5.093787 -7.074515
[1000 rows x 2 columns]
As you can see, the result of the aggregation will have the selected columns, or all columns if none are selected.

### 14.3.1 Applying multiple functions

With windowed `Series` you can also pass a list of functions to do aggregation with, outputting a DataFrame:

```python
In [91]: r['A'].agg([np.sum, np.mean, np.std])
```

```plaintext
Out[91]:

<table>
<thead>
<tr>
<th></th>
<th>sum</th>
<th>mean</th>
<th>std</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-01</td>
<td>-0.289838</td>
<td>-0.289838</td>
<td>NaN</td>
</tr>
<tr>
<td>2000-01-02</td>
<td>-0.216612</td>
<td>-0.108306</td>
<td>0.256725</td>
</tr>
<tr>
<td>2000-01-03</td>
<td>1.154661</td>
<td>0.384887</td>
<td>0.873311</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>2.969393</td>
<td>0.742348</td>
<td>1.009734</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>4.690630</td>
<td>0.938126</td>
<td>0.977914</td>
</tr>
<tr>
<td>2000-01-06</td>
<td>3.880630</td>
<td>0.646772</td>
<td>1.128883</td>
</tr>
<tr>
<td>2000-01-07</td>
<td>4.001957</td>
<td>0.571708</td>
<td>1.049487</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>2002-09-20</td>
<td>2.652493</td>
<td>0.044208</td>
<td>1.164919</td>
</tr>
<tr>
<td>2002-09-21</td>
<td>0.844497</td>
<td>0.014075</td>
<td>1.148231</td>
</tr>
<tr>
<td>2002-09-22</td>
<td>2.860036</td>
<td>0.047667</td>
<td>1.132051</td>
</tr>
<tr>
<td>2002-09-23</td>
<td>3.510163</td>
<td>0.058503</td>
<td>1.134296</td>
</tr>
<tr>
<td>2002-09-24</td>
<td>6.524983</td>
<td>0.108750</td>
<td>1.144204</td>
</tr>
<tr>
<td>2002-09-25</td>
<td>6.409626</td>
<td>0.106827</td>
<td>1.142913</td>
</tr>
<tr>
<td>2002-09-26</td>
<td>5.093787</td>
<td>0.084896</td>
<td>1.151416</td>
</tr>
</tbody>
</table>

[1000 rows x 3 columns]
```

On a windowed DataFrame, you can pass a list of functions to apply to each column, which produces an aggregated result with a hierarchical index:

```python
In [92]: r.agg([np.sum, np.mean])
```

```plaintext
Out[92]:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>sum</td>
<td>mean</td>
<td>sum</td>
</tr>
<tr>
<td>2000-01-01</td>
<td>-0.289838</td>
<td>-0.289838</td>
<td>-0.370545</td>
</tr>
<tr>
<td>2000-01-02</td>
<td>-0.216612</td>
<td>-0.108306</td>
<td>-1.675528</td>
</tr>
<tr>
<td>2000-01-03</td>
<td>1.154661</td>
<td>0.384887</td>
<td>-1.634017</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>2.969393</td>
<td>0.742348</td>
<td>-4.003274</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>4.690630</td>
<td>0.938126</td>
<td>-4.682017</td>
</tr>
<tr>
<td>2000-01-06</td>
<td>3.880630</td>
<td>0.646772</td>
<td>-4.447700</td>
</tr>
<tr>
<td>2000-01-07</td>
<td>4.001957</td>
<td>0.571708</td>
<td>-2.884072</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>2002-09-20</td>
<td>2.652493</td>
<td>0.044208</td>
<td>-10.528875</td>
</tr>
<tr>
<td>2002-09-21</td>
<td>0.844497</td>
<td>0.014075</td>
<td>-9.280944</td>
</tr>
<tr>
<td>2002-09-22</td>
<td>2.860036</td>
<td>0.047667</td>
<td>-9.270337</td>
</tr>
<tr>
<td>2002-09-23</td>
<td>3.510163</td>
<td>0.058503</td>
<td>-8.151439</td>
</tr>
<tr>
<td>2002-09-24</td>
<td>6.524983</td>
<td>0.108750</td>
<td>-10.168078</td>
</tr>
<tr>
<td>2002-09-25</td>
<td>6.409626</td>
<td>0.106827</td>
<td>-9.956226</td>
</tr>
<tr>
<td>2002-09-26</td>
<td>5.093787</td>
<td>0.084896</td>
<td>-7.074515</td>
</tr>
</tbody>
</table>

[1000 rows x 6 columns]
```

Passing a dict of functions has different behavior by default, see the next section.
14.3.2 Applying different functions to DataFrame columns

By passing a dict to `aggregate` you can apply a different aggregation to the columns of a DataFrame:

```
In [93]: r.agg({'A' : np.sum,
         ....:      'B' : lambda x: np.std(x, ddof=1)})
```

```
Out[93]:
    A       B
2000-01-01 -0.289838 NaN
2000-01-02 -0.216612 0.660747
2000-01-03  1.154661 0.689929
2000-01-04  2.969393 1.072199
2000-01-05  4.690630 0.939657
2000-01-06  3.880630 0.966848
2000-01-07  4.001957 1.240137
...       ...
2002-09-20 2.652493 1.114814
2002-09-21 0.844497 1.113220
2002-09-22 2.860036 1.113208
2002-09-23 3.510163 1.132381
2002-09-24 6.524983 1.080963
2002-09-25 6.409626 1.082911
2002-09-26 5.093787 1.136199
```

[1000 rows x 2 columns]

The function names can also be strings. In order for a string to be valid it must be implemented on the windowed object:

```
In [94]: r.agg({'A' : 'sum', 'B' : 'std'})
```

```
Out[94]:
    A       B
2000-01-01 -0.289838 NaN
2000-01-02 -0.216612 0.660747
2000-01-03  1.154661 0.689929
2000-01-04  2.969393 1.072199
2000-01-05  4.690630 0.939657
2000-01-06  3.880630 0.966848
2000-01-07  4.001957 1.240137
...       ...
2002-09-20 2.652493 1.114814
2002-09-21 0.844497 1.113220
2002-09-22 2.860036 1.113208
2002-09-23 3.510163 1.132381
2002-09-24 6.524983 1.080963
2002-09-25 6.409626 1.082911
2002-09-26 5.093787 1.136199
```

[1000 rows x 2 columns]

Furthermore you can pass a nested dict to indicate different aggregations on different columns.

```
In [95]: r.agg({'A' : ['sum','std'], 'B' : ['mean','std']})
```

```
Out[95]:
     A             B
     sum           std   mean       std
2000-01-01 -0.289838  NaN  -0.370545  NaN
```

(continues on next page)
14.4 Expanding Windows

A common alternative to rolling statistics is to use an expanding window, which yields the value of the statistic with all the data available up to that point in time.

These follow a similar interface to .rolling, with the .expanding method returning an Expanding object. As these calculations are a special case of rolling statistics, they are implemented in pandas such that the following two calls are equivalent:

```
In [96]: df.rolling(window=len(df), min_periods=1).mean()[:5]
Out[96]:
   A         B         C         D
2000-01-01 0.314226 -0.001675 0.071823 0.892566
2000-01-02 0.654522 -0.171495 0.179278 0.853361
2000-01-03 0.708733 -0.064489 -0.238271 1.371111
2000-01-04 0.987613 0.163472 -0.919693 1.566485
2000-01-05 1.426971 0.288267 -1.358877 1.808650
```

```
In [97]: df.expanding(min_periods=1).mean()[:5]
```

These have a similar set of methods to .rolling methods.
14.4.1 Method Summary

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>count()</td>
<td>Number of non-null observations</td>
</tr>
<tr>
<td>sum()</td>
<td>Sum of values</td>
</tr>
<tr>
<td>mean()</td>
<td>Mean of values</td>
</tr>
<tr>
<td>median()</td>
<td>Arithmetic median of values</td>
</tr>
<tr>
<td>min()</td>
<td>Minimum</td>
</tr>
<tr>
<td>max()</td>
<td>Maximum</td>
</tr>
<tr>
<td>std()</td>
<td>Unbiased standard deviation</td>
</tr>
<tr>
<td>var()</td>
<td>Unbiased variance</td>
</tr>
<tr>
<td>skew()</td>
<td>Unbiased skewness (3rd moment)</td>
</tr>
<tr>
<td>kurt()</td>
<td>Unbiased kurtosis (4th moment)</td>
</tr>
<tr>
<td>quantile()</td>
<td>Sample quantile (value at %)</td>
</tr>
<tr>
<td>apply()</td>
<td>Generic apply</td>
</tr>
<tr>
<td>cov()</td>
<td>Unbiased covariance (binary)</td>
</tr>
<tr>
<td>corr()</td>
<td>Correlation (binary)</td>
</tr>
</tbody>
</table>

Aside from not having a `window` parameter, these functions have the same interfaces as their `.rolling` counterparts. Like above, the parameters they all accept are:

- **min_periods**: threshold of non-null data points to require. Defaults to minimum needed to compute statistic. No NaNs will be output once `min_periods` non-null data points have been seen.
- **center**: boolean, whether to set the labels at the center (default is False).

**Note:** The output of the `.rolling` and `.expanding` methods do not return a NaN if there are at least `min_periods` non-null values in the current window. For example:

```python
In [98]: sn = pd.Series([1, 2, np.nan, 3, np.nan, 4])

In [99]: sn
Out[99]:
0    1.0
1    2.0
2     NaN
3    3.0
4     NaN
5    4.0
dtype: float64

In [100]: sn.rolling(2).max()
Out[100]:
0     NaN
1    2.0
2     NaN
3     NaN
4     NaN
5     NaN
dtype: float64

In [101]: sn.rolling(2, min_periods=1).max()
```
(continues on next page)
In case of expanding functions, this differs from `cumsum()`, `cumprod()`, `cummax()`, and `cummin()`, which return NaN in the output wherever a NaN is encountered in the input. In order to match the output of `cumsum` with expanding, use `fillna()`:

```
In [102]: sn.expanding().sum()
Out[102]:
   0   1.0
   1   3.0
   2   3.0
   3   6.0
   4   6.0
   5  10.0
dtype: float64
```

```
In [103]: sn.cumsum()
Out[103]:
   0   1.0
   1  NaN
   2   3.0
   3   6.0
   4  NaN
   5  10.0
dtype: float64
```

```
In [104]: sn.cumsum().fillna(method='ffill')
```

An expanding window statistic will be more stable (and less responsive) than its rolling window counterpart as the increasing window size decreases the relative impact of an individual data point. As an example, here is the `mean()` output for the previous time series dataset:

```
In [105]: s.plot(style='k--')
Out[105]: <matplotlib.axes._subplots.AxesSubplot at 0x1c254345f8>
```

```
In [106]: s.expanding().mean().plot(style='k')
```

14.4. Expanding Windows
14.5 Exponentially Weighted Windows

A related set of functions are exponentially weighted versions of several of the above statistics. A similar interface to `.rolling` and `.expanding` is accessed through the `.ewm` method to receive an `EWM` object. A number of expanding EW (exponentially weighted) methods are provided:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>mean()</code></td>
<td>EW moving average</td>
</tr>
<tr>
<td><code>var()</code></td>
<td>EW moving variance</td>
</tr>
<tr>
<td><code>std()</code></td>
<td>EW moving standard deviation</td>
</tr>
<tr>
<td><code>corr()</code></td>
<td>EW moving correlation</td>
</tr>
<tr>
<td><code>cov()</code></td>
<td>EW moving covariance</td>
</tr>
</tbody>
</table>

In general, a weighted moving average is calculated as

\[
y_t = \frac{\sum_{i=0}^{t} w_i x_{t-i}}{\sum_{i=0}^{t} w_i},
\]

where \( x_t \) is the input, \( y_t \) is the result and the \( w_i \) are the weights.

The EW functions support two variants of exponential weights. The default, `adjust=True`, uses the weights \( w_i = \)

\[\text{in general, a weighted moving average is calculated as}\]

\[
y_t = \frac{\sum_{i=0}^{t} w_i x_{t-i}}{\sum_{i=0}^{t} w_i},
\]

\[\text{where } x_t \text{ is the input, } y_t \text{ is the result and the } w_i \text{ are the weights.}\]

\[\text{The EW functions support two variants of exponential weights. The default, adjust=True, uses the weights } w_i =\]
When \( \text{adjust=False} \) is specified, moving averages are calculated as
\[
y_0 = x_0
y_t = (1 - \alpha)y_{t-1} + \alpha x_t,
\]
which is equivalent to using weights
\[
w_i = \begin{cases} 
\alpha(1-\alpha)^i & \text{if } i < t \\
(1-\alpha)^i & \text{if } i = t.
\end{cases}
\]

**Note:** These equations are sometimes written in terms of \( \alpha' = 1 - \alpha \), e.g.
\[
y_t = \alpha' y_{t-1} + (1 - \alpha')x_t.
\]

The difference between the above two variants arises because we are dealing with series which have finite history. Consider a series of infinite history:
\[
y_t = \frac{x_t + (1 - \alpha)x_{t-1} + (1 - \alpha)^2x_{t-2} + \cdots}{1 + (1 - \alpha) + (1 - \alpha)^2 + \cdots}
\]
Noting that the denominator is a geometric series with initial term equal to 1 and a ratio of \( 1 - \alpha \) we have
\[
y_t = \frac{x_t + (1 - \alpha)x_{t-1} + (1 - \alpha)^2x_{t-2} + \cdots}{1 - (1 - \alpha)}
\]
\[= \frac{[x_t + (1 - \alpha)x_{t-1} + (1 - \alpha)^2x_{t-2} + \cdots] \alpha}{\alpha x_t + [(1 - \alpha)x_{t-1} + (1 - \alpha)^2x_{t-2} + \cdots] \alpha}
\]
\[= \alpha x_t + (1 - \alpha)[x_{t-1} + (1 - \alpha)x_{t-2} + \cdots] \alpha
\]
\[= \alpha x_t + (1 - \alpha)y_{t-1}
\]
which shows the equivalence of the above two variants for infinite series. When \( \text{adjust=True} \) we have \( y_0 = x_0 \) and from the last representation above we have \( y_t = \alpha x_t + (1 - \alpha)y_{t-1} \), therefore there is an assumption that \( x_0 \) is not an ordinary value but rather an exponentially weighted moment of the infinite series up to that point.

One must have \( 0 < \alpha \leq 1 \), and while since version 0.18.0 it has been possible to pass \( \alpha \) directly, it’s often easier to think about either the span, center of mass (com) or half-life of an EW moment:
\[
\alpha = \begin{cases} 
\frac{s+1}{s}, & \text{for span } s \geq 1 \\
\frac{1}{1+c}, & \text{for center of mass } c \geq 0 \\
1 - \exp \frac{\log 0.5}{h}, & \text{for half-life } h > 0
\end{cases}
\]
One must specify precisely one of span, center of mass, half-life and alpha to the EW functions:

- **Span** corresponds to what is commonly called an “N-day EW moving average”.
- **Center of mass** has a more physical interpretation and can be thought of in terms of span: \( c = (s - 1)/2 \).
- **Half-life** is the period of time for the exponential weight to reduce to one half.
- **Alpha** specifies the smoothing factor directly.

Here is an example for a univariate time series:
EWM has a `min_periods` argument, which has the same meaning it does for all the `.expanding` and `.rolling` methods: no output values will be set until at least `min_periods` non-null values are encountered in the (expanding) window.

EWM also has an `ignore_na` argument, which determines how intermediate null values affect the calculation of the weights. When `ignore_na=False` (the default), weights are calculated based on absolute positions, so that intermediate null values affect the result. When `ignore_na=True`, weights are calculated by ignoring intermediate null values. For example, assuming `adjust=True`, if `ignore_na=False`, the weighted average of 3, NaN, 5 would be calculated as

\[
\frac{(1 - \alpha)^2 \cdot 3 + 1 \cdot 5}{(1 - \alpha)^2 + 1}.
\]

Whereas if `ignore_na=True`, the weighted average would be calculated as

\[
\frac{(1 - \alpha) \cdot 3 + 1 \cdot 5}{(1 - \alpha) + 1}.
\]

The `var()`, `std()`, and `cov()` functions have a `bias` argument, specifying whether the result should contain biased or unbiased statistics. For example, if `bias=True`, `ewmvar(x)` is calculated as `ewmvar(x) =

\[
\frac{(1 - \alpha)^2 \cdot 3 + 1 \cdot 5}{(1 - \alpha)^2 + 1}.
\]
ewma(x**2) - ewma(x)**2; whereas if bias=False (the default), the biased variance statistics are scaled by debiasing factors

\[ \frac{\left( \sum_{i=0}^{t} w_i \right)^2}{\left( \sum_{i=0}^{t} w_i \right)^2 - \sum_{i=0}^{t} w_i^2} \]

(For \( w_i = 1 \), this reduces to the usual \( N/(N - 1) \) factor, with \( N = t + 1 \).) See Weighted Sample Variance on Wikipedia for further details.
CHAPTER
FIFTEEN

WORKING WITH MISSING DATA

In this section, we will discuss missing (also referred to as NA) values in pandas.

Note: The choice of using NaN internally to denote missing data was largely for simplicity and performance reasons. It differs from the MaskedArray approach of, for example, scikits.timeseries. We are hopeful that NumPy will soon be able to provide a native NA type solution (similar to R) performant enough to be used in pandas.

See the cookbook for some advanced strategies.

15.1 Missing data basics

15.1.1 When / why does data become missing?

Some might quibble over our usage of missing. By “missing” we simply mean NA (“not available”) or “not present for whatever reason”. Many data sets simply arrive with missing data, either because it exists and was not collected or it never existed. For example, in a collection of financial time series, some of the time series might start on different dates. Thus, values prior to the start date would generally be marked as missing.

In pandas, one of the most common ways that missing data is introduced into a data set is by reindexing. For example:

```
In [1]: df = pd.DataFrame(np.random.randn(5, 3), index=['a', 'c', 'e', 'f', 'h'],
                       columns=['one', 'two', 'three'])

In [2]: df['four'] = 'bar'

In [3]: df['five'] = df['one'] > 0

In [4]: df
Out[4]:

   one   two   three  five
a -0.166778 0.501113 -0.355322 bar False
b  0.337890 0.580967  0.983801 bar False
c  0.057802 0.761948 -0.712964 bar True
d -0.443160 -0.974602  1.047704 bar False
f -0.717852 -1.053898 -0.019369 bar False

In [5]: df2 = df.reindex(['a', 'b', 'c', 'd', 'e', 'f', 'g', 'h'])

In [6]: df2
Out[6]:
```
15.1.2 Values considered “missing”

As data comes in many shapes and forms, pandas aims to be flexible with regard to handling missing data. While \texttt{NaN} is the default missing value marker for reasons of computational speed and convenience, we need to be able to easily detect this value with data of different types: floating point, integer, boolean, and general object. In many cases, however, the Python \texttt{None} will arise and we wish to also consider that “missing” or “not available” or “NA”.

\textbf{Note:} If you want to consider \texttt{inf} and \texttt{-inf} to be “NA” in computations, you can set \texttt{pandas.options.mode.use_inf_as_na = True}.

To make detecting missing values easier (and across different array dtypes), pandas provides the \texttt{isna()} and \texttt{notna()} functions, which are also methods on Series and DataFrame objects:

<table>
<thead>
<tr>
<th></th>
<th>one</th>
<th>two</th>
<th>three</th>
<th>four</th>
<th>five</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>-0.166778</td>
<td>0.501113</td>
<td>-0.355322</td>
<td>bar</td>
<td>False</td>
</tr>
<tr>
<td>b</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>c</td>
<td>-0.337890</td>
<td>0.580967</td>
<td>0.983801</td>
<td>bar</td>
<td>False</td>
</tr>
<tr>
<td>d</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>e</td>
<td>0.057802</td>
<td>0.761948</td>
<td>-0.712964</td>
<td>bar</td>
<td>True</td>
</tr>
<tr>
<td>f</td>
<td>-0.443160</td>
<td>-0.974602</td>
<td>1.047704</td>
<td>bar</td>
<td>False</td>
</tr>
<tr>
<td>g</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>h</td>
<td>-0.717852</td>
<td>-1.053898</td>
<td>-0.019369</td>
<td>bar</td>
<td>False</td>
</tr>
</tbody>
</table>
c  True
d  False
e  True
f  True
g  False
h  True
Name: four, dtype: bool

In [10]: df2.isna()

```
   one   two   three   four   five
a  False  False  False  False  False
b   True   True   True   True   True
c  False  False  False  False  False
d   True   True   True   True   True
e  False  False  False  False  False
f  False  False  False  False  False
g   True   True   True   True   True
h  False  False  False  False  False
```

Warning: One has to be mindful that in Python (and NumPy), the nan's don't compare equal, but None's do. Note that pandas/NumPy uses the fact that np.nan != np.nan, and treats None like np.nan.

In [11]: None == None
Out[11]: True

In [12]: np.nan == np.nan
\n\n\n\nOut[12]: False

So as compared to above, a scalar equality comparison versus a None(np.nan doesn’t provide useful information.

In [13]: df2['one'] == np.nan
Out[13]:
a  False
b  False
c  False
d  False
e  False
f  False
g  False
h  False
Name: one, dtype: bool

15.2 Datetimes

For datetime64[ns] types, NaT represents missing values. This is a pseudo-native sentinel value that can be represented by NumPy in a singular dtype (datetime64[ns]). pandas objects provide intercompatibility between NaT and NaN.

In [14]: df2 = df.copy()

In [15]: df2['timestamp'] = pd.Timestamp('20120101')

(continues on next page)
15.3 Inserting missing data

You can insert missing values by simply assigning to containers. The actual missing value used will be chosen based on the dtypes.

For example, numeric containers will always use NaN regardless of the missing value type chosen:

```
In [20]: s = pd.Series([1, 2, 3])

In [21]: s.loc[0] = None

In [22]: s
Out[22]:
0    NaN
1    2.0
2    3.0
dtype: float64
```

Likewise, datetime containers will always use NaT.

For object containers, pandas will use the value given:

```
In [23]: s = pd.Series(["a", "b", "c"])

In [24]: s.loc[0] = None
```

(continues on next page)
In [25]: s.loc[1] = np.nan

In [26]: s
Out[26]:
0   None
1   NaN
2    c
 dtype: object

15.4 Calculations with missing data

Missing values propagate naturally through arithmetic operations between pandas objects.

In [27]: a
Out[27]:
   one   two
a  NaN  0.501113
b  NaN  0.580967
c  NaN  0.761948
d -0.443160 -0.974602
e  0.057802  0.761948
f  1.053898  0.057802
g -0.443160 -0.974602
h -1.053898 -0.057802

In [28]: b
   →
   one   two   three
a  NaN  0.501113 -0.355322
b  NaN  0.580967  0.983801
c  NaN  0.761948  0.712964
d -0.443160 -0.974602  1.047704
e  0.057802  0.761948 -0.712964
f  1.053898  0.057802 -1.047704
g -0.443160 -0.974602  1.047704
h  NaN  0.761948 -0.712964

In [29]: a + b
   →
   one   three   two
a  NaN          NaN  1.002226
b  NaN          NaN  0.983801
c  NaN          NaN  1.523896
d -0.886321     NaN -1.849205
e  0.057802     NaN  0.206935
f  1.053898     NaN  0.019369
g -0.443160     NaN -0.846433
h -1.053898     NaN -2.063263

The descriptive statistics and computational methods discussed in the data structure overview (and listed here and here) are all written to account for missing data. For example:

- When summing data, NA (missing) values will be treated as zero.
- If the data are all NA, the result will be 0.
- Cumulative methods like cumsum() and cumprod() ignore NA values by default, but preserve them in the resulting arrays. To override this behaviour and include NA values, use skipna=False.
pandas: powerful Python data analysis toolkit, Release 0.23.2

(continued from previous page)

<table>
<thead>
<tr>
<th></th>
<th>one</th>
<th>two</th>
<th>three</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>NaN</td>
<td>0.501113</td>
<td>-0.355322</td>
</tr>
<tr>
<td>c</td>
<td>NaN</td>
<td>0.580967</td>
<td>0.983801</td>
</tr>
<tr>
<td>e</td>
<td>0.057802</td>
<td>0.761948</td>
<td>-0.712964</td>
</tr>
<tr>
<td>f</td>
<td>-0.443160</td>
<td>-0.974602</td>
<td>1.047704</td>
</tr>
<tr>
<td>h</td>
<td>NaN</td>
<td>-1.053898</td>
<td>-0.019369</td>
</tr>
</tbody>
</table>

In [31]: df['one'].sum()

Out[31]:
-0.38535826528461409

In [32]: df.mean(1)

Out[32]:
a 0.072895
c 0.782384
e 0.035595
f -0.123353
h -0.536633
dtype: float64

In [33]: df.cumsum()

Out[33]:
<table>
<thead>
<tr>
<th></th>
<th>one</th>
<th>two</th>
<th>three</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>NaN</td>
<td>0.501113</td>
<td>-0.355322</td>
</tr>
<tr>
<td>c</td>
<td>NaN</td>
<td>1.082080</td>
<td>0.628479</td>
</tr>
<tr>
<td>e</td>
<td>0.057802</td>
<td>1.844028</td>
<td>-0.084485</td>
</tr>
<tr>
<td>f</td>
<td>-0.385358</td>
<td>0.869426</td>
<td>0.963219</td>
</tr>
<tr>
<td>h</td>
<td>NaN</td>
<td>-0.184472</td>
<td>0.943850</td>
</tr>
</tbody>
</table>

In [34]: df.cumsum(skipna=False)

Out[34]:
<table>
<thead>
<tr>
<th></th>
<th>one</th>
<th>two</th>
<th>three</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>NaN</td>
<td>0.501113</td>
<td>-0.355322</td>
</tr>
<tr>
<td>c</td>
<td>NaN</td>
<td>1.844028</td>
<td>-0.084485</td>
</tr>
<tr>
<td>e</td>
<td>NaN</td>
<td>1.844028</td>
<td>-0.084485</td>
</tr>
<tr>
<td>f</td>
<td>NaN</td>
<td>0.869426</td>
<td>0.963219</td>
</tr>
<tr>
<td>h</td>
<td>NaN</td>
<td>-0.184472</td>
<td>0.943850</td>
</tr>
</tbody>
</table>

15.4.1 Sum/Prod of Empties/Nans

**Warning**: This behavior is now standard as of v0.22.0 and is consistent with the default in numpy; previously sum/prod of all-NA or empty Series/DataFrames would return NaN. See v0.22.0 whatsnw for more.

The sum of an empty or all-NA Series or column of a DataFrame is 0.

In [35]: pd.Series([np.nan]).sum()
Out[35]: 0.0

In [36]: pd.Series([]).sum()
Out[36]: 0.0
The product of an empty or all-NA Series or column of a DataFrame is 1.

```python
In [37]: pd.Series([np.nan]).prod()
Out[37]: 1.0

In [38]: pd.Series([]).prod()
```

### 15.4.2 NA values in GroupBy

NA groups in GroupBy are automatically excluded. This behavior is consistent with R, for example:

```python
In [39]: df
Out[39]:
\begin{tabular}{ccc}
\hline
one & two & three \\
\hline
a & NaN & 0.501113 -0.355322 \\
c & NaN & 0.580967 0.983801 \\
e & 0.057802 & 0.761948 -0.712964 \\
f & -0.443160 & -0.974602 1.047704 \\
h & NaN & -1.053898 -0.019369 \\
\hline
\end{tabular}

In [40]: df.groupby('one').mean()
```

See the groupby section [here](#) for more information.

### 15.5 Cleaning / filling missing data

pandas objects are equipped with various data manipulation methods for dealing with missing data.

#### 15.5.1 Filling missing values: fillna

`fillna()` can “fill in” NA values with non-NA data in a couple of ways, which we illustrate:

**Replace NA with a scalar value**

```python
In [41]: df2
Out[41]:
\begin{tabular}{cccccc}
\hline
one & two & three & four & five & timestamp \\
\hline
a & NaN & 0.501113 -0.355322 & bar & False & NaT \\
c & NaN & 0.580967 0.983801 & bar & False & NaT \\
e & 0.057802 & 0.761948 -0.712964 & bar & True & 2012-01-01 \\
f & -0.443160 & -0.974602 1.047704 & bar & False & 2012-01-01 \\
h & NaN & -1.053898 -0.019369 & bar & False & NaT \\
\hline
\end{tabular}

In [42]: df2.fillna(0)
```
In [43]: df2['one'].fillna('missing')

→

a missing
b missing
c missing
e 0.057802
  
f -0.44316
  
h missing
Name: one, dtype: object

Fill gaps forward or backward

Using the same filling arguments as *reindexing*, we can propagate non-NA values forward or backward:

In [44]: df

Out[44]:

<table>
<thead>
<tr>
<th>one</th>
<th>two</th>
<th>three</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaN</td>
<td>0.501113</td>
<td>-0.355322</td>
</tr>
<tr>
<td>NaN</td>
<td>0.580967</td>
<td>0.983801</td>
</tr>
<tr>
<td>0.057802</td>
<td>0.761948</td>
<td>-0.712964</td>
</tr>
<tr>
<td>-0.443160</td>
<td>-0.974602</td>
<td>1.047704</td>
</tr>
<tr>
<td>NaN</td>
<td>-1.053898</td>
<td>-0.019369</td>
</tr>
</tbody>
</table>

In [45]: df.fillna(method='pad')

→

<table>
<thead>
<tr>
<th>one</th>
<th>two</th>
<th>three</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaN</td>
<td>0.501113</td>
<td>-0.355322</td>
</tr>
<tr>
<td>NaN</td>
<td>0.580967</td>
<td>0.983801</td>
</tr>
<tr>
<td>0.057802</td>
<td>0.761948</td>
<td>-0.712964</td>
</tr>
<tr>
<td>-0.443160</td>
<td>-0.974602</td>
<td>1.047704</td>
</tr>
<tr>
<td>NaN</td>
<td>-1.053898</td>
<td>-0.019369</td>
</tr>
</tbody>
</table>

Limit the amount of filling

If we only want consecutive gaps filled up to a certain number of data points, we can use the *limit* keyword:

In [46]: df

Out[46]:

<table>
<thead>
<tr>
<th>one</th>
<th>two</th>
<th>three</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaN</td>
<td>0.501113</td>
<td>-0.355322</td>
</tr>
<tr>
<td>NaN</td>
<td>0.580967</td>
<td>0.983801</td>
</tr>
<tr>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>NaN</td>
<td>-1.053898</td>
<td>-0.019369</td>
</tr>
</tbody>
</table>

In [47]: df.fillna(method='pad', limit=1)

→

<table>
<thead>
<tr>
<th>one</th>
<th>two</th>
<th>three</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaN</td>
<td>0.501113</td>
<td>-0.355322</td>
</tr>
<tr>
<td>NaN</td>
<td>0.580967</td>
<td>0.983801</td>
</tr>
<tr>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>NaN</td>
<td>-1.053898</td>
<td>-0.019369</td>
</tr>
</tbody>
</table>
To remind you, these are the available filling methods:

<table>
<thead>
<tr>
<th>Method</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>pad / ffill</td>
<td>Fill values forward</td>
</tr>
<tr>
<td>bfill / backfill</td>
<td>Fill values backward</td>
</tr>
</tbody>
</table>

With time series data, using pad/ffill is extremely common so that the “last known value” is available at every time point.

`ffill()` is equivalent to `fillna(method='ffill')` and `bfill()` is equivalent to `fillna(method='bfill')`

### 15.5.2 Filling with a PandasObject

You can also fillna using a dict or Series that is alignable. The labels of the dict or index of the Series must match the columns of the frame you wish to fill. The use case of this is to fill a DataFrame with the mean of that column.

```python
In [48]: dff = pd.DataFrame(np.random.randn(10,3), columns=list('ABC'))
In [49]: dff.iloc[3:5,0] = np.nan
In [50]: dff.iloc[4:6,1] = np.nan
In [51]: dff.iloc[5:8,2] = np.nan
In [52]: dff
Out[52]:
       A         B         C
0  0.758887  2.340598  0.219039
1 -1.235583  0.031785  0.701683
2 -1.557016 -0.636986 -1.238610
3  NaN  1.002278  0.654052
4  NaN     NaN   1.053999
5  0.651981     NaN     NaN
6  0.109001 -0.533294     NaN
7 -1.037831 -1.150016     NaN
8 -1.037831 -1.150016     NaN
9 -0.258742 -0.706329  0.402547
```

```python
In [53]: dff.fillna(dff.mean())
```
In [54]: dff.fillna(dff.mean()['B':'C'])

    A       B       C
 0  0.758887  2.340598  0.219039
 1 -1.235583  0.031785  0.701683
 2 -1.557016 -0.636986 -1.238610
 3  NaN       -1.002278  0.654052
 4  NaN       0.033067  1.053999
 5  0.651981  0.033067  0.238800
 6  0.109001 -0.533294  0.238800
 7 -1.037831 -1.150016  0.238800
 8 -0.687693  1.921056 -0.121113
 9 -0.258742 -0.706329  0.402547

Same result as above, but is aligning the ‘fill’ value which is a Series in this case.

In [55]: dff.where(pd.notna(dff), dff.mean(), axis='columns')

    A       B       C
 0  0.758887  2.340598  0.219039
 1 -1.235583  0.031785  0.701683
 2 -1.557016 -0.636986 -1.238610
 3 -0.407125 -1.002278  0.654052
 4 -0.407125  0.033067  1.053999
 5  0.651981  0.033067  0.238800
 6  0.109001 -0.533294  0.238800
 7 -1.037831 -1.150016  0.238800
 8 -0.687693  1.921056 -0.121113
 9 -0.258742 -0.706329  0.402547

### 15.5.3 Dropping axis labels with missing data: dropna

You may wish to simply exclude labels from a data set which refer to missing data. To do this, use `dropna()`:

In [56]: df
Out[56]:

    one  two  three
  a  NaN  0.501113 -0.355322
  c  NaN  0.580967  0.983801
  e  NaN  0.000000  0.000000
  f  NaN  0.000000  0.000000
  h  NaN -1.053898  0.019369

In [57]: df.dropna(axis=0)

Empty DataFrame
Columns: [one, two, three]
Index: []

In [58]: df.dropna(axis=1)

   two     three
  a  0.501113 -0.355322
  c  0.580967  0.983801
  e  0.000000  0.000000
  f  0.000000  0.000000
  h -1.053898 -0.019369

In [59]: df['one'].dropna()

Series([], Name: one, dtype: float64)

An equivalent dropna() is available for Series. DataFrame.dropna has considerably more options than Series.dropna, which can be examined in the API.

15.5.4 Interpolation

New in version 0.21.0: The limit_area keyword argument was added.

Both Series and DataFrame objects have interpolate() that, by default, performs linear interpolation at missing datapoints.

In [60]: ts
Out[60]:
2000-01-31 0.469112
2000-02-29 NaN
2000-03-31 NaN
2000-04-28 NaN
2000-05-31 NaN
2000-06-30 NaN
2000-07-31 NaN
... 2007-10-31 -3.305259
2007-11-30 -5.485119
2007-12-31 -6.854968
2008-01-31 -7.809176
2008-02-29 -6.346480
2008-03-31 -8.089641
2008-04-30 -8.916232
Freq: BM, Length: 100, dtype: float64

In [61]: ts.count()

In [62]: ts.interpolate().count()

In [63]: ts.interpolate().plot()
Index aware interpolation is available via the method keyword:

```python
In [64]: ts2
Out[64]:
2000-01-31   0.469112
2000-02-29     NaN
2002-07-31  -5.689738
2005-01-31     NaN
2008-04-30  -8.916232
dtype: float64
```

```python
In [65]: ts2.interpolate()
```

```
→
2000-01-31   0.469112
2000-02-29   -2.610313
2002-07-31  -5.689738
2005-01-31   -7.302985
2008-04-30  -8.916232
```

```python
In [66]: ts2.interpolate(method='time')
```

```
→
2000-01-31   0.469112
2000-02-29   -2.610313
2002-07-31  -5.689738
2005-01-31   -7.302985
2008-04-30  -8.916232
```

(continues on next page)
For a floating-point index, use method='values':

```python
In [67]: ser
Out[67]:
0.0 0.0
1.0 NaN
10.0 10.0
dtype: float64
```

```python
In [68]: ser.interpolate()
Out[68]:
0.0 0.0
1.0 1.0
10.0 10.0
dtype: float64
```

```python
In [69]: ser.interpolate(method='values')
Out[69]:
0.0 0.0
1.0 1.0
10.0 10.0
dtype: float64
```

You can also interpolate with a DataFrame:

```python
In [70]: df = pd.DataFrame({'A': [1, 2.1, np.nan, 4.7, 5.6, 6.8],
                      'B': [.25, np.nan, np.nan, 4, 12.2, 14.4]})
```

```python
In [71]: df
Out[71]:
       A   B
0  1.0  0.25
1  2.1   NaN
2   NaN   NaN
3  4.7   4.00
4  5.6  12.20
5  6.8  14.40
```

```python
In [72]: df.interpolate()
Out[72]:
       A   B
0  1.0  0.25
1  2.1  1.50
2  3.4  2.75
3  4.7  4.00
4  5.6  12.20
5  6.8  14.40
```

The method argument gives access to fancier interpolation methods. If you have scipy installed, you can pass the...
name of a 1-d interpolation routine to method. You’ll want to consult the full scipy interpolation documentation and reference guide for details. The appropriate interpolation method will depend on the type of data you are working with.

- If you are dealing with a time series that is growing at an increasing rate, method='quadratic' may be appropriate.
- If you have values approximating a cumulative distribution function, then method='pchip' should work well.
- To fill missing values with goal of smooth plotting, consider method='akima'.

**Warning:** These methods require scipy.

```
In [73]: df.interpolate(method='barycentric')
Out[73]:
   A   B
0  1.00  0.250
1  2.10 -7.660
2  3.53 -4.515
3  4.70  4.000
4  5.60 12.200
5  6.80 14.400

In [74]: df.interpolate(method='pchip')

In [75]: df.interpolate(method='akima')
```

When interpolating via a polynomial or spline approximation, you must also specify the degree or order of the approximation:

```
In [76]: df.interpolate(method='spline', order=2)
Out[76]:
   A   B
0  1.000000  0.250000
1  2.100000  0.672808
2  3.434545  1.928950
3  4.700000  4.000000
4  5.600000 12.200000
5  6.800000 14.400000
```

(continues on next page)
In [77]: df.interpolate(method='polynomial', order=2)

\[
\begin{array}{cc}
0 & 1.000000 \\
1 & 2.100000 \\
2 & 3.451351 \\
3 & 4.700000 \\
4 & 5.600000 \\
5 & 6.800000 \\
\end{array}
\]

Compare several methods:

```
In [78]: np.random.seed(2)

In [79]: ser = pd.Series(np.arange(1, 10.1, .25)**2 + np.random.randn(37))

In [80]: bad = np.array([4, 13, 14, 15, 16, 17, 18, 20, 29])

In [81]: ser[bad] = np.nan

In [82]: methods = ['linear', 'quadratic', 'cubic']

In [83]: df = pd.DataFrame({m: ser.interpolate(method=m) for m in methods})

In [84]: df.plot()
```

Out[84]: <matplotlib.axes._subplots.AxesSubplot at 0x1c3702e518>
Another use case is interpolation at new values. Suppose you have 100 observations from some distribution. And let's suppose that you're particularly interested in what's happening around the middle. You can mix pandas' `reindex` and `interpolate` methods to interpolate at the new values.

```python
In [85]: ser = pd.Series(np.sort(np.random.uniform(size=100)))

# interpolate at new_index
In [86]: new_index = ser.index | pd.Index([49.25, 49.5, 49.75, 50.25, 50.5, 50.75])

In [87]: interp_s = ser.reindex(new_index).interpolate(method='pchip')

In [88]: interp_s[49:51]
Out[88]:
        49.00  0.471410
        49.25  0.476841
        49.50  0.481780
        49.75  0.485998
        50.00  0.489266
        50.25  0.491814
        50.50  0.493995
        50.75  0.495763
        51.00  0.497074
dtype: float64
```
15.5.4.1 Interpolation Limits

Like other pandas fill methods, `interpolate()` accepts a `limit` keyword argument. Use this argument to limit the number of consecutive NaN values filled since the last valid observation:

```python
In [89]: ser = pd.Series([np.nan, np.nan, 5, np.nan, np.nan, np.nan, 13, np.nan, np.nan])
# fill all consecutive values in a forward direction
In [90]: ser.interpolate()
Out[90]:
   0   NaN
   1   NaN
   2   5.0
   3   7.0
   4   9.0
   5  11.0
   6  13.0
   7  13.0
   8  13.0
dtype: float64
# fill one consecutive value in a forward direction
In [91]: ser.interpolate(limit=1)
```

By default, NaN values are filled in a forward direction. Use `limit_direction` parameter to fill backward or from both directions.

```python
# fill one consecutive value backwards
In [92]: ser.interpolate(limit=1, limit_direction='backward')
Out[92]:
   0   NaN
   1   NaN
   2   5.0
   3   7.0
   4  13.0
   5  13.0
   6   NaN
   7   NaN
   8   NaN
dtype: float64
# fill one consecutive value in both directions
In [93]: ser.interpolate(limit=1, limit_direction='both')
```

(continues on next page)
### pandas: powerful Python data analysis toolkit, Release 0.23.2

<table>
<thead>
<tr>
<th>#</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NaN</td>
</tr>
<tr>
<td>1</td>
<td>5.0</td>
</tr>
<tr>
<td>2</td>
<td>5.0</td>
</tr>
<tr>
<td>3</td>
<td>7.0</td>
</tr>
<tr>
<td>4</td>
<td>NaN</td>
</tr>
<tr>
<td>5</td>
<td>11.0</td>
</tr>
<tr>
<td>6</td>
<td>13.0</td>
</tr>
<tr>
<td>7</td>
<td>13.0</td>
</tr>
<tr>
<td>8</td>
<td>NaN</td>
</tr>
</tbody>
</table>

dtype: float64

By default, NaN values are filled whether they are inside (surrounded by) existing valid values, or outside existing valid values. Introduced in v0.23 the limit_area parameter restricts filling to either inside or outside values.

### # fill all consecutive values in both directions
In [94]: ser.interpolate(limit_direction='both')

<table>
<thead>
<tr>
<th>#</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.0</td>
</tr>
<tr>
<td>1</td>
<td>5.0</td>
</tr>
<tr>
<td>2</td>
<td>5.0</td>
</tr>
<tr>
<td>3</td>
<td>7.0</td>
</tr>
<tr>
<td>4</td>
<td>9.0</td>
</tr>
<tr>
<td>5</td>
<td>11.0</td>
</tr>
<tr>
<td>6</td>
<td>13.0</td>
</tr>
<tr>
<td>7</td>
<td>13.0</td>
</tr>
<tr>
<td>8</td>
<td>13.0</td>
</tr>
</tbody>
</table>

dtype: float64

### # fill one consecutive inside value in both directions
In [95]: ser.interpolate(limit_direction='both', limit_area='inside', limit=1)

<table>
<thead>
<tr>
<th>#</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NaN</td>
</tr>
<tr>
<td>1</td>
<td>NaN</td>
</tr>
<tr>
<td>2</td>
<td>5.0</td>
</tr>
<tr>
<td>3</td>
<td>NaN</td>
</tr>
<tr>
<td>4</td>
<td>11.0</td>
</tr>
<tr>
<td>5</td>
<td>13.0</td>
</tr>
<tr>
<td>6</td>
<td>13.0</td>
</tr>
<tr>
<td>7</td>
<td>NaN</td>
</tr>
<tr>
<td>8</td>
<td>NaN</td>
</tr>
</tbody>
</table>

dtype: float64

### # fill all consecutive outside values backward
In [96]: ser.interpolate(limit_direction='backward', limit_area='outside')

<table>
<thead>
<tr>
<th>#</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.0</td>
</tr>
<tr>
<td>1</td>
<td>5.0</td>
</tr>
<tr>
<td>2</td>
<td>5.0</td>
</tr>
<tr>
<td>3</td>
<td>NaN</td>
</tr>
<tr>
<td>4</td>
<td>NaN</td>
</tr>
<tr>
<td>5</td>
<td>NaN</td>
</tr>
<tr>
<td>6</td>
<td>13.0</td>
</tr>
<tr>
<td>7</td>
<td>NaN</td>
</tr>
<tr>
<td>8</td>
<td>NaN</td>
</tr>
</tbody>
</table>

dtype: float64

(continues on next page)
15.5.5 Replacing Generic Values

Often times we want to replace arbitrary values with other values.

`replace()` in Series and `replace()` in DataFrame provides an efficient yet flexible way to perform such replacements.

For a Series, you can replace a single value or a list of values by another value:

```python
In [98]: ser = pd.Series([0., 1., 2., 3., 4.])
In [99]: ser.replace(0, 5)
```

```
Out[99]:
0   5.0
1   1.0
2   2.0
3   3.0
4   4.0
dtype: float64
```

You can replace a list of values by a list of other values:

```python
In [100]: ser.replace([0, 1, 2, 3, 4], [4, 3, 2, 1, 0])
```

```
Out[100]:
0   4.0
1   3.0
2   2.0
3   1.0
4   0.0
dtype: float64
```

You can also specify a mapping dict:

```python
In [101]: ser.replace({0: 10, 1: 100})
```

```
Out[101]:
0  10.0
1 100.0
2   2.0
```
For a DataFrame, you can specify individual values by column:

```
In [102]: df = pd.DataFrame({'a': [0, 1, 2, 3, 4], 'b': [5, 6, 7, 8, 9]})
In [103]: df.replace({'a': 0, 'b': 5}, 100)
Out[103]:
   a  b
0 100 100
1  1  6
2  2  7
3  3  8
4  4  9
```

Instead of replacing with specified values, you can treat all given values as missing and interpolate over them:

```
In [104]: ser.replace([1, 2, 3], method='pad')
Out[104]:
0 0.0
1 0.0
2 0.0
3 0.0
4 4.0
```

**15.5.6 String/Regular Expression Replacement**

**Note:** Python strings prefixed with the `r` character such as `r'hello world'` are so-called “raw” strings. They have different semantics regarding backslashes than strings without this prefix. Backslashes in raw strings will be interpreted as an escaped backslash, e.g., `r'\' == '\\'. You should read about them if this is unclear.

Replace the `.` with NaN (str -> str):

```
In [105]: d = {'a': list(range(4)), 'b': list('ab..'), 'c': ['a', 'b', np.nan, 'd']}
In [106]: df = pd.DataFrame(d)
In [107]: df.replace('.', np.nan)
Out[107]:
   a  b  c
0  a  a  a
1  b  b  b
2  NaN NaN NaN
3  NaN NaN NaN
```

Now do it with a regular expression that removes surrounding whitespace (regex -> regex):

```
In [108]: df.replace(r'\s*\.', np.nan, regex=True)
Out[108]:
   a  b  c
0  a  a  a
1  b  b  b
2  NaN NaN NaN
3  NaN NaN NaN
```
Replace a few different values (list -> list):

```python
In [109]: df.replace(['a', 'b'], ['b', np.nan])
Out[109]:
   a  b  c
0  0  0  b
1  1  1  b
2  NaN NaN
3  NaN  d
```

list of regex -> list of regex:

```python
In [110]: df.replace([r'.', r'(a)'], ['dot', '{\1}stuff'], regex=True)
Out[110]:
   a  {stuff  c
0  0  {stuff
1  1  b  b
2  dot NaN
3  dot  d
```

Only search in column 'b' (dict -> dict):

```python
In [111]: df.replace({'b': '.'}, {'b': np.nan})
Out[111]:
   a  b  c
0  0  a  a
1  1  b  b
2  NaN NaN
3  NaN  d
```

Same as the previous example, but use a regular expression for searching instead (dict of regex -> dict):

```python
In [112]: df.replace({'b': r'\s*\s*'}, {'b': np.nan}, regex=True)
Out[112]:
   a  b  c
0  0  a  a
1  1  b  b
2  NaN NaN
3  NaN  d
```

You can pass nested dictionaries of regular expressions that use regex=True:

```python
In [113]: df.replace({'b': {'b': r'\s*\s*'}}, regex=True)
Out[113]:
   a  b  c
0  0  a  a
1  1  b  b
2  NaN NaN
3  NaN  d
```

Alternatively, you can pass the nested dictionary like so:

```
15.5. Cleaning / filling missing data 831
```
In [114]: df.replace(regex={'b': {r'\s*\.\s*': np.nan}})
Out[114]:
<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>NaN</td>
<td>d</td>
</tr>
</tbody>
</table>

You can also use the group of a regular expression match when replacing (dict of regex -> dict of regex), this works for lists as well.

In [115]: df.replace({'b': r'\s*(\.)\s*'}, {'b': r'\1ty'}, regex=True)
Out[115]:
<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>.ty</td>
<td>NaN</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>.ty</td>
<td>d</td>
</tr>
</tbody>
</table>

You can pass a list of regular expressions, of which those that match will be replaced with a scalar (list of regex -> regex).

In [116]: df.replace([r'\s*\.\s*', r'a|b'], np.nan, regex=True)
Out[116]:
<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>1</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>2</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>3</td>
<td>NaN</td>
<td>NaN</td>
<td>d</td>
</tr>
</tbody>
</table>

All of the regular expression examples can also be passed with the `to_replace` argument as the `regex` argument. In this case the `value` argument must be passed explicitly by name or `regex` must be a nested dictionary. The previous example, in this case, would then be:

```
In [117]: df.replace(regex=[r'\s*\.\s*', r'a|b'], value=np.nan)
Out[117]:
<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>1</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>2</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>3</td>
<td>NaN</td>
<td>NaN</td>
<td>d</td>
</tr>
</tbody>
</table>
```

This can be convenient if you do not want to pass `regex=True` every time you want to use a regular expression.

**Note:** Anywhere in the above `replace` examples that you see a regular expression a compiled regular expression is valid as well.

### 15.5.7 Numeric Replacement

`replace()` is similar to `fillna()`.

```
In [118]: df = pd.DataFrame(np.random.randn(10, 2))
In [119]: df[np.random.rand(df.shape[0]) > 0.5] = 1.5
```

(continues on next page)
In [120]: df.replace(1.5, np.nan)
Out[120]:
    0  1
0 -0.844214 -1.021415
1  0.432396 -0.323580
2  0.423825  0.799180
3  1.262614  0.751965
4  NaN    NaN
5  NaN    NaN
6 -0.498174 -1.060799
7  0.591667 -0.183257
8  1.019855 -1.482465
9  NaN    NaN

Replacing more than one value is possible by passing a list.

In [121]: df00 = df.values[0, 0]
In [122]: df.replace([1.5, df00], [np.nan, 'a'])
Out[122]:
    0  1
0  a  -1.02141
1  0.432396 -0.32358
2  0.423825  0.79918
3  1.26261  0.751965
4  NaN  NaN
5  NaN  NaN
6 -0.498174 -1.060799
7  0.591667 -0.183257
8  1.01985  -1.48247
9  NaN  NaN

In [123]: df[1].dtype
   ...
   -> dtype('float64')

You can also operate on the DataFrame in place:

In [124]: df.replace(1.5, np.nan, inplace=True)

Warning: When replacing multiple bool or datetime64 objects, the first argument to replace (to_replace) must match the type of the value being replaced. For example,

s = pd.Series([True, False, True])
s.replace({'a string': 'new value', True: False})  # raises

TypeError: Cannot compare types 'ndarray(dtype=bool)' and 'str'

will raise a TypeError because one of the dict keys is not of the correct type for replacement.

However, when replacing a single object such as,
15.6 Missing data casting rules and indexing

While pandas supports storing arrays of integer and boolean type, these types are not capable of storing missing data. Until we can switch to using a native NA type in NumPy, we’ve established some “casting rules”. When a reindexing operation introduces missing data, the Series will be cast according to the rules introduced in the table below.

<table>
<thead>
<tr>
<th>data type</th>
<th>Cast to</th>
</tr>
</thead>
<tbody>
<tr>
<td>integer</td>
<td>float</td>
</tr>
<tr>
<td>boolean</td>
<td>object</td>
</tr>
<tr>
<td>float</td>
<td>no cast</td>
</tr>
<tr>
<td>object</td>
<td>no cast</td>
</tr>
</tbody>
</table>

For example:

In [127]: s = pd.Series(np.random.randn(5), index=[0, 2, 4, 6, 7])

In [128]: s > 0
Out[128]:
0   True
2   True
4   True
6   True
7   True
dtype: bool

In [129]: (s > 0).dtype
Out[129]: dtype('bool')

In [130]: crit = (s > 0).reindex(list(range(8)))

In [131]: crit
Out[131]:
0   True
1   NaN
2   True
3   NaN
4   True
5   NaN
6   True

(continues on next page)
Ordinarily NumPy will complain if you try to use an object array (even if it contains boolean values) instead of a boolean array to get or set values from an ndarray (e.g. selecting values based on some criteria). If a boolean vector contains NAs, an exception will be generated:

```python
In [133]: reindexed = s.reindex(list(range(8))).fillna(0)
```
```
In [134]: reindexed[crit]
```
```
---------------------------------------------------------------------------
ValueError                      Traceback (most recent call last)
<ipython-input-134-0dac417a4890> in <module>()
----> 1 reindexed[crit]

~/sandbox/pandas-release/pandas-docs/pandas/core/series.py in __getitem__(self, key)
     805     key = list(key)
     806 --> 807     if com.is_bool_indexer(key):
     808         key = check_bool_indexer(self.index, key)
     809
~/sandbox/pandas-release/pandas-docs/pandas/core/common.py in is_bool_indexer(key)
     105         if not lib.is_bool_array(key):
     106             if isna(key).any():
--> 107                 raise ValueError('cannot index with vector containing 
     108                 'NA / NaN values')
     109             return False

ValueError: cannot index with vector containing NA / NaN values
```

However, these can be filled in using `fillna()` and it will work fine:

```python
In [135]: reindexed[crit.fillna(False)]
```
```
Out[135]:
0  0.126504
1  0.000000
2  0.697416
3  0.000000
4  0.000000
5  0.000000
6  0.601516
```
```
In [136]: reindexed[crit.fillna(True)]
```
```
Out[136]:
0  0.126504
1  0.000000
2  0.697416
3  0.000000
4  0.697416
5  0.000000
6  0.601516
```

(continues on next page)
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>0.003659</td>
<td></td>
</tr>
</tbody>
</table>

```
dtype: float64
```
GROUP BY: SPLIT-APPLY-COMBINE

By “group by” we are referring to a process involving one or more of the following steps:

- **Splitting** the data into groups based on some criteria.
- **Applying** a function to each group independently.
- **Combining** the results into a data structure.

Out of these, the split step is the most straightforward. In fact, in many situations we may wish to split the data set into groups and do something with those groups. In the apply step, we might wish to one of the following:

- **Aggregation**: compute a summary statistic (or statistics) for each group. Some examples:
  - Compute group sums or means.
  - Compute group sizes / counts.

- **Transformation**: perform some group-specific computations and return a like-indexed object. Some examples:
  - Standardize data (zscore) within a group.
  - Filling NAs within groups with a value derived from each group.

- **Filtration**: discard some groups, according to a group-wise computation that evaluates True or False. Some examples:
  - Discard data that belongs to groups with only a few members.
  - Filter out data based on the group sum or mean.

- Some combination of the above: GroupBy will examine the results of the apply step and try to return a sensibly combined result if it doesn’t fit into either of the above two categories.

Since the set of object instance methods on pandas data structures are generally rich and expressive, we often simply want to invoke, say, a DataFrame function on each group. The name GroupBy should be quite familiar to those who have used a SQL-based tool (or itertools), in which you can write code like:

```sql
SELECT Column1, Column2, mean(Column3), sum(Column4)
FROM SomeTable
GROUP BY Column1, Column2
```

We aim to make operations like this natural and easy to express using pandas. We’ll address each area of GroupBy functionality then provide some non-trivial examples / use cases.

See the *cookbook* for some advanced strategies.
16.1 Splitting an object into groups

Pandas objects can be split on any of their axes. The abstract definition of grouping is to provide a mapping of labels to group names. To create a GroupBy object (more on what the GroupBy object is later), you may do the following:

```python
# default is axis=0
>>> grouped = obj.groupby(key)
>>> grouped = obj.groupby(key, axis=1)
>>> grouped = obj.groupby([key1, key2])
```

The mapping can be specified many different ways:

- A Python function, to be called on each of the axis labels.
- A list or NumPy array of the same length as the selected axis.
- A dict or Series, providing a label -> group name mapping.
- For DataFrame objects, a string indicating a column to be used to group. Of course df.groupby('A') is just syntactic sugar for df.groupby(df['A']), but it makes life simpler.
- For DataFrame objects, a string indicating an index level to be used to group.
- A list of any of the above things.

Collectively we refer to the grouping objects as the keys. For example, consider the following DataFrame:

```python
In [1]: df = pd.DataFrame({'A': ['foo', 'bar', 'foo', 'bar',
                   'foo', 'bar', 'foo', 'foo'],
                   'B': ['one', 'one', 'two', 'three',
                   'two', 'two', 'one', 'three'],
                   'C': np.random.randn(8),
                   'D': np.random.randn(8))
```

```
In [2]: df
Out[2]:
     A  B         C         D
0  foo  one  0.469112 -0.861849
1  bar  one  0.282863 -2.104569
2  foo  two  1.509059  0.494929
3  bar  three  1.35632  1.071804
4  foo  two  1.212112  0.721555
5  bar  two  0.173215  0.706771
6  foo  one  0.119209  0.271860
7  foo  three -1.044236  0.271860
```

On a DataFrame, we obtain a GroupBy object by calling `groupby()`. We could naturally group by either the A or B columns, or both:
These will split the DataFrame on its index (rows). We could also split by the columns:

```python
In [5]: def get_letter_type(letter):
    ...:     if letter.lower() in 'aeiou':
    ...:         return 'vowel'
    ...:     else:
    ...:         return 'consonant'
    ...

In [6]: grouped = df.groupby(get_letter_type, axis=1)
```

pandas `Index` objects support duplicate values. If a non-unique index is used as the group key in a `groupby` operation, all values for the same index value will be considered to be in one group and thus the output of aggregation functions will only contain unique index values:

```python
In [7]: lst = [1, 2, 3, 1, 2, 3]

In [8]: s = pd.Series([1, 2, 3, 10, 20, 30], lst)

In [9]: grouped = s.groupby(level=0)

In [10]: grouped.first()
Out[10]:
   1  1
   2  2
   3  3
   dtype: int64

In [11]: grouped.last()
Out[11]:
   1 10
   2 20
   3 30
   dtype: int64

In [12]: grouped.sum()
Out[12]:
   1 11
   2 22
   3 33
   dtype: int64
```

Note that no splitting occurs until it’s needed. Creating the GroupBy object only verifies that you’ve passed a valid mapping.

**Note:** Many kinds of complicated data manipulations can be expressed in terms of GroupBy operations (though can’t be guaranteed to be the most efficient). You can get quite creative with the label mapping functions.
16.1.1 GroupBy sorting

By default the group keys are sorted during the `groupby` operation. You may however pass `sort=False` for potential speedups:

```python
In [13]: df2 = pd.DataFrame({'X' : ['B', 'B', 'A', 'A'], 'Y' : [1, 2, 3, 4]})
In [14]: df2.groupby(['X']).sum()
Out[14]:
     Y
X    
A    7
B    3
In [15]: df2.groupby(['X'], sort=False).sum()
Out[15]:
     Y
X    
B    3
A    7
```

Note that `groupby` will preserve the order in which `observations` are sorted within each group. For example, the groups created by `groupby()` below are in the order they appeared in the original DataFrame:

```python
In [16]: df3 = pd.DataFrame({'X' : ['A', 'B', 'A', 'B'], 'Y' : [1, 4, 3, 2]})
In [17]: df3.groupby(['X']).get_group('A')
Out[17]:
     X  Y
0    A  1
2    A  3
In [18]: df3.groupby(['X']).get_group('B')
Out[18]:
     X  Y
1    B  4
3    B  2
```

16.1.2 GroupBy object attributes

The `groups` attribute is a dict whose keys are the computed unique groups and corresponding values being the axis labels belonging to each group. In the above example we have:

```python
In [19]: df.groupby('A').groups
Out[19]:
{'bar': Int64Index([1, 3, 5], dtype='int64'),
 'foo': Int64Index([0, 2, 4, 6, 7], dtype='int64')}
In [20]: df.groupby(get_letter_type, axis=1).groups
Out[20]:
{'consonant': Index(['B', 'C', 'D'], dtype='object'),
 'vowel': Index(['A'], dtype='object')}
```

Calling the standard Python `len` function on the GroupBy object just returns the length of the `groups` dict, so it is largely just a convenience:
```python
In [21]: grouped = df.groupby(['A', 'B'])

In [22]: grouped.groups
Out[22]:
{('bar', 'one'): Int64Index([1], dtype='int64'),
 ('bar', 'three'): Int64Index([3], dtype='int64'),
 ('bar', 'two'): Int64Index([5], dtype='int64'),
 ('foo', 'one'): Int64Index([0, 6], dtype='int64'),
 ('foo', 'three'): Int64Index([7], dtype='int64'),
 ('foo', 'two'): Int64Index([2, 4], dtype='int64')}

In [23]: len(grouped)
Out[23]:
6
```

GroupBy will tab complete column names (and other attributes):

```python
In [24]: df
Out[24]:
height  weight  gender
2000-01-01 42.849980 157.500553  male
2000-01-02 49.607315 177.340407  male
2000-01-03 56.293531 171.524640  male
2000-01-04 48.421077 144.251986  female
2000-01-05 46.556882 152.526206  male
2000-01-06 68.448851 168.272968  female
2000-01-07 70.757698 136.431469  male
2000-01-08 58.909500 176.499753  female
2000-01-09 76.435631 174.094104  female
2000-01-10 45.306120 177.540920  male

In [25]: gb = df.groupby('gender')

In [26]: gb.
```

16.1.3 GroupBy with MultiIndex

With **hierarchically-indexed data**, it’s quite natural to group by one of the levels of the hierarchy.

Let’s create a Series with a two-level MultiIndex.

```python
In [27]: arrays = [['bar', 'bar', 'baz', 'baz', 'foo', 'foo', 'qux', 'qux'],
               ['one', 'two', 'one', 'two', 'one', 'two', 'one', 'two']]

In [28]: index = pd.MultiIndex.from_arrays(arrays, names=['first', 'second'])
```

(continues on next page)
We can then group by one of the levels in `s`.

```
In [31]: grouped = s.groupby(level=0)
```

```
In [32]: grouped.sum()
```

```
Out[32]:
   first
bar  one   -0.962232
     two   0.962232
baz  one    1.237723
     two  -0.067723
foo  one   0.785980
     two  -0.945867
qux  one   1.911055
     two  0.136294

dtype: float64
```

If the MultiIndex has names specified, these can be passed instead of the level number:

```
In [33]: s.groupby(level='second').sum()
```

```
Out[33]:
   second
one  0.980950
two  1.991575

dtype: float64
```

The aggregation functions such as `sum` will take the level parameter directly. Additionally, the resulting index will be named according to the chosen level:

```
In [34]: s.sum(level='second')
```

```
Out[34]:
   second
one  0.980950
two  1.991575

dtype: float64
```

Grouping with multiple levels is supported.

```
In [35]: s
```

```
Out[35]:
   first   second   third
bar  doo one -1.131345
     two  0.089329
baz  bee one  0.337863
     two -0.945867
```

(continues on next page)
foo  bop  one  -0.932132
     two  1.956030
qux  bop  one  0.017587
     two -0.016692
dtype: float64

In [36]: s.groupby(level=['first', 'second']).sum()

         first second
bar     doo  -1.220674
baz     bee  -0.608004
foo     bop   1.023898
qux     bop   0.000895
dtype: float64

New in version 0.20.

Index level names may be supplied as keys.

In [37]: s.groupby(['first', 'second']).sum()

Out[37]:
first second
bar     doo  -1.220674
baz     bee  -0.608004
foo     bop   1.023898
qux     bop   0.000895
dtype: float64

More on the sum function and aggregation later.

16.1.4 Grouping DataFrame with Index Levels and Columns

A DataFrame may be grouped by a combination of columns and index levels by specifying the column names as strings and the index levels as pd.Grouper objects.

In [38]: arrays = [['bar', 'bar', 'baz', 'baz', 'foo', 'foo', 'qux', 'qux'],
               ['one', 'two', 'one', 'two', 'one', 'two', 'one', 'two']]
In [39]: index = pd.MultiIndex.from_arrays(arrays, names=['first', 'second'])

In [40]: df = pd.DataFrame({'A': [1, 1, 1, 1, 2, 2, 3, 3],
                   'B': np.arange(8)},
                   index=index)

In [41]: df
Out[41]:
    A  B
first second
bar one  1  0
     two  1  1
baz one  1  2
     two  1  3

(continues on next page)
The following example groups `df` by the `second` index level and the `A` column.

```python
In [42]: df.groupby([pd.Grouper(level='second'), 'A']).sum()
Out[42]:
         B
second A
  one  1  2
        2  4
        3  6
  two  1  4
        2  5
        3  7
```

Index levels may also be specified by name.

```python
In [43]: df.groupby([pd.Grouper(level='second'), 'A']).sum()
Out[43]:
         B
second A
  one  1  2
        2  4
        3  6
  two  1  4
        2  5
        3  7
```

New in version 0.20.

Index level names may be specified as keys directly to `groupby`.

```python
In [44]: df.groupby(['second', 'A']).sum()
Out[44]:
         B
second A
  one  1  2
        2  4
        3  6
  two  1  4
        2  5
        3  7
```

### 16.1.5 DataFrame column selection in GroupBy

Once you have created the `GroupBy` object from a DataFrame, you might want to do something different for each of the columns. Thus, using `[]` similar to getting a column from a DataFrame, you can do:

```python
In [45]: grouped = df.groupby(['A'])
In [46]: grouped_C = grouped['C']
In [47]: grouped_D = grouped['D']
```
This is mainly syntactic sugar for the alternative and much more verbose:

```python
In [48]: df['C'].groupby(df['A'])
Out[48]: <pandas.core.groupby.groupby.SeriesGroupBy object at 0x1c2adc8390>
```

Additionally this method avoids recomputing the internal grouping information derived from the passed key.

### 16.2 Iterating through groups

With the GroupBy object in hand, iterating through the grouped data is very natural and functions similarly to `itertools.groupby()`:

```python
In [49]: grouped = df.groupby('A')
In [50]: for name, group in grouped:
    ....:     print(name)
    ....:     print(group)
    ....:
bar
   A  B   C    D
  1 bar one 0.254161 1.511763
  3 bar three 0.215897 -0.990582
  5 bar two -0.077118 1.211526
foo
   A  B   C    D
  0 foo one -0.575247 1.346061
  2 foo two -1.143704 1.627081
  4 foo two 1.193555 -0.441652
  6 foo one -0.408530 0.268520
  7 foo three -0.862495 0.024580
```

In the case of grouping by multiple keys, the group name will be a tuple:

```python
In [51]: for name, group in df.groupby(['A', 'B']):
    ....:     print(name)
    ....:     print(group)
    ....:
('bar', 'one')
   A  B   C    D
  1 bar one 0.254161 1.511763
('bar', 'three')
   A  B   C    D
  3 bar three 0.215897 -0.990582
('bar', 'two')
   A  B   C    D
  5 bar two -0.077118 1.211526
('foo', 'one')
   A  B   C    D
  0 foo one -0.575247 1.346061
('foo', 'three')
   A  B   C    D
  6 foo one -0.408530 0.268520
('foo', 'two')
   A  B   C    D
  7 foo three -0.862495 0.024580
```

(continues on next page)
It’s standard Python-fu but remember you can unpack the tuple in the for loop statement if you wish: for (k1, k2), group in grouped:

### 16.3 Selecting a group

A single group can be selected using `get_group()`:

```python
In [52]: grouped.get_group('bar')
Out[52]:
    A     B      C      D
   --- ---- ---- ----
  1 bar one  0.254  1.511763
  3 bar three 0.215897  0.990582
  5 bar two -0.077118  1.211526
```

Or for an object grouped on multiple columns:

```python
In [53]: df.groupby([A, B]).get_group(('bar', 'one'))
Out[53]:
    A     B      C      D
   --- ---- ---- ----
  1 bar one  0.254  1.511763
```

### 16.4 Aggregation

Once the GroupBy object has been created, several methods are available to perform a computation on the grouped data. These operations are similar to the aggregating API, window functions API, and resample API.

An obvious one is aggregation via the `aggregate()` or equivalently `agg()` method:

```python
In [54]: grouped = df.groupby('A')
In [55]: grouped.aggregate(np.sum)
Out[55]:
   C      D
  --- ----
  bar 0.392940 1.732707
  foo -1.796421 2.824590
```

```python
In [56]: grouped = df.groupby([A, B])
In [57]: grouped.aggregate(np.sum)
Out[57]:
    A     B      C      D
   --- ---- ---- ----
  bar one 0.254161 1.511763
  three 0.215897  0.990582
  two  -0.077118  1.211526
  foo one -0.983776  1.614581
  three -0.862495   0.024580
  two   0.049851  1.185429
```
As you can see, the result of the aggregation will have the group names as the new index along the grouped axis. In the case of multiple keys, the result is a `MultiIndex` by default, though this can be changed by using the `as_index` option:

```python
In [58]: grouped = df.groupby(['A', 'B'], as_index=False)

In [59]: grouped.aggregate(np.sum)
Out[59]:
   A   B    C      D
0  bar  one  0.254161  1.511763
1  bar  three  0.215897  0.990582
2  bar  two  -0.077118  1.211526
3  foo  one  -0.983776  1.614581
4  foo  three  -0.862495  0.024580
5  foo  two   0.049851  1.185429
```

```python
In [60]: df.groupby('A', as_index=False).sum()

Out[60]:
   A   C      D
0  bar  0.392940  1.732707
1  foo -1.796421  2.824590
```

Note that you could use the `reset_index` DataFrame function to achieve the same result as the column names are stored in the resulting `MultiIndex`:

```python
In [61]: df.groupby(['A', 'B']).sum().reset_index()
Out[61]:
    A   B    C      D
0  bar  one  0.254161  1.511763
1  bar  three  0.215897  0.990582
2  bar  two  -0.077118  1.211526
3  foo  one  -0.983776  1.614581
4  foo  three  -0.862495  0.024580
5  foo  two   0.049851  1.185429
```

Another simple aggregation example is to compute the size of each group. This is included in GroupBy as the `size` method. It returns a Series whose index are the group names and whose values are the sizes of each group.

```python
In [62]: grouped.size()
Out[62]:
    A   B
   bar one 1
    three 1
    two  1
   foo one 2
    three 1
    two  2
dtype: int64
```

```python
In [63]: grouped.describe()
Out[63]:
     C     ...      D
   ...   ...     ...
   count  mean     std    min  25% ...    min  25%  50%  ...  75%  max
   ...  75%    max
   0  1.0  0.254161  NaN  0.254161  0.254161 ...  1.511763  1.511763  1.511763  1.511763
```

(continues on next page)
Aggregating functions are the ones that reduce the dimension of the returned objects. Some common aggregating functions are tabulated below:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean()</td>
<td>Compute mean of groups</td>
</tr>
<tr>
<td>sum()</td>
<td>Compute sum of group values</td>
</tr>
<tr>
<td>size()</td>
<td>Compute group sizes</td>
</tr>
<tr>
<td>count()</td>
<td>Compute count of group</td>
</tr>
<tr>
<td>std()</td>
<td>Standard deviation of groups</td>
</tr>
<tr>
<td>var()</td>
<td>Compute variance of groups</td>
</tr>
<tr>
<td>sem()</td>
<td>Standard error of the mean of groups</td>
</tr>
<tr>
<td>describe()</td>
<td>Generates descriptive statistics</td>
</tr>
<tr>
<td>first()</td>
<td>Compute first of group values</td>
</tr>
<tr>
<td>last()</td>
<td>Compute last of group values</td>
</tr>
<tr>
<td>nth()</td>
<td>Take nth value, or a subset if n is a list</td>
</tr>
<tr>
<td>min()</td>
<td>Compute min of group values</td>
</tr>
<tr>
<td>max()</td>
<td>Compute max of group values</td>
</tr>
</tbody>
</table>

The aggregating functions above will exclude NA values. Any function which reduces a `Series` to a scalar value is an aggregation function and will work, a trivial example is `df.groupby('A').agg(lambda x: x)` Note that `nth()` can act as a reducer or a filter, see [here](#).

### 16.4.1 Applying multiple functions at once

With grouped `Series` you can also pass a list or dict of functions to do aggregation with, outputting a DataFrame:

```python
In [64]: grouped = df.groupby('A')

In [65]: grouped['C'].agg([np.sum, np.mean, np.std])
Out[65]:
          sum   mean   std
A
```

(continues on next page)
On a grouped DataFrame, you can pass a list of functions to apply to each column, which produces an aggregated result with a hierarchical index:

```python
In [66]: grouped.agg([np.sum, np.mean, np.std])
Out[66]:
          C          D
    sum  mean  std   sum  mean  std
   A  
    bar  0.392940  0.130980  0.181231  1.732707  0.577569  1.366330
    foo -1.796421 -0.359284  0.912265  2.824590  0.564918  0.884785
```

The resulting aggregations are named for the functions themselves. If you need to rename, then you can add in a chained operation for a Series like this:

```python
In [67]: (grouped['C'].agg([np.sum, np.mean, np.std])
       .rename(columns={'sum': 'foo',
                        'mean': 'bar',
                        'std': 'baz'}))
Out[67]:
          foo  bar  baz
   A  
    bar  0.392940  0.130980  0.181231
    foo -1.796421 -0.359284  0.912265
```

For a grouped DataFrame, you can rename in a similar manner:

```python
In [68]: (grouped.agg({np.sum, np.mean, np.std})
       .rename(columns={'sum': 'foo',
                        'mean': 'bar',
                        'std': 'baz'}))
Out[68]:
          C          D
    foo  bar  baz   foo  bar  baz
   A  
    bar  0.392940  0.130980  0.181231  1.732707  0.577569  1.366330
    foo -1.796421 -0.359284  0.912265  2.824590  0.564918  0.884785
```

### 16.4.2 Applying different functions to DataFrame columns

By passing a dict to `aggregate` you can apply a different aggregation to the columns of a DataFrame:

```python
In [69]: grouped.agg({'C': np.sum, 'D': lambda x: np.std(x, ddof=1)})
Out[69]:
          C          D
   A  
    bar  0.392940  0.130980  0.181231  1.732707  0.577569  1.366330
    foo -1.796421 -0.359284  0.912265  2.824590  0.564918  0.884785
```
The function names can also be strings. In order for a string to be valid it must be either implemented on GroupBy or available via dispatching:

```python
In [70]: grouped.agg({'C' : 'sum', 'D' : 'std'})
Out[70]:
   C       D
   A  0.392940  1.366330
   bar  0.392940  1.366330
   foo -1.796421  0.884785
```

**Note:** If you pass a dict to `aggregate`, the ordering of the output columns is non-deterministic. If you want to be sure the output columns will be in a specific order, you can use an `OrderedDict`. Compare the output of the following two commands:

```python
In [71]: grouped.agg({'D': 'std', 'C': 'mean'})
Out[71]:
   D       C
   A  1.366330  0.130980
   bar  1.366330  0.130980
   foo  0.884785 -0.359284

In [72]: grouped.agg(OrderedDict([('D', 'std'), ('C', 'mean')]))
```

### 16.4.3 Cython-optimized aggregation functions

Some common aggregations, currently only `sum`, `mean`, `std`, and `sem`, have optimized Cython implementations:

```python
In [73]: df.groupby('A').sum()
Out[73]:
   C       D
   A  0.392940  1.732707
   bar  0.392940  1.732707
   foo -1.796421  2.824590

In [74]: df.groupby(['A', 'B']).mean()
```

(continues on next page)
Of course `sum` and `mean` are implemented on pandas objects, so the above code would work even without the special versions via dispatching (see below).

## 16.5 Transformation

The `transform` method returns an object that is indexed the same (same size) as the one being grouped. The transform function must:

- Return a result that is either the same size as the group chunk or broadcastable to the size of the group chunk (e.g., a scalar, `grouped.transform(lambda x: x.iloc[-1])`).
- Operate column-by-column on the group chunk. The transform is applied to the first group chunk using `chunk.apply`.
- Not perform in-place operations on the group chunk. Group chunks should be treated as immutable, and changes to a group chunk may produce unexpected results. For example, when using `fillna`, `inplace` must be `False` (`grouped.transform(lambda x: x.fillna(inplace=False))`).
- (Optionally) operates on the entire group chunk. If this is supported, a fast path is used starting from the second chunk.

For example, suppose we wished to standardize the data within each group:

```python
In [75]: index = pd.date_range('10/1/1999', periods=1100)
In [76]: ts = pd.Series(np.random.normal(0.5, 2, 1100), index)
In [77]: ts = ts.rolling(window=100,min_periods=100).mean().dropna()
In [78]: ts.head()
Out[78]:
2000-01-08  0.779333
2000-01-09  0.778852
2000-01-10  0.786476
2000-01-11  0.782797
2000-01-12  0.798110
Freq: D, dtype: float64
In [79]: ts.tail()
Out[79]:
2002-09-30  0.660294
2002-10-01  0.631095
2002-10-02  0.673601
2002-10-03  0.709213
2002-10-04  0.719369
Freq: D, dtype: float64
```

```python
In [80]: key = lambda x: x.year
In [81]: zscore = lambda x: (x - x.mean()) / x.std()
In [82]: transformed = ts.groupby(key).transform(zscore)
```
We would expect the result to now have mean 0 and standard deviation 1 within each group, which we can easily check:

```python
# Original Data
In [83]: grouped = ts.groupby(key)

In [84]: grouped.mean()
Out[84]:
2000  0.442441
2001  0.526246
2002  0.459365
dtype: float64

In [85]: grouped.std()
Out[85]:
2000  0.131752
2001  0.210945
2002  0.128753
dtype: float64

# Transformed Data
In [86]: grouped_trans = transformed.groupby(key)

In [87]: grouped_trans.mean()
Out[87]:
2000  1.168208e-15
2001  1.454544e-15
2002  1.726657e-15
dtype: float64

In [88]: grouped_trans.std()
Out[88]:
2000  1.0
2001  1.0
2002  1.0
dtype: float64
```

We can also visually compare the original and transformed data sets.

```python
In [89]: compare = pd.DataFrame({'Original': ts, 'Transformed': transformed})

In [90]: compare.plot()
Out[90]: <matplotlib.axes._subplots.AxesSubplot at 0x1c2ad9db38>
```
Transformation functions that have lower dimension outputs are broadcast to match the shape of the input array.

```
In [91]: data_range = lambda x: x.max() - x.min()

In [92]: ts.groupby(key).transform(data_range)
Out[92]:
       2000-01-08  0.623893
       2000-01-09  0.623893
       2000-01-10  0.623893
       2000-01-11  0.623893
       2000-01-12  0.623893
       2000-01-13  0.623893
       2000-01-14  0.623893
       ...
       2002-09-28  0.558275
       2002-09-29  0.558275
       2002-09-30  0.558275
       2002-10-01  0.558275
       2002-10-02  0.558275
       2002-10-03  0.558275
       2002-10-04  0.558275
Freq: D, Length: 1001, dtype: float64
```

Alternatively the built-in methods can be used to produce the same outputs.
Another common data transform is to replace missing data with the group mean.

In [94]: data_df
Out[94]:
   A      B      C
0  1.539708 -1.166480  0.533026
1  1.302092 -0.505754  NaN
2 -0.371983  1.104803 -0.651520
3 -1.309622  1.118697 -1.161657
4 -1.924296  0.396437  0.812436
5  0.815643  0.367816 -0.469478
6 -0.030651  1.376106 -0.645129
...       ...       ...
993  0.012359  0.554602 -1.976159
994  0.042312 -1.628835  1.013822
995 -0.093110  0.683847 -0.774753
996 -0.185043  1.438572  NaN
997 -0.394469 -0.642343  0.011374
998 -1.174126  1.857148  NaN
999  0.234564  0.517098  0.393534

[1000 rows x 3 columns]

In [95]: countries = np.array(['US', 'UK', 'GR', 'JP'])

In [96]: key = countries[np.random.randint(0, 4, 1000)]

In [97]: grouped = data_df.groupby(key)

# Non-NA count in each group
In [98]: grouped.count()
Out[98]:
   A  B  C
GR 209 217 189
JP 240 255 217
UK 216 231 193
US 239 250 217

(continues on next page)
We can verify that the group means have not changed in the transformed data and that the transformed data contains no NAs.

```python
In [101]: grouped_trans = transformed.groupby(key)

In [102]: grouped.mean()  # original group means
Out[102]:
   A      B      C
GR -0.098371 -0.015420  0.068053
JP  0.069025  0.023100 -0.077324
UK  0.034069 -0.052580 -0.116525
US  0.058664 -0.020399  0.028603

In [103]: grouped_trans.mean()  # transformation did not change group means
    →
   A      B      C
GR -0.098371 -0.015420  0.068053
JP  0.069025  0.023100 -0.077324
UK  0.034069 -0.052580 -0.116525
US  0.058664 -0.020399  0.028603

In [104]: grouped.count()  # original has some missing data points
    →
   A    B    C
GR 209 217 189
JP 240 255 217
UK 216 231 193
US 239 250 217

In [105]: grouped_trans.count()  # counts after transformation
    →
   A    B    C
GR 228 228 228
JP 267 267 267
UK 247 247 247
US 258 258 258

In [106]: grouped_trans.size()  # Verify non-NA count equals group size
    →
   GR 228
   JP 267
   UK 247
   US 258
dtype: int64
```

Note: Some functions will automatically transform the input when applied to a GroupBy object, but returning an object of the same shape as the original. Passing `as_index=False` will not affect these transformation methods.
For example: `fillna, ffill, bfill, shift`.

```
In [107]: grouped.ffill()
Out[107]:
   NaN    A      B      C
0  NaN  1.54  -1.17   0.53
1  US   1.30  -0.51   0.53
2  US  -0.37  1.10  -0.65
3  JP  -1.31  1.12  -1.16
4  JP  -1.92  0.39  0.81
5  US   0.81  0.37  -0.46
6  GR  -0.03  1.37  -0.65
...  ...  ...  ...  ...
993 US   0.01  0.55  -1.97
994 GR   0.04  1.62  1.01
995 JP  -0.09  0.68  -0.77
996 JP  -0.18  1.43  -0.77
997 GR  -0.39  0.64  0.01
998 JP  -1.17  1.85  -0.77
999 UK   0.23  0.51  0.39
[1000 rows x 4 columns]
```

### 16.5.1 New syntax to window and resample operations

New in version 0.18.1.

Working with the resample, expanding or rolling operations on the groupby level used to require the application of helper functions. However, now it is possible to use `resample()`, `expanding()` and `rolling()` as methods on groupby.

The example below will apply the `rolling()` method on the samples of the column B based on the groups of column A.

```
     ...:                     'B': np.arange(20)})
     ...
In [109]: df_re
Out[109]:
   A  B
0  1  0
1  1  1
2  2  2
3  3  3
4  4  4
5  5  5
6  6  6
... ...
13  5 13
14  5 14
15  5 15
16  5 16
17  5 17
18  5 18
19  5 19
```

(continues on next page)
In [110]: df_re.groupby('A').rolling(4).B.mean()

A
1  0   NaN
1  1   NaN
2  2   1.5
3  3   2.5
4  4   3.5
5  5   4.5
... ...
5 13 11.5
14 12.5
15 13.5
16 14.5
17 15.5
18 16.5
19 17.5
Name: B, Length: 20, dtype: float64

The `expanding()` method will accumulate a given operation (sum() in the example) for all the members of each particular group.

In [111]: df_re.groupby('A').expanding().sum()

Out[111]:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1.0 0.0</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>3.0</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>4.0 6.0</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>5.0 10.0</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>6.0 15.0</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>7.0 21.0</td>
</tr>
</tbody>
</table>
... ... ...
| 5 | 13 | 20.0 46.0 |
| 14 | 25.0 60.0 |
| 15 | 30.0 75.0 |
| 16 | 35.0 91.0 |
| 17 | 40.0 108.0 |
| 18 | 45.0 126.0 |
| 19 | 50.0 145.0 |

[20 rows x 2 columns]

Suppose you want to use the `resample()` method to get a daily frequency in each group of your dataframe and wish to complete the missing values with the `ffill()` method.

In [112]: df_re = pd.DataFrame({'date': pd.date_range(start='2016-01-01',
                          .....: period=4,
                          .....: freq='W'),
                          .....: 'group': [1, 1, 2, 2],
                          .....: 'group': [1, 1, 2, 2],
                          .....: })

...
......:
......:
'dval': [5, 6, 7, 8]).set_index('date')

In [113]: df_re
Out[113]:
group  val
date
2016-01-03 1 5
2016-01-10 1 6
2016-01-17 2 7
2016-01-24 2 8

In [114]: df_re.groupby('group').resample('1D').ffill()

16.6 Filtration

The filter method returns a subset of the original object. Suppose we want to take only elements that belong to groups with a group sum greater than 2.

In [115]: sf = pd.Series([1, 1, 2, 3, 3, 3])

In [116]: sf.groupby(sf).filter(lambda x: x.sum() > 2)
Out[116]:
3 3
4 3
5 3
dtype: int64

The argument of filter must be a function that, applied to the group as a whole, returns True or False. Another useful operation is filtering out elements that belong to groups with only a couple members.
In [117]: dff = pd.DataFrame({'A': np.arange(8), 'B': list('aabbbbcc'))

In [118]: dff.groupby('B').filter(lambda x: len(x) > 2)

Out[118]:
   A  B
0  2 b
1  3 b
2  4 b
3  5 b

Alternatively, instead of dropping the offending groups, we can return a like-indexed objects where the groups that do not pass the filter are filled with NaNs.

In [119]: dff.groupby('B').filter(lambda x: len(x) > 2, dropna=False)

Out[119]:
   A  B     
0 NaN NaN
1 NaN NaN
2  2.0 b
3  3.0 b
4  4.0 b
5  5.0 b
6 NaN NaN
7 NaN NaN

For DataFrames with multiple columns, filters should explicitly specify a column as the filter criterion.

In [120]: dff['C'] = np.arange(8)

In [121]: dff.groupby('B').filter(lambda x: len(x['C']) > 2)

Out[121]:
   A  B  C
0  0 a 0
1  1 a 1
2  2 b 2
3  3 b 3
4  4 b 4
5  5 b 5

**Note:** Some functions when applied to a groupby object will act as a filter on the input, returning a reduced shape of the original (and potentially eliminating groups), but with the index unchanged. Passing `as_index=False` will not affect these transformation methods.

For example: head, tail.

In [122]: dff.groupby('B').head(2)

Out[122]:
   A  B  C
0  0 a 0
1  1 a 1
2  2 b 2
3  3 b 3
4  4 b 4
5  5 b 5
16.7 Dispatching to instance methods

When doing an aggregation or transformation, you might just want to call an instance method on each data group. This is pretty easy to do by passing lambda functions:

```
In [123]: grouped = df.groupby('A')
```

```
In [124]: grouped.agg(lambda x: x.std())
Out[124]:
        C       D
A
bar  0.181231  1.366330
foo  0.912265  0.884785
```

But, it’s rather verbose and can be untidy if you need to pass additional arguments. Using a bit of metaprogramming cleverness, GroupBy now has the ability to “dispatch” method calls to the groups:

```
In [125]: grouped.std()
Out[125]:
        C       D
A
bar  0.181231  1.366330
foo  0.912265  0.884785
```

What is actually happening here is that a function wrapper is being generated. When invoked, it takes any passed arguments and invokes the function with any arguments on each group (in the above example, the `std` function). The results are then combined together much in the style of `agg` and `transform` (it actually uses `apply` to infer the gluing, documented next). This enables some operations to be carried out rather succinctly:

```
In [126]: tsdf = pd.DataFrame(np.random.randn(1000, 3),
......:          index=pd.date_range('1/1/2000', periods=1000),
......:          columns=['A', 'B', 'C'])
```

```
In [127]: tsdf.iloc[::2] = np.nan
```

```
In [128]: grouped = tsdf.groupby(lambda x: x.year)
```

```
In [129]: grouped.fillna(method='pad')
Out[129]:
           A       B       C
2000-01-01 NaN     NaN     NaN
2000-01-02 0.353501 0.080957 0.876864
2000-01-03 0.353501 0.080957 0.876864
2000-01-04 0.050976 0.044273 0.559849
2000-01-05 0.050976 0.044273 0.559849
2000-01-06 0.030091 0.186460 0.680149
2000-01-07 0.030091 0.186460 0.680149
......       ......       ......
2002-09-20 2.310215 0.157482 0.064476
2002-09-21 2.310215 0.157482 0.064476
2002-09-22 0.005011 0.053897 1.026922
2002-09-23 0.005011 0.053897 1.026922
2002-09-24 -0.456542 1.849051 1.559856
2002-09-25 -0.456542 1.849051 1.559856
2002-09-26 1.123162 0.354660 1.128135
```

(continues on next page)
In this example, we chopped the collection of time series into yearly chunks then independently called `fillna` on the groups.

The `nlargest` and `nsmallest` methods work on `Series` style groupbys:

```
In [130]: s = pd.Series([9, 8, 7, 5, 19, 1, 4.2, 3.3])
In [131]: g = pd.Series(list('abababab'))
In [132]: gb = s.groupby(g)
In [133]: gb.nlargest(3)
Out[133]:
   a  4  19.0
      0  9.0
      2  7.0
   b  1  8.0
      3  5.0
      7  3.3
dtype: float64
```

```
In [134]: gb.nsmallest(3)
Out[134]:
   ->
   a  6  4.2
      2  7.0
      0  9.0
   b  5  1.0
      7  3.3
      3  5.0
dtype: float64
```

### 16.8 Flexible apply

Some operations on the grouped data might not fit into either the aggregate or transform categories. Or, you may simply want `GroupBy` to infer how to combine the results. For these, use the `apply` function, which can be substituted for both `aggregate` and `transform` in many standard use cases. However, `apply` can handle some exceptional use cases, for example:

```
In [135]: df
Out[135]:
   A    B      C    D
  0 foo   one -0.575247 1.346061
  1 bar   one  0.254161 1.511763
  2 foo   two -1.143704 1.627081
  3 bar   three  0.215897 -0.990582
  4 foo   two  1.193555 -0.441652
  5 bar   two -0.077118 1.211526
  6 foo   one  -0.408530 0.268520
  7 foo   three -0.862495  0.024580
```
pandas: powerful Python data analysis toolkit, Release 0.23.2

In [136]: grouped = df.groupby('A')

# could also just call .describe()
In [137]: grouped['C'].apply(lambda x: x.describe())

Out[137]:

<table>
<thead>
<tr>
<th></th>
<th>bar</th>
<th>count</th>
<th>mean</th>
<th>std</th>
<th>min</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.000000</td>
<td>0.130980</td>
<td>0.181231</td>
<td>-0.077118</td>
<td>0.069390</td>
<td>0.215897</td>
<td>0.235029</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>foo</td>
<td>-0.359284</td>
<td>0.912265</td>
<td>-1.143704</td>
<td>-0.862495</td>
<td>-0.575247</td>
<td>-0.408530</td>
<td>1.193555</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The dimension of the returned result can also change:

In [138]: grouped = df.groupby('A')['C']

In [139]: def f(group):
       .....:     return pd.DataFrame({'original': group,'demeaned': group - group.mean()})
       .....:

In [140]: grouped.apply(f)

Out[140]:

<table>
<thead>
<tr>
<th></th>
<th>original</th>
<th>demeaned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 -0.575247</td>
<td>-0.215962</td>
</tr>
<tr>
<td></td>
<td>1 0.254161</td>
<td>0.123181</td>
</tr>
<tr>
<td></td>
<td>2 -1.143704</td>
<td>-0.784420</td>
</tr>
<tr>
<td></td>
<td>3 0.215897</td>
<td>0.084917</td>
</tr>
<tr>
<td></td>
<td>4 1.193555</td>
<td>1.552839</td>
</tr>
<tr>
<td></td>
<td>5 -0.077118</td>
<td>-0.208098</td>
</tr>
<tr>
<td></td>
<td>6 -0.408530</td>
<td>-0.049245</td>
</tr>
<tr>
<td></td>
<td>7 -0.862495</td>
<td>-0.503211</td>
</tr>
</tbody>
</table>

apply on a Series can operate on a returned value from the applied function, that is itself a series, and possibly upcast the result to a DataFrame:

In [141]: def f(x):
       .....:     return pd.Series([ x, x**2 ], index = ['x', 'x^2'])
       .....:

In [142]: s

Out[142]:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>9.0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>7.0</td>
<td></td>
</tr>
</tbody>
</table>
3  5.0
4  19.0
5  1.0
6  4.2
7  3.3
dtype: float64

In [143]: s.apply(f)
\  
\  x  x^2
\  0  9.0  81.00
\  1  8.0  64.00
\  2  7.0  49.00
\  3  5.0  25.00
\  4  19.0  361.00
\  5  1.0  1.00
\  6  4.2  17.64
\  7  3.3  10.89

Note: apply can act as a reducer, transformer, or filter function, depending on exactly what is passed to it. So depending on the path taken, and exactly what you are grouping. Thus the grouped columns(s) may be included in the output as well as set the indices.

Warning: In the current implementation apply calls func twice on the first group to decide whether it can take a fast or slow code path. This can lead to unexpected behavior if func has side-effects, as they will take effect twice for the first group.

In [144]: d = pd.DataFrame({"a": ["x", "y"], "b": [1, 2]})

In [145]: def identity(df):
   .....:
   ......:  print(df)
   ......:  return df
   ......:

In [146]: d.groupby("a").apply(identity)
a b
0 x 1
  a b
0 x 1
  a b
1 y 2
Out[146]:
a b
0 x 1
1 y 2

16.8. Flexible apply
16.9 Other useful features

16.9.1 Automatic exclusion of “nuisance” columns

Again consider the example DataFrame we’ve been looking at:

```python
In [147]: df
Out[147]:
   A  B    C     D
0  foo one -0.575247  1.346061
1  bar one  0.254161  1.511763
2  foo two -1.143704  1.627081
3  bar three 0.215897 -0.990582
4  foo two  1.193555 -0.441652
5  bar two -0.077118  1.211526
6  foo one -0.408530  0.268520
7  foo three -0.862495  0.024580
```

Suppose we wish to compute the standard deviation grouped by the `A` column. There is a slight problem, namely that we don’t care about the data in column `B`. We refer to this as a “nuisance” column. If the passed aggregation function can’t be applied to some columns, the troublesome columns will be (silently) dropped. Thus, this does not pose any problems:

```python
In [148]: df.groupby('A').std()
Out[148]:
     C     D
A
bar 0.181231  1.366330
foo 0.912265  0.884785
```

Note that `df.groupby('A').colname.std().` is more efficient than `df.groupby('A').std().colname`, so if the result of an aggregation function is only interesting over one column (here `colname`), it may be filtered `before` applying the aggregation function.

16.9.2 Handling of (un)observed Categorical values

When using a `Categorical` grouper (as a single grouper, or as part of multipler groupers), the `observed` keyword controls whether to return a cartesian product of all possible groupers values (observed=False) or only those that are observed groupers (observed=True).

Show all values:

```python
In [149]: pd.Series([1, 1, 1]).groupby(pd.Categorical(['a', 'a', 'a'], categories=['a →', 'b']), observed=False).count()
Out[149]:
a    3
b    0
dtype: int64
```

Show only the observed values:

```python
In [150]: pd.Series([1, 1, 1]).groupby(pd.Categorical(['a', 'a', 'a'], categories=['a →', 'b']), observed=True).count()
Out[150]:
```

(continues on next page)
The returned dtype of the grouped will always include all of the categories that were grouped.

```
In [151]: s = pd.Series([1, 1, 1]).groupby(pd.Categorical(['a', 'a', 'a'],
                                 categories=['a', 'b'], observed=False)).count()
In [152]: s.index.dtype
Out[152]: CategoricalDtype(categories=['a', 'b'], ordered=False)
```

### 16.9.3 NA and NaT group handling

If there are any NaN or NaT values in the grouping key, these will be automatically excluded. In other words, there will never be an “NA group” or “NaT group”. This was not the case in older versions of pandas, but users were generally discarding the NA group anyway (and supporting it was an implementation headache).

### 16.9.4 Grouping with ordered factors

Categorical variables represented as instance of pandas’s `Categorical` class can be used as group keys. If so, the order of the levels will be preserved:

```
In [153]: data = pd.Series(np.random.randn(100))
In [154]: factor = pd.qcut(data, [0, .25, .5, .75, 1.])
In [155]: data.groupby(factor).mean()
Out[155]:

(continues on next page)
```

### 16.9.5 Grouping with a Grouper specification

You may need to specify a bit more data to properly group. You can use the `pd.Grouper` to provide this local control.

```
In [156]: import datetime
In [157]: df = pd.DataFrame(
   ....:     'Branch' : 'A A A A A A A B'.split(),
   ....:     'Buyer' : 'Carl Mark Carl Carl Joe Joe Joe Carl'.split(),
   ....:     'Quantity': [1,3,5,1,8,1,9,3],
   ....:     'Date' : [
   ....:         datetime.datetime(2013,1,1,13,0),
   ....:         datetime.datetime(2013,1,1,13,5),
   ....:         datetime.datetime(2013,10,1,20,0),
   ....:         datetime.datetime(2013,10,2,10,0),
   ....:         datetime.datetime(2013,10,1,20,0),
   ....:     ]
   ....:
```

(continues on next page)
Groupby a specific column with the desired frequency. This is like resampling.

```python
In [159]: df.groupby([pd.Grouper(freq='1M', key='Date'), 'Buyer']).sum()
```

```
Quantity
Date  Buyer
2013-01-31 Carl 1
      Mark 3
2013-10-31 Carl 6
      Joe 9
```

You have an ambiguous specification in that you have a named index and a column that could be potential groupers.

```python
In [160]: df = df.set_index('Date')
In [161]: df['Date'] = df.index + pd.offsets.MonthEnd(2)
In [162]: df.groupby([pd.Grouper(freq='6M', key='Date'), 'Buyer']).sum()
```

```
Quantity
Date  Buyer
2013-02-28 Carl 1
      Mark 3
2014-02-28 Carl 9
      Joe 18
```

```python
In [163]: df.groupby([pd.Grouper(freq='6M', level='Date'), 'Buyer']).sum()
```

```
Quantity
Date  Buyer
2013-01-31 Carl 1
      Mark 3
2014-01-31 Carl 9
      Joe 18
```
16.9.6 Taking the first rows of each group

Just like for a DataFrame or Series you can call head and tail on a groupby:

```
In [164]: df = pd.DataFrame([[1, 2], [1, 4], [5, 6]], columns=['A', 'B'])

In [165]: df
Out[165]:
   A  B
0  1  2
1  1  4
2  5  6

In [166]: g = df.groupby('A')

In [167]: g.head(1)
Out[167]:
   A  B
0  1  2
2  5  6

In [168]: g.tail(1)
```

This shows the first or last n rows from each group.

16.9.7 Taking the nth row of each group

To select from a DataFrame or Series the nth item, use nth(). This is a reduction method, and will return a single row (or no row) per group if you pass an int for n:

```
In [169]: df = pd.DataFrame([[1, np.nan], [1, 4], [5, 6]], columns=['A', 'B'])

In [170]: g = df.groupby('A')

In [171]: g.nth(0)
Out[171]:
   B
A
1  NaN
5  6.0

In [172]: g.nth(-1)
Out[172]:
   B
A
1  4.0
5  6.0

In [173]: g.nth(1)
```

(continues on next page)
If you want to select the nth not-null item, use the `dropna` kwarg. For a DataFrame this should be either 'any' or 'all' just like you would pass to `dropna`:

```python
# nth(0) is the same as g.first()
In [174]: g.nth(0, dropna='any')
Out[174]:
   B
A
  1  4.0
  5  6.0

In [175]: g.first()
Out[175]:
   B
A
  1  4.0
  5  6.0

# nth(-1) is the same as g.last()
In [176]: g.nth(-1, dropna='any')  # NaNs denote group exhausted when using dropna
Out[176]:
   B
A
  1  4.0
  5  6.0

In [177]: g.last()
Out[177]:
   B
A
  1  4.0
  5  6.0

In [178]: g.B.nth(0, dropna='all')
Out[178]:
   B
A
  1  4.0
  5  6.0
Name: B, dtype: float64
```

As with other methods, passing `as_index=False`, will achieve a filtration, which returns the grouped row.

```python
In [179]: df = pd.DataFrame([[1, np.nan], [1, 4], [5, 6]], columns=['A', 'B'])
In [180]: g = df.groupby('A', as_index=False)
In [181]: g.nth(0)
Out[181]:
   A   B
0  1  NaN
```
2 5 6.0

In [182]: g.nth(-1)
\nOut[182]:
<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.0</td>
</tr>
<tr>
<td>2</td>
<td>6.0</td>
</tr>
</tbody>
</table>

You can also select multiple rows from each group by specifying multiple nth values as a list of ints.

```
In [183]: business_dates = pd.date_range(start='4/1/2014', end='6/30/2014', freq='B')

In [184]: df = pd.DataFrame(1, index=business_dates, columns=['a', 'b'])

# get the first, 4th, and last date index for each month
In [185]: df.groupby([df.index.year, df.index.month]).nth([0, 3, -1])
Out[185]:
<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>
```

### 16.9.8 Enumerate group items

To see the order in which each row appears within its group, use the `cumcount` method:

```
In [186]: dfg = pd.DataFrame(list('aabba'), columns=['A'])

In [187]: dfg
Out[187]:
    A
0   a
1   a
2   a
3   b
4   b
5   a

In [188]: dfg.groupby('A').cumcount()
Out[188]:
<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>
```

```
In [189]: dfg.groupby('A').cumcount(ascending=False)
```

(continues on next page)
16.9.9 Enumerate groups

New in version 0.20.2.

To see the ordering of the groups (as opposed to the order of rows within a group given by cumcount) you can use ngroup().

Note that the numbers given to the groups match the order in which the groups would be seen when iterating over the groupby object, not the order they are first observed.

```python
In [190]: dfg = pd.DataFrame(list('aaabba'), columns=['A'])

In [191]: dfg
Out[191]:
     A
0   a
1   a
2   a
3   b
4   b
5   a

In [192]: dfg.groupby('A').ngroup()
Out[192]:
0  0
1  0
2  0
3  1
4  1
5  0
dtype: int64

In [193]: dfg.groupby('A').ngroup(ascending=False)
Out[193]:
         0  1
0         1  1
1         1  1
2         1  1
3         0  0
4         0  0
5         1  1
dtype: int64
```
16.9.10 Plotting

Groupby also works with some plotting methods. For example, suppose we suspect that some features in a DataFrame may differ by group, in this case, the values in column 1 where the group is “B” are 3 higher on average.

```python
In [194]: np.random.seed(1234)
In [195]: df = pd.DataFrame(np.random.randn(50, 2))
In [196]: df['g'] = np.random.choice(['A', 'B'], size=50)
In [197]: df.loc[df['g'] == 'B', 1] += 3
```

We can easily visualize this with a boxplot:

```python
In [198]: df.groupby('g').boxplot()
Out[198]:
A    AxesSubplot(0.1,0.15;0.363636x0.75)
B    AxesSubplot(0.536364,0.15;0.363636x0.75)
dtype: object
```

The result of calling `boxplot` is a dictionary whose keys are the values of our grouping column `g` (“A” and “B”). The values of the resulting dictionary can be controlled by the `return_type` keyword of `boxplot`. See the visualization documentation for more.

16.9. Other useful features
Warning: For historical reasons, `df.groupby('g').boxplot()` is not equivalent to `df.boxplot(by='g')`. See [here](#) for an explanation.

### 16.9.11 Piping function calls

New in version 0.21.0.

Similar to the functionality provided by `DataFrame` and `Series`, functions that take `GroupBy` objects can be chained together using a `pipe` method to allow for a cleaner, more readable syntax. To read about `.pipe` in general terms, see [here](#).

Combining `.groupby` and `.pipe` is often useful when you need to reuse `GroupBy` objects.

As an example, imagine having a DataFrame with columns for stores, products, revenue and quantity sold. We’d like to do a groupwise calculation of prices (i.e. revenue/quantity) per store and per product. We could do this in a multi-step operation, but expressing it in terms of piping can make the code more readable. First we set the data:

```python
In [199]: import numpy as np
In [200]: n = 1000
In [201]: df = pd.DataFrame({'Store': np.random.choice(['Store_1', 'Store_2'], n),
                           'Product': np.random.choice(['Product_1', 'Product_2'], n),
                           'Revenue': (np.random.random(n)*50+10).round(2),
                           'Quantity': np.random.randint(1, 10, size=n)})
In [202]: df.head(2)
```

```
<table>
<thead>
<tr>
<th>Store</th>
<th>Product</th>
<th>Revenue</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store_2</td>
<td>Product_1</td>
<td>26.12</td>
<td>1</td>
</tr>
<tr>
<td>Store_2</td>
<td>Product_1</td>
<td>28.86</td>
<td>1</td>
</tr>
</tbody>
</table>
```

Now, to find prices per store/product, we can simply do:

```python
In [203]: (df.groupby(['Store', 'Product']).pipe(
   ...:     lambda grp: grp.Revenue.sum()/grp.Quantity.sum())
   ...:     .unstack().round(2))
```

```
<table>
<thead>
<tr>
<th>Product</th>
<th>Product_1</th>
<th>Product_2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Store_1</td>
<td>6.82</td>
<td>7.05</td>
</tr>
<tr>
<td>Store_2</td>
<td>6.30</td>
<td>6.64</td>
</tr>
</tbody>
</table>
```

Piping can also be expressive when you want to deliver a grouped object to some arbitrary function, for example:

```python
(df.groupby(['Store', 'Product'])).pipe(report_func)
```

where `report_func` takes a `GroupBy` object and creates a report from that.
pandas: powerful Python data analysis toolkit, Release 0.23.2

16.10 Examples
16.10.1 Regrouping by factor
Regroup columns of a DataFrame according to their sum, and sum the aggregated ones.
In [204]: df = pd.DataFrame({'a':[1,0,0], 'b':[0,1,0], 'c':[1,0,0], 'd':[2,3,4]})
In [205]: df
Out[205]:
a b c d
0 1 0 1 2
1 0 1 0 3
2 0 0 0 4
In [206]: df.groupby(df.sum(), axis=1).sum()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[206]:
1 9
0 2 2
1 1 3
2 0 4

16.10.2 Multi-column factorization
By using ngroup(), we can extract information about the groups in a way similar to factorize() (as described
further in the reshaping API) but which applies naturally to multiple columns of mixed type and different sources.
This can be useful as an intermediate categorical-like step in processing, when the relationships between the group
rows are more important than their content, or as input to an algorithm which only accepts the integer encoding.
(For more information about support in pandas for full categorical data, see the Categorical introduction and the API
documentation.)
In [207]: dfg = pd.DataFrame({"A": [1, 1, 2, 3, 2], "B": list("aaaba")})
In [208]: dfg
Out[208]:
A B
0 1 a
1 1 a
2 2 a
3 3 b
4 2 a
In [209]: dfg.groupby(["A", "B"]).ngroup()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[209]:
0
0
1
0
2
1
3
2
4
1
dtype: int64

In [210]: dfg.groupby(["A", [0, 0, 0, 1, 1]]).ngroup()
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
˓→

0

0
(continues on next page)

16.10. Examples

873


16.10.3 Groupby by Indexer to ‘resample’ data

Resampling produces new hypothetical samples (resamples) from already existing observed data or from a model that generates data. These new samples are similar to the pre-existing samples.

In order to resample to work on indices that are non-datetimelike, the following procedure can be utilized.

In the following examples, `df.index // 5` returns a binary array which is used to determine what gets selected for the groupby operation.

Note: The below example shows how we can downsample by consolidation of samples into fewer samples. Here by using `df.index // 5`, we are aggregating the samples in bins. By applying `std()` function, we aggregate the information contained in many samples into a small subset of values which is their standard deviation thereby reducing the number of samples.

```
In [211]: df = pd.DataFrame(np.random.randn(10,2))
In [212]: df
Out[212]:
   0  1
0 -0.793893  0.321153
1  0.342250  1.618906
2 -0.975807  1.918201
3 -0.810847 -1.405919
4 -0.810847 -1.405919
5 -0.810847 -1.405919
6 -0.810847 -1.405919
7 -0.810847 -1.405919
8 -0.810847 -1.405919
9 -0.810847 -1.405919

In [213]: df.index // 5
Int64Index([0, 0, 0, 0, 0, 1, 1, 1, 1, 1], dtype='int64')

In [214]: df.groupby(df.index // 5).std()
```

16.10.4 Returning a Series to propagate names

Group DataFrame columns, compute a set of metrics and return a named Series. The Series name is used as the name for the column index. This is especially useful in conjunction with reshaping operations such as stacking in which the
column index name will be used as the name of the inserted column:

```python
In [215]: df = pd.DataFrame({
    .....:     'a': [0, 0, 0, 1, 1, 1, 2, 2, 2, 2],
    .....:     'b': [0, 1, 0, 0, 1, 1, 0, 0, 1, 1],
    .....:     'c': [1, 0, 1, 0, 1, 0, 1, 0, 1, 0],
    .....:     'd': [0, 0, 1, 0, 0, 1, 0, 0, 0, 1],
    .....:  })
```

```python
In [216]: def compute_metrics(x):
    .....:     result = {'b_sum': x['b'].sum(), 'c_mean': x['c'].mean()}
    .....:     return pd.Series(result, name='metrics')
```

```python
In [217]: result = df.groupby('a').apply(compute_metrics)
```

```python
In [218]: result
```

```
Out[218]:
```
```
metrics  b_sum  c_mean
a
0  2.0  0.5
1  2.0  0.5
2  2.0  0.5
```

```python
In [219]: result.stack()
```

```
Out[219]:
```
```
metrics     a     b_sum  c_mean
0          a    2.0     0.5
1          a    2.0     0.5
2          a    2.0     0.5
dtype: float64
```

16.10. Examples 875
pandas provides various facilities for easily combining together Series, DataFrame, and Panel objects with various kinds of set logic for the indexes and relational algebra functionality in the case of join / merge-type operations.

### 17.1 Concatenating objects

The `concat()` function (in the main pandas namespace) does all of the heavy lifting of performing concatenation operations along an axis while performing optional set logic (union or intersection) of the indexes (if any) on the other axes. Note that I say “if any” because there is only a single possible axis of concatenation for Series.

Before diving into all of the details of `concat` and what it can do, here is a simple example:

```python
In [1]: df1 = pd.DataFrame({'A': ['A0', 'A1', 'A2', 'A3'],     
                      'B': ['B0', 'B1', 'B2', 'B3'],     
                      'C': ['C0', 'C1', 'C2', 'C3'],     
                      'D': ['D0', 'D1', 'D2', 'D3'],     
                      index=[0, 1, 2, 3])
...

In [2]: df2 = pd.DataFrame({'A': ['A4', 'A5', 'A6', 'A7'],     
                      'B': ['B4', 'B5', 'B6', 'B7'],     
                      'C': ['C4', 'C5', 'C6', 'C7'],     
                      'D': ['D4', 'D5', 'D6', 'D7'],     
                      index=[4, 5, 6, 7])
...

In [3]: df3 = pd.DataFrame({'A': ['A8', 'A9', 'A10', 'A11'],    
                      'B': ['B8', 'B9', 'B10', 'B11'],   
                      'C': ['C8', 'C9', 'C10', 'C11'],  
                      'D': ['D8', 'D9', 'D10', 'D11'],  
                      index=[8, 9, 10, 11])
...

In [4]: frames = [df1, df2, df3]

In [5]: result = pd.concat(frames)
```
Like its sibling function on ndarrays, `numpy.concatenate`, `pandas.concat` takes a list or dict of homogeneously-typed objects and concatenates them with some configurable handling of “what to do with the other axes”:

```
pd.concat(objs, axis=0, join='outer', join_axes=None, keys=None, levels=None, names=None, verify_integrity=False, copy=True)
```

- **objs**: a sequence or mapping of Series, DataFrame, or Panel objects. If a dict is passed, the sorted keys will be used as the `keys` argument, unless it is passed, in which case the values will be selected (see below). Any None objects will be dropped silently unless they are all None in which case a ValueError will be raised.

- **axis**: {0, 1, …}, default 0. The axis to concatenate along.

- **join**: {‘inner’, ‘outer’}, default ‘outer’. How to handle indexes on other axis(es). Outer for union and inner for intersection.

- **ignore_index**: boolean, default False. If True, do not use the index values on the concatenation axis. The resulting axis will be labeled 0, …, n - 1. This is useful if you are concatenating objects where the concatenation axis does not have meaningful indexing information. Note the index values on the other axes are still respected in the join.

- **join_axes**: list of Index objects. Specific indexes to use for the other n - 1 axes instead of performing inner/outer set logic.

- **keys**: sequence, default None. Construct hierarchical index using the passed keys as the outermost level. If multiple levels passed, should contain tuples.

- **levels**: list of sequences, default None. Specific levels (unique values) to use for constructing a MultiIndex. Otherwise they will be inferred from the keys.

- **names**: list, default None. Names for the levels in the resulting hierarchical index.

- **verify_integrity**: boolean, default False. Check whether the new concatenated axis contains duplicates. This can be very expensive relative to the actual data concatenation.
• **copy** : boolean, default True. If False, do not copy data unnecessarily.

Without a little bit of context many of these arguments don’t make much sense. Let’s revisit the above example. Suppose we wanted to associate specific keys with each of the pieces of the chopped up DataFrame. We can do this using the **keys** argument:

```
In [6]: result = pd.concat(frames, keys=['x', 'y', 'z'])
```

As you can see (if you’ve read the rest of the documentation), the resulting object’s index has a **hierarchical index**. This means that we can now select out each chunk by key:

```
In [7]: result.loc['y']
Out[7]:
        A  B  C  D
0 A0  B0  C0  D0
1 A1  B1  C1  D1
2 A2  B2  C2  D2
3 A3  B3  C3  D3
```

It’s not a stretch to see how this can be very useful. More detail on this functionality below.

**Note:** It is worth noting that **concat ()** (and therefore **append ()**) makes a full copy of the data, and that constantly reusing this function can create a significant performance hit. If you need to use the operation over several datasets, use a list comprehension.

```
frames = [ process_your_file(f) for f in files ]
result = pd.concat(f)
```
17.1.1 Set logic on the other axes

When gluing together multiple DataFrames, you have a choice of how to handle the other axes (other than the one being concatenated). This can be done in the following three ways:

- Take the union of them all, `join='outer'`. This is the default option as it results in zero information loss.
- Take the intersection, `join='inner'`.
- Use a specific index, as passed to the `join_axes` argument.

Here is an example of each of these methods. First, the default `join='outer'` behavior:

```python
In [8]: df4 = pd.DataFrame({'B': ['B2', 'B3', 'B6', 'B7'],
                         'C': ['C2', 'C3', 'C6', 'C7'],
                         'D': ['D2', 'D3', 'D6', 'D7'],
                         'F': ['F2', 'F3', 'F6', 'F7']},
                      index=[2, 3, 6, 7])
In [9]: result = pd.concat([df1, df4], axis=1, sort=False)

Warning: Changed in version 0.23.0. The default behavior with `join='outer'` is to sort the other axis (columns in this case). In a future version of pandas, the default will be to not sort. We specified `sort=False` to opt in to the new behavior now.

Here is the same thing with `join='inner'`:

```python
In [10]: result = pd.concat([df1, df4], axis=1, join='inner')
```

Lastly, suppose we just wanted to reuse the exact index from the original DataFrame:
In [11]: result = pd.concat([df1, df4], axis=1, join_axes=[df1.index])

17.1.2 Concatenating using \texttt{append}

A useful shortcut to \texttt{concat}() are the \texttt{append()} instance methods on \texttt{Series} and \texttt{DataFrame}. These methods actually predated \texttt{concat}. They concatenate along \texttt{axis}=0, namely the index:

In [12]: result = df1.append(df2)

In the case of \texttt{DataFrame}, the indexes must be disjoint but the columns do not need to be:

In [13]: result = df1.append(df4)
append may take multiple objects to concatenate:

```python
In [14]: result = df1.append([df2, df3])
```

Note: Unlike the `append()` method, which appends to the original list and returns `None`, `append()` here does not modify `df1` and returns its copy with `df2` appended.
17.1.3 Ignoring indexes on the concatenation axis

For DataFrame s which don’t have a meaningful index, you may wish to append them and ignore the fact that they may have overlapping indexes. To do this, use the `ignore_index` argument:

```
In [15]: result = pd.concat([df1, df4], ignore_index=True)
```

This is also a valid argument to `DataFrame.append()`:

```
In [16]: result = df1.append(df4, ignore_index=True)
```

17.1.4 Concatenating with mixed ndims

You can concatenate a mix of Series and DataFrame s. The Series will be transformed to DataFrame with the column name as the name of the Series.
In [17]: s1 = pd.Series(['X0', 'X1', 'X2', 'X3'], name='X')

In [18]: result = pd.concat([df1, s1], axis=1)

Note: Since we're concatenating a Series to a DataFrame, we could have achieved the same result with DataFrame.assign(). To concatenate an arbitrary number of pandas objects (DataFrame or Series), use concat.

If unnamed Series are passed they will be numbered consecutively.

In [19]: s2 = pd.Series(['_0', '_1', '_2', '_3'])

In [20]: result = pd.concat([df1, s2, s2, s2], axis=1)

Passing ignore_index=True will drop all name references.

In [21]: result = pd.concat([df1, s1], axis=1, ignore_index=True)
17.1.5 More concatenating with group keys

A fairly common use of the keys argument is to override the column names when creating a new DataFrame based on existing Series. Notice how the default behaviour consists on letting the resulting DataFrame inherit the parent Series' name, when these existed.

```
In [22]: s3 = pd.Series([0, 1, 2, 3], name='foo')
In [23]: s4 = pd.Series([0, 1, 2, 3])
In [24]: s5 = pd.Series([0, 1, 4, 5])
In [25]: pd.concat([s3, s4, s5], axis=1)
```

```
Out[25]:
  foo 0 1
0 0 0 0
1 1 1 1
2 2 2 4
3 3 3 5
```

Through the keys argument we can override the existing column names.

```
In [26]: pd.concat([s3, s4, s5], axis=1, keys=['red','blue','yellow'])
```

```
Out[26]:
      red  blue  yellow
0       0     0       0
1       1     1       1
2       2     2       4
3       3     3       5
```

Let's consider a variation of the very first example presented:

```
In [27]: result = pd.concat(frames, keys=['x', 'y', 'z'])
```
You can also pass a dict to `concat` in which case the dict keys will be used for the `keys` argument (unless other keys are specified):

```
In [28]: pieces = {'x': df1, 'y': df2, 'z': df3}
In [29]: result = pd.concat(pieces)
```
In [30]: result = pd.concat(pieces, keys=['z', 'y'])

The MultiIndex created has levels that are constructed from the passed keys and the index of the DataFrame pieces:
In [31]: result.index.levels
Out[31]: FrozenList([['z', 'y'], [4, 5, 6, 7, 8, 9, 10, 11]])

If you wish to specify other levels (as will occasionally be the case), you can do so using the `levels` argument:

```python
In [32]: result = pd.concat(pieces, keys=['x', 'y', 'z'],
......:   levels=[['z', 'y', 'x', 'w']],
......:   names=['group_key'])
```

This is fairly esoteric, but it is actually necessary for implementing things like GroupBy where the order of a categorical variable is meaningful.

### 17.1.6 Appending rows to a DataFrame

While not especially efficient (since a new object must be created), you can append a single row to a `DataFrame` by passing a `Series` or dict to `append`, which returns a new `DataFrame` as above.

```python
In [34]: s2 = pd.Series(['X0', 'X1', 'X2', 'X3'], index=['A', 'B', 'C', 'D'])
In [35]: result = df1.append(s2, ignore_index=True)
```
You should use `ignore_index` with this method to instruct DataFrame to discard its index. If you wish to preserve the index, you should construct an appropriately-indexed DataFrame and append or concatenate those objects.

You can also pass a list of dicts or Series:

```python
In [36]: dicts = [{'A': 1, 'B': 2, 'C': 3, 'X': 4},
   {'A': 5, 'B': 6, 'C': 7, 'Y': 8}]
   ...

In [37]: result = df1.append(dicts, ignore_index=True)
```

17.2 Database-style DataFrame joining/merging

pandas has full-featured, **high performance** in-memory join operations idiomatically very similar to relational databases like SQL. These methods perform significantly better (in some cases well over an order of magnitude better) than other open source implementations (like `base::merge.data.frame` in R). The reason for this is careful algorithmic design and the internal layout of the data in DataFrame.

See the **cookingbook** for some advanced strategies.

Users who are familiar with SQL but new to pandas might be interested in a **comparison with SQL**.

pandas provides a single function, `merge()`, as the entry point for all standard database join operations between DataFrame objects:
pd.merge(left, right, how='inner', on=None, left_on=None, right_on=None,
left_index=False, right_index=False, sort=True,
suffixes=('_x', '_y'), copy=True, indicator=False,
validate=None)

- **left**: A DataFrame object.
- **right**: Another DataFrame object.
- **on**: Column or index level names to join on. Must be found in both the left and right DataFrame objects. If not passed and left_index and right_index are False, the intersection of the columns in the DataFrames will be inferred to be the join keys.
- **left_on**: Columns or index levels from the left DataFrame to use as keys. Can either be column names, index level names, or arrays with length equal to the length of the DataFrame.
- **right_on**: Columns or index levels from the right DataFrame to use as keys. Can either be column names, index level names, or arrays with length equal to the length of the DataFrame.
- **left_index**: If True, use the index (row labels) from the left DataFrame as its join key(s). In the case of a DataFrame with a MultiIndex (hierarchical), the number of levels must match the number of join keys from the right DataFrame.
- **right_index**: Same usage as left_index for the right DataFrame
- **how**: One of 'left', 'right', 'outer', 'inner'. Defaults to inner. See below for more detailed description of each method.
- **sort**: Sort the result DataFrame by the join keys in lexicographical order. Defaults to True, setting to False will improve performance substantially in many cases.
- **suffixes**: A tuple of string suffixes to apply to overlapping columns. Defaults to ('_x', '_y').
- **copy**: Always copy data (default True) from the passed DataFrame objects, even when reindexing is not necessary. Cannot be avoided in many cases but may improve performance / memory usage. The cases where copying can be avoided are somewhat pathological but this option is provided nonetheless.
- **indicator**: Add a column to the output DataFrame called _merge with information on the source of each row. _merge is Categorical-type and takes on a value of left_only for observations whose merge key only appears in 'left' DataFrame, right_only for observations whose merge key only appears in 'right' DataFrame, and both if the observation’s merge key is found in both.
- **validate**: string, default None. If specified, checks if merge is of specified type.
  - “one_to_one” or “1:1”: checks if merge keys are unique in both left and right datasets.
  - “one_to_many” or “1:m”: checks if merge keys are unique in left dataset.
  - “many_to_one” or “m:1”: checks if merge keys are unique in right dataset.
  - “many_to_many” or “m:m”: allowed, but does not result in checks.

New in version 0.21.0.

**Note**: Support for specifying index levels as the on, left_on, and right_on parameters was added in version 0.23.0.

The return type will be the same as left. If left is a DataFrame and right is a subclass of DataFrame, the return type will still be DataFrame.

merge is a function in the pandas namespace, and it is also available as a DataFrame instance method merge(), with the calling DataFrame being implicitly considered the left object in the join.
The related `join()` method, uses `merge` internally for the index-on-index (by default) and column(s)-on-index join. If you are joining on index only, you may wish to use `DataFrame.join` to save yourself some typing.

### 17.2.1 Brief primer on merge methods (relational algebra)

Experienced users of relational databases like SQL will be familiar with the terminology used to describe join operations between two SQL-table like structures (`DataFrame` objects). There are several cases to consider which are very important to understand:

- **one-to-one** joins: for example when joining two `DataFrame` objects on their indexes (which must contain unique values).
- **many-to-one** joins: for example when joining an index (unique) to one or more columns in a different `DataFrame`.
- **many-to-many** joins: joining columns on columns.

**Note:** When joining columns on columns (potentially a many-to-many join), any indexes on the passed `DataFrame` objects will be discarded.

It is worth spending some time understanding the result of the **many-to-many** join case. In SQL / standard relational algebra, if a key combination appears more than once in both tables, the resulting table will have the **Cartesian product** of the associated data. Here is a very basic example with one unique key combination:

```python
In [38]: left = pd.DataFrame({'key': ['K0', 'K1', 'K2', 'K3'],
                        'A': ['A0', 'A1', 'A2', 'A3'],
                        'B': ['B0', 'B1', 'B2', 'B3']})

In [39]: right = pd.DataFrame({'key': ['K0', 'K1', 'K2', 'K3'],
                        'C': ['C0', 'C1', 'C2', 'C3'],
                        'D': ['D0', 'D1', 'D2', 'D3']})

In [40]: result = pd.merge(left, right, on='key')
```

Here is a more complicated example with multiple join keys. Only the keys appearing in `left` and `right` are present (the intersection), since `how='inner'` by default.

```python
In [41]: left = pd.DataFrame({'key1': ['K0', 'K0', 'K1', 'K2'],
                        'key2': ['K0', 'K1', 'K0', 'K1'],
                        'A': ['A0', 'A1', 'A2', 'A3'],
                        'B': ['B0', 'B1', 'B2', 'B3']})
```

(continues on next page)
In [42]: right = pd.DataFrame({'key1': ['K0', 'K1', 'K1', 'K2'],
                        'key2': ['K0', 'K0', 'K0', 'K0'],
                        'C': ['C0', 'C1', 'C2', 'C3'],
                        'D': ['D0', 'D1', 'D2', 'D3']})

In [43]: result = pd.merge(left, right, on=['key1', 'key2'])

The `how` argument to `merge` specifies how to determine which keys are to be included in the resulting table. If a key combination does not appear in either the left or right tables, the values in the joined table will be `NA`. Here is a summary of the `how` options and their SQL equivalent names:

<table>
<thead>
<tr>
<th>Merge method</th>
<th>SQL Join Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>left</td>
<td>LEFT OUTER JOIN</td>
<td>Use keys from left frame only</td>
</tr>
<tr>
<td>right</td>
<td>RIGHT OUTER JOIN</td>
<td>Use keys from right frame only</td>
</tr>
<tr>
<td>outer</td>
<td>FULL OUTER JOIN</td>
<td>Use union of keys from both frames</td>
</tr>
<tr>
<td>inner</td>
<td>INNER JOIN</td>
<td>Use intersection of keys from both frames</td>
</tr>
</tbody>
</table>

In [44]: result = pd.merge(left, right, how='left', on=['key1', 'key2'])

In [45]: result = pd.merge(left, right, how='right', on=['key1', 'key2'])
In [46]: result = pd.merge(left, right, how='outer', on=['key1', 'key2'])

In [47]: result = pd.merge(left, right, how='inner', on=['key1', 'key2'])

Here is another example with duplicate join keys in DataFrames:

In [48]: left = pd.DataFrame({'A': [1, 2], 'B': [2, 2]})
In [49]: right = pd.DataFrame({'A': [4, 5, 6], 'B': [2, 2, 2]})
In [50]: result = pd.merge(left, right, on='B', how='outer')
17.2.2 Checking for duplicate keys

New in version 0.21.0.

Users can use the `validate` argument to automatically check whether there are unexpected duplicates in their merge keys. Key uniqueness is checked before merge operations and so should protect against memory overflows. Checking key uniqueness is also a good way to ensure user data structures are as expected.

In the following example, there are duplicate values of `B` in the right DataFrame. As this is not a one-to-one merge— as specified in the `validate` argument—an exception will be raised.

```python
In [51]: left = pd.DataFrame({'A': [1, 2], 'B': [1, 2]})
In [52]: right = pd.DataFrame({'A': [4, 5, 6], 'B': [2, 2, 2]})
In [53]: result = pd.merge(left, right, on='B', how='outer', validate="one_to_one")
...:
MergeError: Merge keys are not unique in right dataset; not a one-to-one merge
```

If the user is aware of the duplicates in the right DataFrame but wants to ensure there are no duplicates in the left DataFrame, one can use the `validate='one_to_many'` argument instead, which will not raise an exception.

```python
In [53]: pd.merge(left, right, on='B', how='outer', validate="one_to_many")
Out[53]:
   A_x  B  A_y
0   1  1  NaN
1   2  2  4.0
2   2  2  5.0
3   2  2  6.0
```

17.2.3 The merge indicator

`merge()` accepts the argument `indicator`. If `True`, a Categorical-type column called `_merge` will be added to the output object that takes on values:

```
left  right  Result
A  B  A  B  A_x  B  A_y
0 1 2 0 4 1 2 4
1 2 2 1 2 2 5
2 3 2 2 2 2 6
3 2 2 3 2 2 4
4 2 2 4 2 2 5
5 2 2 5 2 2 6
```
### Observation Origin

<table>
<thead>
<tr>
<th>Merge key in both frames</th>
<th>right_only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merge key only in 'left' frame</td>
<td>left_only</td>
</tr>
<tr>
<td>Merge key only in 'right' frame</td>
<td>right_only</td>
</tr>
</tbody>
</table>

#### In [54]:
```python
df1 = pd.DataFrame({'col1': [0, 1], 'col_left': ['a', 'b']})
```

#### In [55]:
```python
df2 = pd.DataFrame({'col1': [1, 2, 2], 'col_right': [2, 2, 2]})
```

#### In [56]:
```python
df.merge(df1, df2, on='col1', how='outer', indicator=True)
```

```python
Out[56]:
<table>
<thead>
<tr>
<th>col1</th>
<th>col_left</th>
<th>col_right</th>
<th>_merge</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>a</td>
<td>NaN</td>
<td>left_only</td>
</tr>
<tr>
<td>1</td>
<td>b</td>
<td>2.0</td>
<td>both</td>
</tr>
<tr>
<td>2</td>
<td>NaN</td>
<td>2.0</td>
<td>right_only</td>
</tr>
<tr>
<td>3</td>
<td>NaN</td>
<td>2.0</td>
<td>right_only</td>
</tr>
</tbody>
</table>
```

The `indicator` argument will also accept string arguments, in which case the indicator function will use the value of the passed string as the name for the indicator column.

#### In [57]:
```python
df.merge(df1, df2, on='col1', how='outer', indicator='indicator_column')
```

```python
Out[57]:
<table>
<thead>
<tr>
<th>coll</th>
<th>col_left</th>
<th>col_right</th>
<th>indicator_column</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>a</td>
<td>NaN</td>
<td>left_only</td>
</tr>
<tr>
<td>1</td>
<td>b</td>
<td>2.0</td>
<td>both</td>
</tr>
<tr>
<td>2</td>
<td>NaN</td>
<td>2.0</td>
<td>right_only</td>
</tr>
<tr>
<td>3</td>
<td>NaN</td>
<td>2.0</td>
<td>right_only</td>
</tr>
</tbody>
</table>
```

### 17.2.4 Merge Dtypes

New in version 0.19.0.

Merging will preserve the dtype of the join keys.

#### In [58]:
```python
left = pd.DataFrame({'key': [1], 'v1': [10]})
```

#### In [59]:
```python
left
```

```python
Out[59]:
<table>
<thead>
<tr>
<th>key</th>
<th>v1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>
```

#### In [60]:
```python
right = pd.DataFrame({'key': [1, 2], 'v1': [20, 30]})
```

#### In [61]:
```python
right
```

```python
Out[61]:
<table>
<thead>
<tr>
<th>key</th>
<th>v1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
</tr>
</tbody>
</table>
```

We are able to preserve the join keys:

#### In [62]:
```python
pd.merge(left, right, how='outer')
```

```python
Out[62]:
<table>
<thead>
<tr>
<th>key</th>
<th>v1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>
```

(continues on next page)
In [63]: pd.merge(left, right, how='outer').dtypes
Out[63]

<table>
<thead>
<tr>
<th>key</th>
<th>int64</th>
</tr>
</thead>
<tbody>
<tr>
<td>v1</td>
<td>int64</td>
</tr>
</tbody>
</table>

dtype: object

Of course if you have missing values that are introduced, then the resulting dtype will be upcast.

In [64]: pd.merge(left, right, how='outer', on='key')
Out[64]

<table>
<thead>
<tr>
<th>key</th>
<th>v1_x</th>
<th>v1_y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10.0</td>
<td>20</td>
</tr>
<tr>
<td>1</td>
<td>NaN</td>
<td>30</td>
</tr>
</tbody>
</table>

In [65]: pd.merge(left, right, how='outer', on='key').dtypes
Out[65]

<table>
<thead>
<tr>
<th>key</th>
<th>int64</th>
</tr>
</thead>
<tbody>
<tr>
<td>v1_x</td>
<td>float64</td>
</tr>
<tr>
<td>v1_y</td>
<td>int64</td>
</tr>
</tbody>
</table>

dtype: object

New in version 0.20.0.

Merging will preserve category dtypes of the mergands. See also the section on *categoricals*.

The left frame.

In [66]: from pandas.api.types import CategoricalDtype

In [67]: X = pd.Series(np.random.choice(['foo', 'bar'], size=(10,)))

In [68]: X = X.astype(CategoricalDtype(categories=['foo', 'bar']))

In [69]: left = pd.DataFrame({'X': X,
                          'Y': np.random.choice(['one', 'two', 'three'], size=(10,))})

In [70]: left
Out[70]

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>bar</td>
<td>one</td>
</tr>
<tr>
<td>foo</td>
<td>one</td>
</tr>
<tr>
<td>foo</td>
<td>three</td>
</tr>
<tr>
<td>bar</td>
<td>three</td>
</tr>
<tr>
<td>foo</td>
<td>one</td>
</tr>
<tr>
<td>bar</td>
<td>one</td>
</tr>
<tr>
<td>bar</td>
<td>three</td>
</tr>
<tr>
<td>bar</td>
<td>three</td>
</tr>
<tr>
<td>foo</td>
<td>three</td>
</tr>
</tbody>
</table>

In [71]: left.dtypes
(continues on next page)
The right frame.

```python
In [72]: right = pd.DataFrame({
       ...: 'X': pd.Series(['foo', 'bar'],
       ...: dtype=CategoricalDtype(['foo', 'bar'])),
       ...: 'Z': [1, 2]
       ...: })
       ...

In [73]: right
Out[73]:
   X  Z
0  foo  1
1  bar  2
```

The merged result:

```python
In [75]: result = pd.merge(left, right, how='outer')

In [76]: result
Out[76]:
   X  Y  Z
0  bar one  2
1  bar three  2
2  bar one  2
3  bar three  2
4  bar three  2
5  foo one  1
6  foo three  1
7  foo one  1
8  foo three  1
9  foo three  1
```

Note: The category dtypes must be exactly the same, meaning the same categories and the ordered attribute. Otherwise the result will coerce to object dtype.
Note: Merging on category dtypes that are the same can be quite performant compared to object dtype merging.

17.2.5 Joining on index

`DataFrame.join()` is a convenient method for combining the columns of two potentially differently-indexed DataFrames into a single result DataFrame. Here is a very basic example:

```python
In [78]: left = pd.DataFrame({'A': ['A0', 'A1', 'A2'],
    ....:                   'B': ['B0', 'B1', 'B2'],
    ....:                   index=['K0', 'K1', 'K2'])
    ....:
In [79]: right = pd.DataFrame({'C': ['C0', 'C2', 'C3'],
    ....:                  'D': ['D0', 'D2', 'D3'],
    ....:                  index=['K0', 'K2', 'K3'])
    ....:
In [80]: result = left.join(right)
```

The same as above, but with `how='inner'`.

```python
In [81]: result = left.join(right, how='inner')
```

In [82]: result = left.join(right, how='outer')
The data alignment here is on the indexes (row labels). This same behavior can be achieved using `merge` plus additional arguments instructing it to use the indexes:

```python
In [83]: result = pd.merge(left, right, left_index=True, right_index=True, how='outer')
```

17.2.6 Joining key columns on an index

`join()` takes an optional `on` argument which may be a column or multiple column names, which specifies that the passed DataFrame is to be aligned on that column in the DataFrame. These two function calls are completely equivalent:

```python
left.join(right, on=key_or_keys)
pd.merge(left, right, left_on=key_or_keys, right_index=True, how='left', sort=False)
```

Obviously you can choose whichever form you find more convenient. For many-to-one joins (where one of the DataFrame's is already indexed by the join key), using `join` may be more convenient. Here is a simple example:

```python
In [85]: left = pd.DataFrame({'A': ['A0', 'A1', 'A2', 'A3'],
                        'B': ['B0', 'B1', 'B2', 'B3'],
                        'key': ['K0', 'K1', 'K0', 'K1']})

In [86]: right = pd.DataFrame({'C': ['C0', 'C1'],
                           'D': ['D0', 'D1']},
                          index=['K0', 'K1'])

In [87]: result = left.join(right, on='key')
```
In [88]: result = pd.merge(left, right, left_on='key', right_index=True,
how='left', sort=False);

To join on multiple keys, the passed DataFrame must have a MultiIndex:

In [89]: left = pd.DataFrame({'A': ['A0', 'A1', 'A2', 'A3'],
'B': ['B0', 'B1', 'B2', 'B3'],
'key1': ['K0', 'K0', 'K1', 'K2'],
'key2': ['K0', 'K1', 'K0', 'K1']})

In [90]: index = pd.MultiIndex.from_tuples([('K0', 'K0'), ('K1', 'K0'),
('K2', 'K0'), ('K2', 'K1')])

In [91]: right = pd.DataFrame({'C': ['C0', 'C1', 'C2', 'C3'],
'D': ['D0', 'D1', 'D2', 'D3']},
index=index)

Now this can be joined by passing the two key column names:

In [92]: result = left.join(right, on=['key1', 'key2'])

The default for DataFrame.join is to perform a left join (essentially a “VLOOKUP” operation, for Excel users), which
uses only the keys found in the calling DataFrame. Other join types, for example inner join, can be just as easily performed:

```
In [93]: result = left.join(right, on=['key1', 'key2'], how='inner')
```

As you can see, this drops any rows where there was no match.

### 17.2.7 Joining a single Index to a Multi-index

You can join a singly-indexed DataFrame with a level of a multi-indexed DataFrame. The level will match on the name of the index of the singly-indexed frame against a level name of the multi-indexed frame.

```
In [94]: left = pd.DataFrame({'A': ['A0', 'A1', 'A2'],
                        'B': ['B0', 'B1', 'B2'],
                        index=pd.Index(['K0', 'K1', 'K2'], name='key'))

In [95]: index = pd.MultiIndex.from_tuples([('K0', 'Y0'), ('K1', 'Y1'), ('K2', 'Y2'), ('K2', 'Y3')],
                                        names=['key', 'Y'])

In [96]: right = pd.DataFrame({'C': ['C0', 'C1', 'C2', 'C3'],
                          'D': ['D0', 'D1', 'D2', 'D3'],
                          index=index)

In [97]: result = left.join(right, how='inner')
```

This is equivalent but less verbose and more memory efficient / faster than this.

```
In [98]: result = pd.merge(left.reset_index(), right.reset_index(),
                       on=['key'], how='inner').set_index(['key', 'Y'])
```

---

**17.2. Database-style DataFrame joining/merging**

901
17.2.8 Joining with two multi-indexes

This is not implemented via `join` at-the-moment, however it can be done using the following code.

```
In [99]: index = pd.MultiIndex.from_tuples([('K0', 'X0'), ('K0', 'X1'),
                                           ('K1', 'X2')],
                                          names=['key', 'X'])

In [100]: left = pd.DataFrame({'A': ['A0', 'A1', 'A2'],
                          'B': ['B0', 'B1', 'B2'],
                          'key2': ['K0', 'K1', 'K0'],
                          index=left_index)

In [101]: result = pd.merge(left.reset_index(), right.reset_index(),
                        on=['key'], how='inner').set_index(['key', 'X', 'Y'])
```

17.2.9 Merging on a combination of columns and index levels

New in version 0.22.

Strings passed as the `on`, `left_on`, and `right_on` parameters may refer to either column names or index level names. This enables merging `DataFrame` instances on a combination of index levels and columns without resetting indexes.

```
In [102]: left_index = pd.Index(['K0', 'K0', 'K1', 'K2'], name='key1')

In [103]: left = pd.DataFrame({'A': ['A0', 'A1', 'A2', 'A3'],
                          'B': ['B0', 'B1', 'B2', 'B3'],
                          'key2': ['K0', 'K1', 'K0', 'K1'],
                          index=left_index)
```

(continues on next page)
In [104]: right_index = pd.Index(['K0', 'K1', 'K2', 'K2'], name='key1')

In [105]: right = pd.DataFrame({'C': ['C0', 'C1', 'C2', 'C3'],
                     'D': ['D0', 'D1', 'D2', 'D3'],
                     'key2': ['K0', 'K0', 'K0', 'K1'],
                     index=right_index)

In [106]: result = left.merge(right, on=['key1', 'key2'])

Note: When DataFrames are merged on a string that matches an index level in both frames, the index level is preserved as an index level in the resulting DataFrame.

Note: If a string matches both a column name and an index level name, then a warning is issued and the column takes precedence. This will result in an ambiguity error in a future version.

17.2.10 Overlapping value columns

The merge suffixes argument takes a tuple of list of strings to append to overlapping column names in the input DataFrames to disambiguate the result columns:

In [107]: left = pd.DataFrame({'k': ['K0', 'K1', 'K2'], 'v': [1, 2, 3]})

In [108]: right = pd.DataFrame({'k': ['K0', 'K0', 'K3'], 'v': [4, 5, 6]})

In [109]: result = pd.merge(left, right, on='k')

17.2. Database-style DataFrame joining/merging
In [110]: result = pd.merge(left, right, on='k', suffixes=['_l', '_r'])

DataFrame.join() has lsuffix and rsuffix arguments which behave similarly.

In [111]: left = left.set_index('k')
In [112]: right = right.set_index('k')
In [113]: result = left.join(right, lsuffix='_l', rsuffix='_r')

17.2.11 Joining multiple DataFrame or Panel objects

A list or tuple of DataFrames can also be passed to join() to join them together on their indexes.

In [114]: right2 = pd.DataFrame({'v': [7, 8, 9], index=['K1', 'K1', 'K2']})
In [115]: result = left.join([right, right2])

Chapter 17. Merge, join, and concatenate
### 17.2.12 Merging together values within Series or DataFrame columns

Another fairly common situation is to have two like-indexed (or similarly indexed) Series or DataFrame objects and wanting to “patch” values in one object from values for matching indices in the other. Here is an example:

```
In [116]: df1 = pd.DataFrame([[np.nan, 3., 5.], [-4.6, np.nan, np.nan],
                        ...:                      [np.nan, 7., np.nan]])

In [117]: df2 = pd.DataFrame([[-42.6, np.nan, -8.2], [-5., 1.6, 4.]],
                        ...:                      index=[1, 2])
```

For this, use the `combine_first()` method:

```
In [118]: result = df1.combine_first(df2)
```

Note that this method only takes values from the right DataFrame if they are missing in the left DataFrame. A related method, `update()`, alters non-NA values inplace:

```
In [119]: df1.update(df2)
```

### 17.3 Timeseries friendly merging

#### 17.3.1 Merging Ordered Data

A `merge_ordered()` function allows combining time series and other ordered data. In particular it has an optional `fill_method` keyword to fill/interpolate missing data:

```
In [120]: left = pd.DataFrame({'k': ['K0', 'K1', 'K1', 'K2'],
                           ...:                        'lv': [1, 2, 3, 4],
                           ...:                        's': ['a', 'b', 'c', 'd']})

In [121]: right = pd.DataFrame({'k': ['K1', 'K2', 'K4'],
                           ...:                        ...
```

(continues on next page)
In [122]: pd.merge_ordered(left, right, fill_method='ffill', left_by='s')
Out[122]:
       k lv  s  rv
0    K0  1.0  a  NaN
1    K1  1.0  a   1.0
2    K2  1.0  a   2.0
3    K4  1.0  a   3.0
4    K1  2.0  b   1.0
5    K2  2.0  b   2.0
6    K4  2.0  b   3.0
7    K1  3.0  c   1.0
8    K2  3.0  c   2.0
9    K4  3.0  c   3.0
10  K1  NaN  d   1.0
11  K2   4.0  d   2.0
12  K4   4.0  d   3.0

17.3.2 Merging AsOf

New in version 0.19.0.

A merge_asof() is similar to an ordered left-join except that we match on nearest key rather than equal keys. For each row in the left DataFrame, we select the last row in the right DataFrame whose on key is less than the left’s key. Both DataFrames must be sorted by the key.

Optionally an asof merge can perform a group-wise merge. This matches the by key equally, in addition to the nearest match on the on key.

For example; we might have trades and quotes and we want to asof merge them.

In [123]: trades = pd.DataFrame({
       'time': pd.to_datetime(['20160525 13:30:00.023',
       '20160525 13:30:00.038',
       '20160525 13:30:00.048'],
       columns=['time', 'ticker', 'price', 'quantity'])

In [124]: quotes = pd.DataFrame({
       'time': pd.to_datetime(['20160525 13:30:00.023',
       '20160525 13:30:00.038',
       '20160525 13:30:00.048'],
       columns=['time', 'ticker', 'price', 'quantity'])

(continues on next page)
In [125]: trades
Out[125]:

<table>
<thead>
<tr>
<th>time</th>
<th>ticker</th>
<th>price</th>
<th>quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016-05-25 13:30:00.023</td>
<td>MSFT</td>
<td>51.95</td>
<td>75</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.038</td>
<td>MSFT</td>
<td>51.95</td>
<td>155</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.048</td>
<td>GOOG</td>
<td>720.77</td>
<td>100</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.048</td>
<td>GOOG</td>
<td>720.92</td>
<td>100</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.048</td>
<td>AAPL</td>
<td>98.00</td>
<td>100</td>
</tr>
</tbody>
</table>

In [126]: quotes

<table>
<thead>
<tr>
<th>time</th>
<th>ticker</th>
<th>bid</th>
<th>ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016-05-25 13:30:00.023</td>
<td>GOOG</td>
<td>720.50</td>
<td>720.93</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.023</td>
<td>MSFT</td>
<td>51.95</td>
<td>51.96</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.030</td>
<td>MSFT</td>
<td>51.97</td>
<td>51.98</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.041</td>
<td>MSFT</td>
<td>51.99</td>
<td>52.00</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.048</td>
<td>GOOG</td>
<td>720.50</td>
<td>720.93</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.049</td>
<td>AAPL</td>
<td>97.99</td>
<td>98.01</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.072</td>
<td>GOOG</td>
<td>720.50</td>
<td>720.88</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.075</td>
<td>MSFT</td>
<td>52.01</td>
<td>52.03</td>
</tr>
</tbody>
</table>

By default we are taking the asof of the quotes.

In [127]: pd.merge_asof(trades, quotes,
......: on='time',
......: by='ticker')
......:
Out[127]:

<table>
<thead>
<tr>
<th>time</th>
<th>ticker</th>
<th>price</th>
<th>quantity</th>
<th>bid</th>
<th>ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016-05-25 13:30:00.023</td>
<td>MSFT</td>
<td>51.95</td>
<td>75</td>
<td>51.95</td>
<td>51.96</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.038</td>
<td>MSFT</td>
<td>51.95</td>
<td>155</td>
<td>51.97</td>
<td>51.98</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.048</td>
<td>GOOG</td>
<td>720.77</td>
<td>100</td>
<td>720.50</td>
<td>720.93</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.048</td>
<td>GOOG</td>
<td>720.92</td>
<td>100</td>
<td>720.50</td>
<td>720.93</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.048</td>
<td>AAPL</td>
<td>98.00</td>
<td>100</td>
<td>NaN</td>
<td>NaN</td>
</tr>
</tbody>
</table>

We only asof within 2ms between the quote time and the trade time.

In [128]: pd.merge_asof(trades, quotes,
......: on='time',
......: by='ticker',
......: tolerance=pd.Timedelta('2ms'))
......:
Out[128]:

<table>
<thead>
<tr>
<th>time</th>
<th>ticker</th>
<th>price</th>
<th>quantity</th>
<th>bid</th>
<th>ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016-05-25 13:30:00.023</td>
<td>MSFT</td>
<td>51.95</td>
<td>75</td>
<td>51.95</td>
<td>51.96</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.038</td>
<td>MSFT</td>
<td>51.95</td>
<td>155</td>
<td>51.97</td>
<td>51.98</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.048</td>
<td>GOOG</td>
<td>720.77</td>
<td>100</td>
<td>720.50</td>
<td>720.93</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.048</td>
<td>GOOG</td>
<td>720.92</td>
<td>100</td>
<td>720.50</td>
<td>720.93</td>
</tr>
<tr>
<td>2016-05-25 13:30:00.048</td>
<td>AAPL</td>
<td>98.00</td>
<td>100</td>
<td>NaN</td>
<td>NaN</td>
</tr>
</tbody>
</table>

(continues on next page)
We only asof within 10ms between the quote time and the trade time and we exclude exact matches on time. Note that though we exclude the exact matches (of the quotes), prior quotes do propagate to that point in time.

```
In [129]: pd.merge_asof(trades, quotes,
.....:     on='time',
.....:     by='ticker',
.....:     tolerance=pd.Timedelta('10ms'),
.....:     allow_exact_matches=False)
.....:
Out[129]:
```

<table>
<thead>
<tr>
<th></th>
<th>time</th>
<th>ticker</th>
<th>price</th>
<th>quantity</th>
<th>bid</th>
<th>ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2016-05-25 13:30:00.023</td>
<td>MSFT</td>
<td>51.95</td>
<td>75</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>1</td>
<td>2016-05-25 13:30:00.038</td>
<td>MSFT</td>
<td>51.95</td>
<td>155</td>
<td>51.97</td>
<td>51.98</td>
</tr>
<tr>
<td>2</td>
<td>2016-05-25 13:30:00.048</td>
<td>GOOG</td>
<td>720.77</td>
<td>100</td>
<td>720.50</td>
<td>720.93</td>
</tr>
<tr>
<td>3</td>
<td>2016-05-25 13:30:00.048</td>
<td>GOOG</td>
<td>720.92</td>
<td>100</td>
<td>720.50</td>
<td>720.93</td>
</tr>
<tr>
<td>4</td>
<td>2016-05-25 13:30:00.048</td>
<td>AAPL</td>
<td>98.00</td>
<td>100</td>
<td>NaN</td>
<td>NaN</td>
</tr>
</tbody>
</table>
18.1 Reshaping by pivoting DataFrame objects

Data is often stored in CSV files or databases in so-called “stacked” or “record” format:

```python
In [1]: df
Out[1]:
   date variable  value
0  2000-01-03      A    0.469112
1  2000-01-04      A   -0.282863
2  2000-01-05      A   -1.509059
3  2000-01-03      B   -1.135632
4  2000-01-04      B    1.212112
5  2000-01-05      B   -0.173215
6  2000-01-03      C    0.119209
7  2000-01-04      C   -1.044236
8  2000-01-05      C   -0.861849
9  2000-01-03      D   -2.104569
10 2000-01-04      D   -0.494929
11 2000-01-05      D    1.071804
```

For the curious here is how the above DataFrame was created:

```python
import pandas.util.testing as tm; tm.N = 3
def unpivot(frame):
    N, K = frame.shape
    data = {'value' : frame.values.ravel('F'),
            'variable' : np.asarray(frame.columns).repeat(N),
            'date' : np.tile(np.asarray(frame.index), K)}
    return pd.DataFrame(data, columns=['date', 'variable', 'value'])
df = unpivot(tm.makeTimeDataFrame())
```

To select out everything for variable A we could do:

```python
In [2]: df[df['variable'] == 'A']
Out[2]:
   date variable  value
0  2000-01-03      A    0.469112
1  2000-01-04      A   -0.282863
2  2000-01-05      A   -1.509059
```
But suppose we wish to do time series operations with the variables. A better representation would be where the columns are the unique variables and an index of dates identifies individual observations. To reshape the data into this form, we use the DataFrame.pivot() method (also implemented as a top level function pivot()):

```
In [3]: df.pivot(index='date', columns='variable', values='value')
```

```
Out[3]:

<table>
<thead>
<tr>
<th>variable</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>date</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000-01-03</td>
<td>0.469112</td>
<td>-1.135632</td>
<td>0.119209</td>
<td>-2.104569</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>-0.282863</td>
<td>1.212112</td>
<td>-1.044236</td>
<td>-0.494929</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>-1.509059</td>
<td>-0.173215</td>
<td>-0.861849</td>
<td>1.071804</td>
</tr>
</tbody>
</table>
```

If the values argument is omitted, and the input DataFrame has more than one column of values which are not used as column or index inputs to pivot, then the resulting “pivoted” DataFrame will have hierarchical columns whose topmost level indicates the respective value column:

```
In [4]: df['value2'] = df['value'] * 2
In [5]: pivoted = df.pivot('date', 'variable')
In [6]: pivoted
```

```
Out[6]:

<table>
<thead>
<tr>
<th>variable</th>
<th>value</th>
<th>value2</th>
</tr>
</thead>
<tbody>
<tr>
<td>date</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000-01-03</td>
<td>0.469112</td>
<td>0.938225</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>-0.282863</td>
<td>-0.565727</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>-1.509059</td>
<td>-3.018117</td>
</tr>
</tbody>
</table>
```

You can then select subsets from the pivoted DataFrame:
Note that this returns a view on the underlying data in the case where the data are homogeneously-typed.

### 18.2 Reshaping by stacking and unstacking

#### Stack

Closely related to the `pivot()` method are the related `stack()` and `unstack()` methods available on `Series` and `DataFrame`. These methods are designed to work together with `MultiIndex` objects (see the section on `hierarchical indexing`). Here are essentially what these methods do:

- **stack**: “pivot” a level of the (possibly hierarchical) column labels, returning a `DataFrame` with an index with a new inner-most level of row labels.
- **unstack**: (inverse operation of `stack`) “pivot” a level of the (possibly hierarchical) row index to the column axis, producing a reshaped `DataFrame` with a new inner-most level of column labels.
The clearest way to explain is by example. Let’s take a prior example data set from the hierarchical indexing section:

```python
In [8]: tuples = list(zip(*[['bar', 'bar', 'baz', 'baz',
...:               'foo', 'foo', 'qux', 'qux'],
...:               ['one', 'two', 'one', 'two',
...:               'one', 'two', 'one', 'two']]))

In [9]: index = pd.MultiIndex.from_tuples(tuples, names=['first', 'second'])

In [10]: df = pd.DataFrame(np.random.randn(8, 2), index=index, columns=['A', 'B'])

In [11]: df2 = df[:4]

In [12]: df2
Out[12]:

<table>
<thead>
<tr>
<th>first</th>
<th>second</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>bar</td>
<td>one</td>
<td>0.721555</td>
<td>-0.706771</td>
</tr>
<tr>
<td></td>
<td>two</td>
<td>-1.039575</td>
<td>0.271860</td>
</tr>
<tr>
<td>baz</td>
<td>one</td>
<td>-0.424972</td>
<td>0.567020</td>
</tr>
<tr>
<td></td>
<td>two</td>
<td>0.276232</td>
<td>-1.087401</td>
</tr>
</tbody>
</table>
```

The `stack` function “compresses” a level in the DataFrame’s columns to produce either:

- A Series, in the case of a simple column Index.
- A DataFrame, in the case of a MultiIndex in the columns.

If the columns have a MultiIndex, you can choose which level to stack. The stacked level becomes the new lowest level in a MultiIndex on the columns:
With a “stacked” DataFrame or Series (having a MultiIndex as the index), the inverse operation of stack is unstack, which by default unstacks the last level:

```python
In [15]: stacked.unstack()
Out[15]:
                        A         B
bar one 0.721555    -0.706771
   two -1.039575   -1.087401
baz one -0.424972    0.567020
   two  0.276232    -1.087401
```

```python
In [16]: stacked.unstack(1)
```

```python
In [17]: stacked.unstack(0)
```

18.2. Reshaping by stacking and unstacking
If the indexes have names, you can use the level names instead of specifying the level numbers:

```
In [18]: stacked.unstack('second')
Out[18]:
        second   one    two
    first   
bar   A  0.721555 -1.039575
      B -0.706771  0.271860
baz   A -0.424972  0.276232
      B  0.567020 -1.087401
```

```
stacked.unstack(1)
```

```
stacked.unstack('second')
```

If the indexes have names, you can use the level names instead of specifying the level numbers:
Unstack(0)

stacked

<table>
<thead>
<tr>
<th></th>
<th>first</th>
<th>second</th>
</tr>
</thead>
<tbody>
<tr>
<td>bar</td>
<td>one</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>two</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>baz</td>
<td>one</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>two</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
</tr>
</tbody>
</table>

or

stacked.unstack(0)

<table>
<thead>
<tr>
<th></th>
<th>first</th>
<th>second</th>
</tr>
</thead>
<tbody>
<tr>
<td>bar</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>two</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>baz</td>
<td>one</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>two</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
</tr>
</tbody>
</table>

Notice that the stack and unstack methods implicitly sort the index levels involved. Hence a call to stack and then unstack, or vice versa, will result in a sorted copy of the original DataFrame or Series:

```
In [19]: index = pd.MultiIndex.from_product([[2,1], ['a', 'b']])
In [20]: df = pd.DataFrame(np.random.randn(4), index=index, columns=['A'])
In [21]: df
Out[21]:
     A
2 a -0.370647
    b -1.157892
1 a -1.344312
    b  0.844885
In [22]: all(df.unstack().stack() == df.sort_index())
True
```

The above code will raise a `TypeError` if the call to `sort_index` is removed.

18.2.1 Multiple Levels

You may also stack or unstack more than one level at a time by passing a list of levels, in which case the end result is as if each level in the list were processed individually.

```
In [23]: columns = pd.MultiIndex.from_tuples([
         ('A', 'cat', 'long'), ('B', 'cat', 'long'),
         ('A', 'dog', 'short'), ('B', 'dog', 'short')
     ], names=['exp', 'animal', 'hair_length'])
```

(continues on next page)
In [24]: df = pd.DataFrame(np.random.randn(4, 4), columns=columns)

In [25]: df
Out[25]:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>animal</td>
<td>cat</td>
<td>cat</td>
<td>dog</td>
<td>dog</td>
</tr>
<tr>
<td>hair_length</td>
<td>long</td>
<td>long</td>
<td>short</td>
<td>short</td>
</tr>
<tr>
<td>0</td>
<td>1.075770</td>
<td>-0.109050</td>
<td>1.643563</td>
<td>-1.469388</td>
</tr>
<tr>
<td>1</td>
<td>0.357021</td>
<td>-0.674600</td>
<td>-1.776904</td>
<td>-0.968914</td>
</tr>
<tr>
<td>2</td>
<td>-1.294524</td>
<td>0.413738</td>
<td>0.276662</td>
<td>-0.472035</td>
</tr>
<tr>
<td>3</td>
<td>-0.013960</td>
<td>-0.362543</td>
<td>-0.006154</td>
<td>-0.923061</td>
</tr>
</tbody>
</table>

In [26]: df.stack(level=['animal', 'hair_length'])

 exp  A          B
animal hair_length
0 cat long 1.075770 -0.109050
  dog short 1.643563 -1.469388
1 cat long 0.357021 -0.674600
  dog short -1.776904 -0.968914
2 cat long -1.294524 0.413738
  dog short 0.276662 -0.472035
3 cat long -0.013960 -0.362543
  dog short -0.006154 -0.923061

The list of levels can contain either level names or level numbers (but not a mixture of the two).

# df.stack(level=['animal', 'hair_length'])
# from above is equivalent to:

In [27]: df.stack(level=[1, 2])
Out[27]:

 exp  A          B
animal hair_length
0 cat long 1.075770 -0.109050
  dog short 1.643563 -1.469388
1 cat long 0.357021 -0.674600
  dog short -1.776904 -0.968914
2 cat long -1.294524 0.413738
  dog short 0.276662 -0.472035
3 cat long -0.013960 -0.362543
  dog short -0.006154 -0.923061

18.2.2 Missing Data

These functions are intelligent about handling missing data and do not expect each subgroup within the hierarchical index to have the same set of labels. They also can handle the index being unsorted (but you can make it sorted by calling sort_index, of course). Here is a more complex example:

In [28]: columns = pd.MultiIndex.from_tuples([('A', 'cat'), ('B', 'dog'),
                                           ('B', 'cat'), ('A', 'dog')],
                                          names=['exp', 'animal'])

(continues on next page)
As mentioned above, stack can be called with a level argument to select which level in the columns to stack:

```
In [33]: df2.stack('exp')
Out[33]:
        A         B
animal
first second
bar   one 0.895717  0.805244
      two 1.431256  1.340309
baz   one 0.410835  0.132003
      two 0.875906 -2.211372
foo   one 1.413681  1.607920
      two 0.875906 -2.006747
qux   two 0.769804  0.769804

In [34]: df2.stack('animal')
```

(continues on next page)
Unstacking can result in missing values if subgroups do not have the same set of labels. By default, missing values will be replaced with the default fill value for that data type, NaN for float, NaT for datetimelike, etc. For integer types, by default data will be converted to float and missing values will be set to NaN.

```
In [35]: df3 = df.iloc[[0, 1, 4, 7], [1, 2]]

In [36]: df3
Out[36]:
exp  
animal  B
first second
bar one 0.805244 -1.206412
  two 1.340309 -1.170299
foo one 1.607920 1.024180
  two 0.769804 -1.281247
qux two -1.226825 -1.281247

dog  

   0.727707 0.769804
```

New in version 0.18.0.

Alternatively, unstack takes an optional fill_value argument, for specifying the value of missing data.

```
In [37]: df3.unstack()

exp  
animal  B
animal dog cat
first second
bar one 0.805244 1.340309 -1.206412 
  two 1.340309 -1.170299 
foo one 1.607920 NaN 1.024180
  two 0.769804 NaN -1.281247
qux NaN NaN NaN NaN
```

```
In [38]: df3.unstack(fill_value=-1e9)

exp  
animal  B
animal dog cat
first second
bar one 8.052440e-01 1.340309e+00 -1.206412e+00
  two 1.340309e+00 -1.170299e+00
foo one 1.607920e+00 -1.000000e+09 1.024180e+00
  two -1.000000e+09 7.698036e-01 -1.281247e+00
qux -1.000000e+09 7.698036e-01 -1.000000e+09 -1.281247e+00
```

### 18.2.3 With a MultiIndex

Unstacking when the columns are a MultiIndex is also careful about doing the right thing:

```
In [39]: df[:3].unstack(0)

exp  
animal  B
animal cat dog cat dog
first second
bar one 0.895717 0.410835 0.805244 0.81385 -1.206412 0.132003 2.565646
  two 0.805244 -1.206412 -1.206412e+00 -1.206412e+00
foo one 0.805244 -1.206412 0.805244 0.81385 -1.206412 0.132003 2.565646
  two 0.805244 -1.206412 -1.206412e+00 -1.206412e+00
qux one 0.895717 0.410835 0.805244 0.81385 -1.206412 0.132003 2.565646
  two 0.805244 -1.206412 -1.206412e+00 -1.206412e+00
```
18.3 Reshaping by Melt

The top-level `melt()` function and the corresponding `DataFrame.melt()` are useful to massage a DataFrame into a format where one or more columns are identifier variables, while all other columns, considered measured variables, are “unpivoted” to the row axis, leaving just two non-identifier columns, “variable” and “value”. The names of those columns can be customized by supplying the `var_name` and `value_name` parameters.

For instance,

```python
In [41]: cheese = pd.DataFrame({'first': ['John', 'Mary'],
                           'last': ['Doe', 'Bo'],
                           'height': [5.5, 6.0],
                           'weight': [130, 150]})
```

```
In [42]: cheese
Out[42]:
```

The top-level `melt()` function and the corresponding `DataFrame.melt()` are useful to massage a DataFrame into a format where one or more columns are identifier variables, while all other columns, considered measured variables, are “unpivoted” to the row axis, leaving just two non-identifier columns, “variable” and “value”. The names of those columns can be customized by supplying the `var_name` and `value_name` parameters.

For instance,

```python
In [41]: cheese = pd.DataFrame({'first': ['John', 'Mary'],
                           'last': ['Doe', 'Bo'],
                           'height': [5.5, 6.0],
                           'weight': [130, 150]})
```

```
In [42]: cheese
Out[42]:
```
Another way to transform is to use the `wide_to_long()` panel data convenience function. It is less flexible than `melt()`, but more user-friendly.

```python
In [45]: dft = pd.DataFrame({
    "A1970" : {0 : "a", 1 : "b", 2 : "c"},
    ....:    "A1980" : {0 : "d", 1 : "e", 2 : "f"},
    ....:    "B1970" : {0 : 2.5, 1 : 1.2, 2 : .7},
    ....:    "B1980" : {0 : 3.2, 1 : 1.3, 2 : .1},
    ....:    "X" : dict(zip(range(3), np.random.randn(3))
    ....:    })

In [46]: dft["id"] = dft.index

In [47]: dft
Out[47]:
0      a      d  2.5    3.2 -0.121306     0
1      b      e  1.2    1.3 -0.097883     1
2      c      f  0.7    0.1  0.695775     2

In [48]: pd.wide_to_long(dft, ["A", "B"], i="id", j="year")
```

```output
   X  A   B
0 1970 -0.121306 a  2.5
1 1970 -0.097883 b  1.2
2 1970  0.695775 c  0.7
0 1980 -0.121306 d  3.2
1 1980 -0.097883 e  1.3
2 1980  0.695775 f  0.1
```
18.4 Combining with stats and GroupBy

It should be no shock that combining `pivot`/`stack`/`unstack` with `GroupBy` and the basic `Series` and `DataFrame` statistical functions can produce some very expressive and fast data manipulations.

```
In [49]: df
Out[49]:
exp  A     B
    cat   dog cat   dog
animal first second
bar  one 0.895717 0.805244 -1.206412 2.565646
    two 1.431256 1.340309 -1.170299 -0.226169
baz  one 0.410835 0.813850 0.132003 -0.827317
    two -0.076467 -1.187678 1.130127 -1.436737
foo  one -1.413681 1.607920 1.024180 0.569605
    two 0.875906 -2.211372 0.974466 -2.006747
qux  one -0.410001 -0.078638 0.545952 -1.219217
    two -1.226825 0.769804 -1.281247 -0.727707

In [50]: df.stack().mean(1).unstack()
animal   cat    dog
first second
bar   one   -0.155347 1.685445
    two    0.130479 0.557070
baz   one    0.271419 -0.006733
    two    0.526830 -1.312207
foo   one   -0.194750 1.088763
    two    0.925186 -2.109060
qux   one    0.067976 -0.648927
    two   -1.254036 0.021048

# same result, another way
In [51]: df.groupby(level=1, axis=1).mean()
animal   cat    dog
first second
bar   one   -0.155347 1.685445
    two    0.130479 0.557070
baz   one    0.271419 -0.006733
    two    0.526830 -1.312207
foo   one   -0.194750 1.088763
    two    0.925186 -2.109060
qux   one    0.067976 -0.648927
    two   -1.254036 0.021048

In [52]: df.stack().groupby(level=1).mean()
exp second
    A     B
one  0.071448 0.455513
    -0.424186 -0.204486

In [53]: df.mean().unstack(0)
```

(continues on next page)
\begin{tabular}{lrr}
  \hline
  \textbf{exp} & \textbf{A} & \textbf{B} \\
  \hline
  animal & 0.060843 & 0.018596 \\
  cat & -0.413580 & 0.232430 \\
  \hline
\end{tabular}

18.5 Pivot tables

While \texttt{pivot()} provides general purpose pivoting with various data types (strings, numerics, etc.), pandas also provides \texttt{pivot_table()} for pivoting with aggregation of numeric data.

The function \texttt{pivot_table()} can be used to create spreadsheet-style pivot tables. See the \texttt{cookbook} for some advanced strategies.

It takes a number of arguments:

- **data**: a DataFrame object.
- **values**: a column or a list of columns to aggregate.
- **index**: a column, Grouper, array which has the same length as data, or list of them. Keys to group by on the pivot table index. If an array is passed, it is being used as the same manner as column values.
- **columns**: a column, Grouper, array which has the same length as data, or list of them. Keys to group by on the pivot table column. If an array is passed, it is being used as the same manner as column values.
- **aggfunc**: function to use for aggregation, defaulting to \texttt{numpy.mean}.

Consider a data set like this:

\begin{verbatim}
In [54]: import datetime
In [55]: df = pd.DataFrame({'A': ['one', 'one', 'two', 'three'] * 6,
                         'B': ['A', 'B', 'C'] * 8,
                         'C': ['foo', 'foo', 'foo', 'bar', 'bar', 'bar'] * 4,
                         'D': np.random.randn(24),
                         'E': np.random.randn(24),
                         'F': [datetime.datetime(2013, i, 1) for i in range(1, 13)] +
                         [datetime.datetime(2013, i, 15) for i in range(1, 13)]})
In [56]: df
Out [56]:
\end{verbatim}
We can produce pivot tables from this data very easily:

```
In [57]: pd.pivot_table(df, values='D', index=['A', 'B'], columns=['C'])
Out[57]:
                   C    bar    foo
   A          B
one A  1.120915 -0.514058
       B -0.338421  0.002759
       C -0.538846  0.699535
three A -1.181568    NaN
       B    NaN  0.433512
       C   0.588783    NaN
two A   NaN  1.000985
       B  0.158248    NaN
       C -0.176180    NaN
```

```
In [58]: pd.pivot_table(df, values='D', index=['B'], columns=['A', 'C'], aggfunc=np.sum)
Out[58]:
            A one       three       two
   C      B  bar foo   bar foo   bar foo
one
A   2.241830 -1.028115 -2.363137    NaN    NaN  2.001971
B -0.676843  0.005518    NaN  0.867024  0.316495    NaN
C -1.077692  1.399070  1.177566    NaN    NaN  0.352360
```

```
In [59]: pd.pivot_table(df, values=['D','E'], index=['B'], columns=['A', 'C'], aggfunc=np.sum)
Out[59]:
    D ...        E
         A one       three       two ... one       three
         B                   ...                   ...
   C       two
         B                   ...                   ...
         A  2.241830 -1.028115 -2.363137    NaN    NaN ... -0.043211  1.922577
         B -0.676843  0.005518    NaN  0.867024  0.316495 ... -1.103384    NaN -2.
         C -1.077692  1.399070  1.177566    NaN    NaN ...  1.495717 -0.263660
   B                   ...                   ...
         A   NaN    NaN  0.128491    NaN    NaN ... -0.194294    NaN -2.
         B   NaN    NaN -1.103384    NaN    NaN ... -1.103384    NaN -2.
         C   NaN    NaN  0.128491    NaN    NaN ...  1.495717 -0.263660
[3 rows x 12 columns]
```

The result object is a DataFrame having potentially hierarchical indexes on the rows and columns. If the values
column name is not given, the pivot table will include all of the data that can be aggregated in an additional level of hierarchy in the columns:

```
In [60]: pd.pivot_table(df, index=['A', 'B'], columns=['C'])
Out[60]:

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th></th>
<th>E</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>bar</td>
<td>foo</td>
<td>bar</td>
<td>foo</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>one</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>-0.514058</td>
<td>1.393057</td>
<td>-0.021605</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>-0.338421</td>
<td>0.002759</td>
<td>0.684140</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>-0.538846</td>
<td>0.699535</td>
<td>-0.988442</td>
</tr>
<tr>
<td>three</td>
<td>A</td>
<td>-1.181568</td>
<td>NaN</td>
<td>0.961289</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>NaN</td>
<td>0.433512</td>
<td>NaN</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0.588783</td>
<td>NaN</td>
<td>-0.131830</td>
</tr>
<tr>
<td>two</td>
<td>A</td>
<td>NaN</td>
<td>1.000985</td>
<td>NaN</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.158248</td>
<td>NaN</td>
<td>-0.097147</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>NaN</td>
<td>0.176180</td>
<td>NaN</td>
</tr>
</tbody>
</table>
```

Also, you can use `Grouper` for `index` and `columns` keywords. For detail of `Grouper`, see *Grouping with a Grouper specification*.

```
In [61]: pd.pivot_table(df, values='D', index=pd.Grouper(freq='M', key='F'), columns=['C'])
Out[61]:

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-01-31</td>
<td>NaN</td>
<td>-0.514058</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-02-28</td>
<td>NaN</td>
<td>0.002759</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-03-31</td>
<td>NaN</td>
<td>0.176180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-04-30</td>
<td>-1.181568</td>
<td>NaN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-05-31</td>
<td>-0.338421</td>
<td>NaN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-06-30</td>
<td>-0.538846</td>
<td>NaN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-07-31</td>
<td>NaN</td>
<td>1.000985</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-08-31</td>
<td>NaN</td>
<td>0.433512</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-09-30</td>
<td>NaN</td>
<td>0.699535</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-10-31</td>
<td>1.120915</td>
<td>NaN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-11-30</td>
<td>0.158248</td>
<td>NaN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-12-31</td>
<td>0.588783</td>
<td>NaN</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

You can render a nice output of the table omitting the missing values by calling `to_string` if you wish:

```
In [62]: table = pd.pivot_table(df, index=['A', 'B'], columns=['C'])
```

```
In [63]: print(table.to_string(na_rep=''))
```

```
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td></td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>bar</td>
<td>foo</td>
<td>bar</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>one</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>-0.514058</td>
<td>1.393057</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>-0.338421</td>
<td>0.002759</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>-0.538846</td>
<td>0.699535</td>
</tr>
<tr>
<td>three</td>
<td>A</td>
<td>-1.181568</td>
<td>0.961289</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.433512</td>
<td>NaN</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0.588783</td>
<td>-0.131830</td>
</tr>
<tr>
<td>two</td>
<td>A</td>
<td>1.000985</td>
<td>NaN</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.158248</td>
<td>-0.097147</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0.176180</td>
<td>0.436241</td>
</tr>
</tbody>
</table>
```

Note that `pivot_table` is also available as an instance method on DataFrame, i.e. `DataFrame.pivot_table()`.

924 Chapter 18. Reshaping and Pivot Tables
18.5.1 Adding margins

If you pass `margins=True` to `pivot_table`, special `All` columns and rows will be added with partial group aggregates across the categories on the rows and columns:

```python
In [64]: df.pivot_table(index=['A', 'B'], columns='C', margins=True, aggfunc=np.std)
Out[64]:
       D       E
   bar  foo  All  bar  foo  All
A
one  1.804346 1.210272 1.569879 0.179483 0.418374 0.858005
    0.690376 1.353355 0.898998 1.083825 0.968138 1.101401
    0.273641 0.418926 0.771139 1.689271 0.446140 1.422136
three  0.794212 NaN  2.049040  NaN  2.049040
      NaN  0.363548  0.363548  NaN  1.625237  1.625237
      3.915454 NaN  3.915454  1.035215  NaN  1.035215
two  0.442998  NaN  0.442998  NaN  0.447104  0.447104
     0.202765  NaN  0.202765  0.560757  NaN  0.560757
      NaN  1.819408  1.819408  NaN  0.650439  0.650439
All  1.556868  0.952552  1.246608  1.250924  0.899904  1.059389
    1.556868  0.952552  1.246608  1.250924  0.899904  1.059389
```

18.6 Cross tabulations

Use `crosstab()` to compute a cross-tabulation of two (or more) factors. By default `crosstab` computes a frequency table of the factors unless an array of values and an aggregation function are passed.

It takes a number of arguments

- `index`: array-like, values to group by in the rows.
- `columns`: array-like, values to group by in the columns.
- `values`: array-like, optional, array of values to aggregate according to the factors.
- `aggfunc`: function, optional, If no values array is passed, computes a frequency table.
- `rownames`: sequence, default `None`, must match number of row arrays passed.
- `colnames`: sequence, default `None`, if passed, must match number of column arrays passed.
- `margins`: boolean, default `False`, Add row/column margins (subtotals)
- `normalize`: boolean, {‘all’, ‘index’, ‘columns’}, or {0,1}, default `False`. Normalize by dividing all values by the sum of values.

Any `Series` passed will have their name attributes used unless row or column names for the cross-tabulation are specified

For example:

```python
In [65]: foo, bar, dull, shiny, one, two = 'foo', 'bar', 'dull', 'shiny', 'one', 'two'
In [66]: a = np.array([foo, foo, bar, bar, foo, foo], dtype=object)
In [67]: b = np.array([one, one, two, one, two, one], dtype=object)
In [68]: c = np.array([dull, dull, shiny, dull, dull, shiny], dtype=object)
In [69]: pd.crosstab(a, [b, c], rownames=['a'], colnames=['b', 'c'])
```
Out[69]:

<table>
<thead>
<tr>
<th>b</th>
<th>one</th>
<th>two</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>dull</td>
<td>shiny</td>
</tr>
<tr>
<td>a</td>
<td>bar</td>
<td>1</td>
</tr>
<tr>
<td>foo</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

If `crosstab` receives only two Series, it will provide a frequency table.

In [70]: df = pd.DataFrame({'A': [1, 2, 2, 2, 2], 'B': [3, 3, 4, 4, 4],
                      'C': [1, 1, np.nan, 1, 1]})

In [71]: df

Out[71]:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

In [72]: pd.crosstab(df.A, df.B)

Out[72]:

<table>
<thead>
<tr>
<th></th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Any input passed containing `Categorical` data will have all of its categories included in the cross-tabulation, even if the actual data does not contain any instances of a particular category.

In [73]: foo = pd.Categorical(['a', 'b'], categories=['a', 'b', 'c'])

In [74]: bar = pd.Categorical(['d', 'e'], categories=['d', 'e', 'f'])

In [75]: pd.crosstab(foo, bar)

Out[75]:

<table>
<thead>
<tr>
<th></th>
<th>d</th>
<th>e</th>
</tr>
</thead>
<tbody>
<tr>
<td>row_0</td>
<td>a</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>1</td>
</tr>
</tbody>
</table>

### 18.6.1 Normalization

New in version 0.18.1.

Frequency tables can also be normalized to show percentages rather than counts using the `normalize` argument:

In [76]: pd.crosstab(df.A, df.B, normalize=True)

Out[76]:

<table>
<thead>
<tr>
<th></th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>0.6</td>
</tr>
</tbody>
</table>
normalize can also normalize values within each row or within each column:

```python
In [77]: pd.crosstab(df.A, df.B, normalize='columns')
Out[77]:
    B  3  4
   A
   1  0.5  0.0
   2  0.5  1.0
```

crosstab can also be passed a third Series and an aggregation function (aggfunc) that will be applied to the values of the third Series within each group defined by the first two Series:

```python
In [78]: pd.crosstab(df.A, df.B, values=df.C, aggfunc=np.sum)
Out[78]:
    B  3  4
   A
   1  1.0  NaN
   2  1.0  2.0
```

### 18.6.2 Adding Margins

Finally, one can also add margins or normalize this output.

```python
In [79]: pd.crosstab(df.A, df.B, values=df.C, aggfunc=np.sum, normalize=True, margins=True)
```

### 18.7 Tiling

The `cut()` function computes groupings for the values of the input array and is often used to transform continuous variables to discrete or categorical variables:

```python
In [80]: ages = np.array([10, 15, 13, 12, 23, 25, 28, 59, 60])

In [81]: pd.cut(ages, bins=3)
Out[81]:
```

If the `bins` keyword is an integer, then equal-width bins are formed. Alternatively we can specify custom bin-edges:

```python
In [82]: c = pd.cut(ages, bins=[0, 18, 35, 70])
In [83]: c
Out[83]:
```

(continues on next page)
(continued from previous page)

New in version 0.20.0.

If the bins keyword is an IntervalIndex, then these will be used to bin the passed data:

```python
pd.cut([25, 20, 50], bins=c.categories)
```

## 18.8 Computing indicator / dummy variables

To convert a categorical variable into a “dummy” or “indicator” DataFrame, for example a column in a DataFrame (a Series) which has \( k \) distinct values, can derive a DataFrame containing \( k \) columns of 1s and 0s using `get_dummies()`:

```python
In [84]: df = pd.DataFrame({'key': list('bbacab'), 'data1': range(6)})
In [85]: pd.get_dummies(df['key'])
Out[85]:
   a  b  c
0  0  1  0
1  0  1  0
2  1  0  0
3  0  0  1
4  1  0  0
5  0  1  0
```

Sometimes it’s useful to prefix the column names, for example when merging the result with the original DataFrame:

```python
In [86]: dummies = pd.get_dummies(df['key'], prefix='key')
In [87]: dummies
Out[87]:
   key_a  key_b  key_c
0     0     1     0
1     0     1     0
2     1     0     0
3     0     0     1
4     1     0     0
5     0     1     0
```

```python
In [88]: df[['data1']].join(dummies)
```

This function is often used along with discretization functions like `cut`:
In [89]: values = np.random.randn(10)

In [90]: values
Out[90]:
array([ 0.4082, -1.0481, -0.0257, -0.9884,  0.0941,  1.2627,  1.29 
       ,  0.0824, -0.0558,  0.5366])

In [91]: bins = [0, 0.2, 0.4, 0.6, 0.8, 1]

In [92]: pd.get_dummies(pd.cut(values, bins))
Out[92]:
(0.0, 0.2] (0.2, 0.4] (0.4, 0.6] (0.6, 0.8] (0.8, 1.0]
0   0   0   1   0   0
1   0   0   0   0   0
2   0   0   0   0   0
3   0   0   0   0   0
4   1   0   0   0   0
5   0   0   0   0   0
6   0   0   0   0   0
7   1   0   0   0   0
8   0   0   0   0   0
9   0   0   1   0   0

See also Series.str.get_dummies.

get_dummies() also accepts a DataFrame. By default all categorical variables (categorical in the statistical sense, those with object or categorical dtype) are encoded as dummy variables.

In [93]: df = pd.DataFrame({'A': ['a', 'b', 'a'], 'B': ['c', 'c', 'b'],
                   'C': [1, 2, 3]})

In [94]: pd.get_dummies(df)
Out[94]:
   C  A_a  A_b  B_b  B_c
0  1    1    0    0    1
1  2    0    1    0    1
2  3    1    0    1    0

All non-object columns are included untouched in the output. You can control the columns that are encoded with the columns keyword.

In [95]: pd.get_dummies(df, columns=['A'])
Out[95]:
   B  C  A_a  A_b
0  c  1    1    1
1  c  2    0    1
2  b  3    1    0

Notice that the B column is still included in the output, it just hasn’t been encoded. You can drop B before calling get_dummies if you don’t want to include it in the output.

As with the Series version, you can pass values for the prefix and prefix_sep. By default the column name is used as the prefix, and '_' as the prefix separator. You can specify prefix and prefix_sep in 3 ways:

- string: Use the same value for prefix or prefix_sep for each column to be encoded.
- list: Must be the same length as the number of columns being encoded.
- dict: Mapping column name to prefix.
In [96]: simple = pd.get_dummies(df, prefix='new_prefix')

In [97]: simple
Out[97]:
   C  new_prefix_a  new_prefix_b  new_prefix_b  new_prefix_c
0  1          1           0           0           1
1  2           0           1           0           1
2  3           1           0           1           0

In [98]: from_list = pd.get_dummies(df, prefix=['from_A', 'from_B'])

In [99]: from_list
Out[99]:
   C   from_A_a  from_A_b   from_B_b   from_B_c
0  1           1           0           0           1
1  2           0           1           0           1
2  3           1           0           1           0

In [100]: from_dict = pd.get_dummies(df, prefix={'B': 'from_B', 'A': 'from_A'})

In [101]: from_dict
Out[101]:
   C   from_A_a  from_A_b   from_B_b   from_B_c
0  1           1           0           0           1
1  2           0           1           0           1
2  3           1           0           1           0

New in version 0.18.0.
Sometimes it will be useful to only keep k-1 levels of a categorical variable to avoid collinearity when feeding the result to statistical models. You can switch to this mode by turn on drop_first.

In [102]: s = pd.Series(list('abcaa'))

In [103]: pd.get_dummies(s)
Out[103]:
   a  b  c
0  1  0  0
1  0  1  0
2  0  0  1
3  1  0  0
4  1  0  0

In [104]: pd.get_dummies(s, drop_first=True)

   b  c
0  0  0
1  1  0
2  0  1
3  0  0
4  0  0

When a column contains only one level, it will be omitted in the result.

In [105]: df = pd.DataFrame({'A':list('aaaaa'),'B':list('ababc')})

In [106]: pd.get_dummies(df)
Out[106]:
   A_a  B_a  B_b  B_c
0   1    1    0    0
1   1    0    1    0
2   1    1    0    0
3   1    0    1    0
4   1    0    0    1

In [107]: pd.get_dummies(df, drop_first=True)

→
   B_b  B_c
0    0    0
1    1    0
2    0    0
3    1    0
4    0    1

By default new columns will have np.uint8 dtype. To choose another dtype, use the ‘dtype’ argument:

In [108]: df = pd.DataFrame({'A': list('abc'), 'B': [1.1, 2.2, 3.3]})

In [109]: pd.get_dummies(df, dtype=bool).dtypes
Out[109]:
   B    float64
  A_a   bool
  A_b   bool
  A_c   bool
dtype: object

New in version 0.23.0.

18.9 Factorizing values

To encode 1-d values as an enumerated type use factorize():

In [110]: x = pd.Series(['A', 'A', np.nan, 'B', 3.14, np.inf])

In [111]: x
Out[111]:
   0    A
   1    A
   2  NaN
   3    B
   4    3.14
   5     inf
dtype: object

In [112]: labels, uniques = pd.factorize(x)

In [113]: labels
Out[113]: array([ 0,  0, -1,  1,  2,  3])

In [114]: uniques

(continues on next page)
Note that `factorize` is similar to `numpy.unique`, but differs in its handling of NaN:

**Note:** The following `numpy.unique` will fail under Python 3 with a `TypeError` because of an ordering bug. See also here.

```python
In [2]: pd.factorize(x, sort=True)
Out[2]:
(array([ 2, 2, -1, 3,  0,  1]),
 Index([3.14, inf, u'A', u'B'], dtype='object'))
```

```python
In [3]: np.unique(x, return_inverse=True)[::-1]
Out[3]: (array([3, 3, 0, 4, 1, 2]), array([nan, 3.14, inf, 'A', 'B'], dtype=object))
```

**Note:** If you just want to handle one column as a categorical variable (like R's factor), you can use `df['cat_col'] = pd.Categorical(df['col'])` or `df['cat_col'] = df['col'].astype('category')`. For full docs on `Categorical`, see the `Categorical introduction` and the `API documentation`. 

pandas has proven very successful as a tool for working with time series data, especially in the financial data analysis space. Using the NumPy datetime64 and timedelta64 dtypes, we have consolidated a large number of features from other Python libraries like scikits.timeseries as well as created a tremendous amount of new functionality for manipulating time series data.

In working with time series data, we will frequently seek to:

- generate sequences of fixed-frequency dates and time spans
- conform or convert time series to a particular frequency
- compute “relative” dates based on various non-standard time increments (e.g. 5 business days before the last business day of the year), or “roll” dates forward or backward

pandas provides a relatively compact and self-contained set of tools for performing the above tasks.

Create a range of dates:

```python
# 72 hours starting with midnight Jan 1st, 2011
In [1]: rng = pd.date_range('1/1/2011', periods=72, freq='H')
In [2]: rng[:5]
Out[2]:
```

```python
DatetimeIndex(['2011-01-01 00:00:00', '2011-01-01 01:00:00',
              '2011-01-01 02:00:00', '2011-01-01 03:00:00',
              '2011-01-01 04:00:00'],
             dtype='datetime64[ns]', freq='H')
```

Index pandas objects with dates:

```python
In [3]: ts = pd.Series(np.random.randn(len(rng)), index=rng)
In [4]: ts.head()
Out[4]:
```

```python
2011-01-01 00:00:00 0.469112
2011-01-01 01:00:00 -0.282863
2011-01-01 02:00:00 -1.509059
2011-01-01 03:00:00 -1.135632
2011-01-01 04:00:00 1.212112
Freq: H, dtype: float64
```

Change frequency and fill gaps:

```python
# to 45 minute frequency and forward fill
In [5]: converted = ts.asfreq('45Min', method='pad')
```

(continues on next page)
In [6]: converted.head()
Out[6]:
2011-01-01 00:00:00 0.469112
2011-01-01 00:45:00 0.469112
2011-01-01 01:30:00 -0.282863
2011-01-01 02:15:00 -1.509059
2011-01-01 03:00:00 -1.135632
Freq: 45T, dtype: float64

Resample the series to a daily frequency:

# Daily means
In [7]: ts.resample('D').mean()
Out[7]:
2011-01-01 -0.319569
2011-01-02 -0.337703
2011-01-03 0.117258
Freq: D, dtype: float64

19.1 Overview

The following table shows the type of time-related classes pandas can handle and how to create them.

<table>
<thead>
<tr>
<th>Class</th>
<th>Remarks</th>
<th>How to create</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timestamp</td>
<td>Represents a single timestamp</td>
<td>to_datetime, Timestamp</td>
</tr>
<tr>
<td>DatetimeIndex</td>
<td>Index of Timestamp</td>
<td>to_datetime, date_range, bdate_range, DatetimeIndex</td>
</tr>
<tr>
<td>Period</td>
<td>Represents a single time span</td>
<td>Period</td>
</tr>
<tr>
<td>PeriodIndex</td>
<td>Index of Period</td>
<td>period_range, PeriodIndex</td>
</tr>
</tbody>
</table>

19.2 Timestamps vs. Time Spans

Timestamped data is the most basic type of time series data that associates values with points in time. For pandas objects it means using the points in time.

In [8]: pd.Timestamp(datetime(2012, 5, 1))
Out[8]: Timestamp('2012-05-01 00:00:00')

In [9]: pd.Timestamp('2012-05-01')
Out[9]: Timestamp('2012-05-01 00:00:00')

In [10]: pd.Timestamp(2012, 5, 1)
Out[10]: Timestamp('2012-05-01 00:00:00')

However, in many cases it is more natural to associate things like change variables with a time span instead. The span represented by Period can be specified explicitly, or inferred from datetime string format.

For example:
In [11]: pd.Period('2011-01')
Out[11]: Period('2011-01', 'M')

In [12]: pd.Period('2012-05', freq='D')
Out[12]: Period('2012-05-01', 'D')

**Timestamp** and **Period** can serve as an index. Lists of Timestamp and Period are automatically coerced to **DatetimeIndex** and **PeriodIndex** respectively.

In [14]: ts = pd.Series(np.random.randn(3), dates)
In [15]: type(ts.index)
Out[15]: pandas.core.indexes.datetimes.DatetimeIndex

In [16]: ts.index
Out[16]: DatetimeIndex(['2012-05-01', '2012-05-02', '2012-05-03'], dtype='datetime64[ns]', freq=None)

In [17]: ts
Out[17]:
2012-05-01 -0.410001
2012-05-02 -0.078638
2012-05-03  0.545952
dtype: float64

In [18]: periods = [pd.Period('2012-01'), pd.Period('2012-02'), pd.Period('2012-03')]
In [19]: ts = pd.Series(np.random.randn(3), periods)
In [20]: type(ts.index)
Out[20]: pandas.core.indexes.period.PeriodIndex

In [21]: ts.index
Out[21]: PeriodIndex(['2012-01', '2012-02', '2012-03'], dtype='period[M]', freq='M')

In [22]: ts
Out[22]:
2012-01  -1.219217
2012-02  -1.226825
2012-03   0.769804
Freq: M, dtype: float64

pandas allows you to capture both representations and convert between them. Under the hood, pandas represents timestamps using instances of **Timestamp** and sequences of timestamps using instances of **DatetimeIndex**. For regular time spans, pandas uses **Period** objects for scalar values and **PeriodIndex** for sequences of spans. Better support for irregular intervals with arbitrary start and end points are forth-coming in future releases.

19.2. Timestamps vs. Time Spans
19.3 Converting to Timestamps

To convert a `Series` or list-like object of date-like objects e.g. strings, epochs, or a mixture, you can use the `to_datetime` function. When passed a `Series`, this returns a `Series` (with the same index), while a list-like is converted to a `DatetimeIndex`:

```python
In [23]: pd.to_datetime(pd.Series(["Jul 31, 2009", '2010-01-10', None]))
Out[23]:
0  2009-07-31
1  2010-01-10
2  NaT
dtype: datetime64[ns]
```

```python
In [24]: pd.to_datetime(["2005/11/23", '2010.12.31'])
```

If you use dates which start with the day first (i.e. European style), you can pass the `dayfirst` flag:

```python
In [25]: pd.to_datetime(["04-01-2012 10:00"], dayfirst=True)
Out[25]:
 DatetimeIndex(["2012-01-04 10:00:00"], dtype='datetime64[ns]', freq=None)
```

```python
In [26]: pd.to_datetime(["14-01-2012", "01-14-2012"], dayfirst=True)
```

**Warning:** You see in the above example that `dayfirst` isn’t strict, so if a date can’t be parsed with the day being first it will be parsed as if `dayfirst` were False.

If you pass a single string to `to_datetime`, it returns a single `Timestamp`. `Timestamp` can also accept string input, but it doesn’t accept string parsing options like `dayfirst` or `format`, so use `to_datetime` if these are required.

```python
In [27]: pd.to_datetime('2010/11/12')
Out[27]: Timestamp('2010-11-12 00:00:00')
```

```python
In [28]: pd.Timestamp('2010/11/12')
```

19.3.1 Providing a Format Argument

In addition to the required datetime string, a `format` argument can be passed to ensure specific parsing. This could also potentially speed up the conversion considerably.

```python
In [29]: pd.to_datetime('2010/11/12', format='%Y/%m/%d')
Out[29]:
 Timestamp('2010-11-12 00:00:00')
```

```python
In [30]: pd.to_datetime('12-11-2010 00:00', format='%d-%m-%Y %H:%M')
```

For more information on the choices available when specifying the `format` option, see the Python `datetime` documentation.
19.3.2 Assembling Datetime from Multiple DataFrame Columns

New in version 0.18.1.

You can also pass a DataFrame of integer or string columns to assemble into a Series of Timestamps.

```
In [31]: df = pd.DataFrame({'year': [2015, 2016],
          ....:               'month': [2, 3],
          ....:               'day': [4, 5],
          ....:               'hour': [2, 3]})
```

```
In [32]: pd.to_datetime(df)
Out[32]:
0 2015-02-04 02:00:00
1 2016-03-05 03:00:00
dtype: datetime64[ns]
```

You can pass only the columns that you need to assemble.

```
In [33]: pd.to_datetime(df[['year', 'month', 'day']])
Out[33]:
0 2015-02-04
1 2016-03-05
dtype: datetime64[ns]
```

`pd.to_datetime` looks for standard designations of the datetime component in the column names, including:

- **required**: year, month, day
- **optional**: hour, minute, second, millisecond, microsecond, nanosecond

19.3.3 Invalid Data

The default behavior, `errors='raise'`, is to raise when unparsable:

```
In [2]: pd.to_datetime(['2009/07/31', 'asd'], errors='raise')
ValueError: Unknown string format
```

Pass `errors='ignore'` to return the original input when unparsable:

```
In [34]: pd.to_datetime(['2009/07/31', 'asd'], errors='ignore')
Out[34]: array(['2009/07/31', 'asd'], dtype=object)
```

Pass `errors='coerce'` to convert unparsable data to NaT (not a time):

```
In [35]: pd.to_datetime(['2009/07/31', 'asd'], errors='coerce')
Out[35]: DatetimeIndex(['2009-07-31', 'NaT'], dtype='datetime64[ns]', freq=None)
```

19.3.4 Epoch Timestamps

pandas supports converting integer or float epoch times to `Timestamp` and `DatetimeIndex`. The default unit is nanoseconds, since that is how `Timestamp` objects are stored internally. However, epochs are often stored in another unit which can be specified. These are computed from the starting point specified by the `origin` parameter.
In [36]: pd.to_datetime([1349720105, 1349806505, 1349892905, 1349979305, 1350065705], unit='s')

Out[36]:
dtype='datetime64[ns]', freq=None)

In [37]: pd.to_datetime([1349720105100, 1349720105200, 1349720105300, 1349720105400, 1349720105500], unit='ms')

Out[37]:
DateTimeIndex(['2012-10-08 18:15:05.100000', '2012-10-08 18:15:05.200000', '2012-10-08 18:15:05.300000', '2012-10-08 18:15:05.400000', '2012-10-08 18:15:05.500000'],
dtype='datetime64[ns]', freq=None)

Note: Epoch times will be rounded to the nearest nanosecond.

Warning: Conversion of float epoch times can lead to inaccurate and unexpected results. Python floats have about 15 digits precision in decimal. Rounding during conversion from float to high precision Timestamp is unavoidable. The only way to achieve exact precision is to use a fixed-width types (e.g. an int64).

In [38]: pd.to_datetime([1490195805.433, 1490195805.433502912], unit='s')

Out[38]:
DateTimeIndex(['2017-03-22 15:16:45.433000088', '2017-03-22 15:16:45.433502913'],
dtype='datetime64[ns]', freq=None)

In [39]: pd.to_datetime(1490195805433502912, unit='ns')

Out[39]:
Timestamp('2017-03-22 15:16:45.433502912')

See also:
Using the origin Parameter

19.3.5 From Timestamps to Epoch

To invert the operation from above, namely, to convert from a Timestamp to a ‘unix’ epoch:

In [40]: stamps = pd.date_range('2012-10-08 18:15:05', periods=4, freq='D')

In [41]: stamps
Out[41]:
DateTimeIndex(['2012-10-08 18:15:05', '2012-10-09 18:15:05', '2012-10-10 18:15:05', '2012-10-11 18:15:05'],
dtype='datetime64[ns]', freq='D')

We subtract the epoch (midnight at January 1, 1970 UTC) and then floor divide by the “unit” (1 second).

In [42]: (stamps - pd.Timestamp("1970-01-01")) // pd.Timedelta('1s')
Out[42]:
Int64Index([1349720105, 1349806505, 1349892905, 1349979305], dtype='int64')
19.3.6 Using the origin Parameter

New in version 0.20.0.

Using the origin parameter, one can specify an alternative starting point for creation of a DatetimeIndex. For example, to use 1960-01-01 as the starting date:

```
In [43]: pd.to_datetime([1, 2, 3], unit='D', origin=pd.Timestamp('1960-01-01'))
Out[43]: DatetimeIndex(['1960-01-02', '1960-01-03', '1960-01-04'], dtype='datetime64[ns]', freq=None)
```

The default is set at origin='unix', which defaults to 1970-01-01 00:00:00. Commonly called ‘unix epoch’ or POSIX time.

```
In [44]: pd.to_datetime([1, 2, 3], unit='D')
Out[44]: DatetimeIndex(['1970-01-02', '1970-01-03', '1970-01-04'], dtype='datetime64[ns]', freq=None)
```

19.4 Generating Ranges of Timestamps

To generate an index with timestamps, you can use either the DatetimeIndex or Index constructor and pass in a list of datetime objects:

```
In [45]: dates = [datetime(2012, 5, 1), datetime(2012, 5, 2), datetime(2012, 5, 3)]
   # Note the frequency information
In [46]: index = pd.DatetimeIndex(dates)

In [47]: index
Out[47]: DatetimeIndex(['2012-05-01', '2012-05-02', '2012-05-03'], dtype='datetime64[ns]', freq=None)
   # Automatically converted to DatetimeIndex
In [48]: index = pd.Index(dates)

In [49]: index
Out[49]: DatetimeIndex(['2012-05-01', '2012-05-02', '2012-05-03'], dtype='datetime64[ns]', freq=None)
```

In practice this becomes very cumbersome because we often need a very long index with a large number of timestamps. If we need timestamps on a regular frequency, we can use the date_range() and bdate_range() functions to create a DatetimeIndex. The default frequency for date_range is a calendar day while the default for bdate_range is a business day:

```
In [50]: start = datetime(2011, 1, 1)
In [51]: end = datetime(2012, 1, 1)
In [52]: index = pd.date_range(start, end)
In [53]: index
   '2011-01-09', '2011-01-10'],
   (continues on next page)
```
... '2011-12-23', '2011-12-24', '2011-12-25', '2011-12-26',
'2011-12-27', '2011-12-28', '2011-12-29', '2011-12-30',
'2011-12-31', '2012-01-01'],
dtype='datetime64[ns]', length=366, freq='D')

In [54]: index = pd.bdate_range(start, end)

In [55]: index
Out[55]:
               '2011-01-13', '2011-01-14',
               ...
               '2011-12-19', '2011-12-20', '2011-12-21', '2011-12-22',
               '2011-12-23', '2011-12-26', '2011-12-27', '2011-12-28',
               '2011-12-29', '2011-12-30'],
dtype='datetime64[ns]', length=260, freq='B')

Convenience functions like `date_range` and `bdate_range` can utilize a variety of frequency aliases:

In [56]: pd.date_range(start, periods=1000, freq='M')
Out[56]:
               '2011-09-30', '2011-10-31',
               ...
               '2093-07-31', '2093-08-31', '2093-09-30', '2093-10-31',
               '2093-11-30', '2093-12-31', '2094-01-31', '2094-02-28',
               '2094-03-31', '2094-04-30'],
dtype='datetime64[ns]', length=1000, freq='M')

In [57]: pd.bdate_range(start, periods=250, freq='BQS')

               '2012-01-02', '2012-04-02', '2012-07-02', '2012-10-01',
               '2013-01-01', '2013-04-01',
               ...
               '2071-01-01', '2071-04-01', '2071-07-01', '2071-10-01',
               '2072-01-01', '2072-04-01', '2072-07-01', '2072-10-03',
               '2073-01-02', '2073-04-03'],
dtype='datetime64[ns]', length=250, freq='BQS-JAN')

date_range and bdate_range make it easy to generate a range of dates using various combinations of parameters like start, end, periods, and freq. The start and end dates are strictly inclusive, so dates outside of those specified will not be generated:

In [58]: pd.date_range(start, end, freq='BM')
Out[58]:
               '2011-09-30', '2011-10-30',
               ...
               '2071-01-01', '2071-04-01', '2071-07-01', '2071-10-01',
               '2072-01-01', '2072-04-01', '2072-07-01', '2072-10-03',
               '2073-01-02', '2073-04-03'],
dtype='datetime64[ns]', freq='BM')

In [59]: pd.date_range(start, end, freq='W')

(continues on next page)
dtype='datetime64[ns]', freq='W-SUN')

In [60]: pd.bdate_range(end=end, periods=20)

dtype='datetime64[ns]', freq='B')

In [61]: pd.bdate_range(start=start, periods=20)

dtype='datetime64[ns]', freq='B')

New in version 0.23.0.

Specifying start, end, and periods will generate a range of evenly spaced dates from start to end inclusively, with periods number of elements in the resulting DatetimeIndex:

In [62]: pd.date_range('2018-01-01', '2018-01-05', periods=5)
Out[62]:
dtype='datetime64[ns]', freq=None)

In [63]: pd.date_range('2018-01-01', '2018-01-05', periods=10)

DatetimeIndex(['2018-01-01 00:00:00', '2018-01-01 01:00:00', '2018-01-01 02:00:00', '2018-01-01 03:00:00', '2018-01-01 04:00:00', '2018-01-01 05:00:00', '2018-01-01 06:00:00', '2018-01-01 07:00:00', '2018-01-01 08:00:00', '2018-01-01 09:00:00'],
dtype='datetime64[ns]', freq=None)
19.4.1 Custom Frequency Ranges

**Warning:** This functionality was originally exclusive to `cdate_range`, which is deprecated as of version 0.21.0 in favor of `bdate_range`. Note that `cdate_range` only utilizes the `weekmask` and `holidays` parameters when custom business day, ‘C’, is passed as the frequency string. Support has been expanded with `bdate_range` to work with any custom frequency string.

New in version 0.21.0.

`bdate_range` can also generate a range of custom frequency dates by using the `weekmask` and `holidays` parameters. These parameters will only be used if a custom frequency string is passed.

```
In [64]: weekmask = 'Mon Wed Fri'
In [65]: holidays = [datetime(2011, 1, 5), datetime(2011, 3, 14)]
In [66]: pd.bdate_range(start, end, freq='C', weekmask=weekmask, holidays=holidays)
Out[66]:
              '2011-01-24', '2011-01-26',
              '2011-12-09', '2011-12-12', '2011-12-14', '2011-12-16',
              '2011-12-19', '2011-12-21', '2011-12-23', '2011-12-26',
              '2011-12-28', '2011-12-30'],
dtype='datetime64[ns]', length=154, freq='C')
```

```
In [67]: pd.bdate_range(start, end, freq='CBMS', weekmask=weekmask)
    --->
DatetimeIndex(['2011-01-03', '2011-02-02', '2011-03-02', '2011-04-01',
                '2011-09-02', '2011-10-03', '2011-11-02', '2011-12-02'],
dtype='datetime64[ns]', freq='CBMS')
```

See also:

*Custom Business Days*

19.5 Timestamp Limitations

Since pandas represents timestamps in nanosecond resolution, the time span that can be represented using a 64-bit integer is limited to approximately 584 years:

```
In [68]: pd.Timestamp.min
Out[68]: Timestamp('1677-09-21 00:12:43.145225')
```

```
In [69]: pd.Timestamp.max
```
See also:
Representing Out-of-Bounds Spans

19.6 Indexing

One of the main uses for `DatetimeIndex` is as an index for pandas objects. The `DatetimeIndex` class contains many time series related optimizations:

- A large range of dates for various offsets are pre-computed and cached under the hood in order to make generating subsequent date ranges very fast (just have to grab a slice).
- Fast shifting using the `shift` and `tshift` method on pandas objects.
- Unioning of overlapping `DatetimeIndex` objects with the same frequency is very fast (important for fast data alignment).
- Quick access to date fields via properties such as `year`, `month`, etc.
- Regularization functions like `snap` and very fast `asof` logic.

`DatetimeIndex` objects have all the basic functionality of regular `Index` objects, and a smorgasbord of advanced time series specific methods for easy frequency processing.

See also:
Reindexing methods

**Note:** While pandas does not force you to have a sorted date index, some of these methods may have unexpected or incorrect behavior if the dates are unsorted.

`DatetimeIndex` can be used like a regular index and offers all of its intelligent functionality like selection, slicing, etc.

```
In [70]: rng = pd.date_range(start, end, freq='BM')
In [71]: ts = pd.Series(np.random.randn(len(rng)), index=rng)
In [72]: ts.index
```

```
                       dtype='datetime64[ns]', freq='BM')
```

```
In [73]: ts[:5].index
```

```
                       '2011-05-31'],
                       dtype='datetime64[ns]', freq='BM')
```

```
In [74]: ts[::2].index
```

```
Out[74]: (continues on next page)
```

(continues on next page)
19.6.1 Partial String Indexing

Dates and strings that parse to timestamps can be passed as indexing parameters:

In [75]: ts['1/31/2011']
Out[75]: -1.2812473076599531

In [76]: ts[datetime(2011, 12, 25):]
Out[76]:
2011-12-30 0.687738
Freq: BM, dtype: float64

In [77]: ts['10/31/2011':'12/31/2011']
Out[77]:
2011-10-31 0.149748
2011-11-30 -0.732339
2011-12-30 0.687738
Freq: BM, dtype: float64

To provide convenience for accessing longer time series, you can also pass in the year or year and month as strings:

In [78]: ts['2011']
Out[78]:
2011-01-31 -1.281247
2011-02-28 -0.727707
2011-03-31 -0.121306
2011-04-29 -0.097883
2011-05-31 0.695775
2011-06-30 0.341734
2011-07-29 0.959726
2011-08-31 -1.110336
2011-09-30 -0.619976
2011-10-31 0.149748
2011-11-30 -0.732339
2011-12-30 0.687738
Freq: BM, dtype: float64

In [79]: ts['2011-6']
Out[79]:
2011-06-30 0.341734
Freq: BM, dtype: float64

This type of slicing will work on a DataFrame with a DatetimeIndex as well. Since the partial string selection is a form of label slicing, the endpoints will be included. This would include matching times on an included date:

In [80]: dft = pd.DataFrame(randn(100000,1),
                   columns=['A'],
                   index=pd.date_range('20130101',periods=100000,freq='T'))
In [81]: dft
Out[81]:
\[
\begin{array}{c}
\text{A} \\
2013-01-01 00:00:00 0.176444 \\
2013-01-01 00:01:00 0.403310 \\
2013-01-01 00:02:00 -0.154951 \\
2013-01-01 00:03:00 0.301624 \\
2013-01-01 00:04:00 -2.179861 \\
2013-01-01 00:05:00 -1.369849 \\
2013-01-01 00:06:00 -0.954208 \\
\ldots \\
2013-03-11 10:33:00 -0.293083 \\
2013-03-11 10:34:00 -0.059881 \\
2013-03-11 10:35:00 1.252450 \\
2013-03-11 10:36:00 0.046611 \\
2013-03-11 10:37:00 0.059478 \\
2013-03-11 10:38:00 -0.286539 \\
2013-03-11 10:39:00 0.841669 \\
\end{array}
\]

[100000 rows x 1 columns]

In [82]: dft['2013']
\[
\begin{array}{c}
\text{A} \\
2013-01-01 00:00:00 0.176444 \\
2013-01-01 00:01:00 0.403310 \\
2013-01-01 00:02:00 -0.154951 \\
2013-01-01 00:03:00 0.301624 \\
2013-01-01 00:04:00 -2.179861 \\
2013-01-01 00:05:00 -1.369849 \\
2013-01-01 00:06:00 -0.954208 \\
\ldots \\
2013-03-11 10:33:00 -0.293083 \\
2013-03-11 10:34:00 -0.059881 \\
2013-03-11 10:35:00 1.252450 \\
2013-03-11 10:36:00 0.046611 \\
2013-03-11 10:37:00 0.059478 \\
2013-03-11 10:38:00 -0.286539 \\
2013-03-11 10:39:00 0.841669 \\
\end{array}
\]

[100000 rows x 1 columns]

This starts on the very first time of the month, and includes the last date and time for the month:

In [83]: dft['2013-1':'2013-2']
Out[83]:
\[
\begin{array}{c}
\text{A} \\
2013-01-01 00:00:00 0.176444 \\
2013-01-01 00:01:00 0.403310 \\
2013-01-01 00:02:00 -0.154951 \\
2013-01-01 00:03:00 0.301624 \\
2013-01-01 00:04:00 -2.179861 \\
2013-01-01 00:05:00 -1.369849 \\
2013-01-01 00:06:00 -0.954208 \\
\ldots \\
2013-03-11 10:33:00 -0.293083 \\
2013-03-11 10:34:00 -0.059881 \\
2013-03-11 10:35:00 1.252450 \\
2013-03-11 10:36:00 0.046611 \\
2013-03-11 10:37:00 0.059478 \\
2013-03-11 10:38:00 -0.286539 \\
2013-03-11 10:39:00 0.841669 \\
\end{array}
\]

[100000 rows x 1 columns]
This specifies a stop time that includes all of the times on the last day:

```
In [84]: dft['2013-1':'2013-2-28']
Out[84]:
                   A
2013-01-01 00:00:00  0.176444
2013-01-01 00:01:00  0.403310
2013-01-01 00:02:00  -0.154951
2013-01-01 00:03:00  0.301624
2013-01-01 00:04:00  -2.179861
2013-01-01 00:05:00  -1.369849
2013-01-01 00:06:00  -0.954208
...            ...
2013-02-28 23:53:00  0.103114
2013-02-28 23:54:00  -1.303422
2013-02-28 23:55:00  0.451943
2013-02-28 23:56:00  0.220534
2013-02-28 23:57:00  -1.624220
2013-02-28 23:58:00  0.093915
2013-02-28 23:59:00  -1.087454
```

[84960 rows x 1 columns]

This specifies an exact stop time (and is not the same as the above):

```
In [85]: dft['2013-1':'2013-2-28 00:00:00']
Out[85]:
                   A
2013-01-01 00:00:00  0.176444
2013-01-01 00:01:00  0.403310
2013-01-01 00:02:00  -0.154951
2013-01-01 00:03:00  0.301624
2013-01-01 00:04:00  -2.179861
2013-01-01 00:05:00  -1.369849
2013-01-01 00:06:00  -0.954208
...            ...
2013-02-27 23:54:00  0.897051
2013-02-27 23:55:00  -0.309230
2013-02-27 23:56:00  1.944713
2013-02-27 23:57:00  0.369265
2013-02-27 23:58:00  0.053071
2013-02-27 23:59:00  -0.019734
2013-02-28 00:00:00  1.388189
```

[83521 rows x 1 columns]

We are stopping on the included end-point as it is part of the index:
In [86]: dft['2013-1-15':'2013-1-15 12:30:00']
Out[86]:
      A
2013-01-15 00:00:00  0.501288
2013-01-15 00:01:00 -0.605198
2013-01-15 00:02:00  0.215146
2013-01-15 00:03:00  0.924732
2013-01-15 00:04:00 -2.228519
2013-01-15 00:05:00  1.517331
2013-01-15 00:06:00 -1.188774
... ...
2013-01-15 12:24:00  1.358314
2013-01-15 12:25:00 -0.737727
2013-01-15 12:26:00  1.838323
2013-01-15 12:27:00 -0.774090
2013-01-15 12:28:00  0.622261
2013-01-15 12:29:00 -0.631649
2013-01-15 12:30:00  0.193284
[751 rows x 1 columns]

New in version 0.18.0.

DatetimeIndex partial string indexing also works on a DataFrame with a MultiIndex:

In [87]: dft2 = pd.DataFrame(np.random.randn(20, 1),
                   columns=['A'],
                   index=pd.MultiIndex.from_product([pd.date_range('20130101',
                                                      periods=10,
                                                      freq='12H'),
                                                      ['a', 'b']))

In [88]: dft2
Out[88]:
      A
2013-01-01 00:00:00 a  -0.659574
   b   1.494522
2013-01-01 12:00:00 a  -0.778425
   b  -0.253355
2013-01-02 00:00:00 a  -2.816159
   b  -1.210929
2013-01-02 12:00:00 a   0.144669
   b   0.149867
... ...
2013-01-04 00:00:00 b  -1.624463
2013-01-04 12:00:00 a   0.056912
   b   0.149867
2013-01-05 00:00:00 a  -1.256173
   b   2.324544
2013-01-05 12:00:00 a  -1.067396
   b  -0.660996
[20 rows x 1 columns]

In [89]: dft2.loc['2013-01-05'] (continues on next page)
A timestamp string less accurate than a minute gives a `Series` object.

```python
In [95]: series_minute['2011-12-31 23']
Out[95]:
2011-12-31 23:59:00    1
Name: 2011-12-31 23:59:00, dtype: int64
```

A timestamp string with minute resolution (or more accurate), gives a scalar instead, i.e. it is not casted to a slice.

```python
In [96]: series_minute['2011-12-31 23:59']
Out[96]: 1
```

```python
In [97]: series_minute['2011-12-31 23:59:00']
```

If index resolution is second, then the minute-accurate timestamp gives a `Series`.

```python
In [98]: idx = pd.IndexSlice
```

```python
In [99]: dft2 = dft2.swaplevel(0, 1).sort_index()
```

```python
In [100]: dft2.loc[idx[:, '2013-01-05'], :]
```

19.6.2 Slice vs. Exact Match

Changed in version 0.20.0.

The same string used as an indexing parameter can be treated either as a slice or as an exact match depending on the resolution of the index. If the string is less accurate than the index, it will be treated as a slice, otherwise as an exact match.

Consider a `Series` object with a minute resolution index:

```python
In [93]: series_minute = pd.Series([1, 2, 3],
       ...: index=datetime_index(['2011-12-31 23:59:00',
       ...: '2012-01-01 00:00:00',
       ...: '2012-01-01 00:02:00']))
```

A timestamp string less accurate than a minute gives a `Series` object.

```python
In [94]: series_minute.index.resolution
Out[94]: 'minute'
```

```python
In [95]: series_minute['2011-12-31 23']
Out[95]:
2011-12-31 23:59:00    1
Name: 2011-12-31 23:59:00, dtype: int64
```

A timestamp string with minute resolution (or more accurate), gives a scalar instead, i.e. it is not casted to a slice.

```python
In [96]: series_minute['2011-12-31 23:59']
Out[96]: 1
```

If index resolution is second, then the minute-accurate timestamp gives a `Series`. 

```python
In [97]: series_minute['2011-12-31 23:59:00']
```
If the timestamp string is treated as a slice, it can be used to index DataFrame with [] as well.

```
In [101]: dft_minute = pd.DataFrame({'a': [1, 2, 3], 'b': [4, 5, 6]},
                           index=series_minute.index)

In [102]: dft_minute['2011-12-31 23:59']
Out[102]:
   a   b
2011-12-31 23:59:00 1   4
```

**Warning:** However, if the string is treated as an exact match, the selection in DataFrame's [] will be column-wise and not row-wise, see *Indexing Basics*. For example `dft_minute['2011-12-31 23:59']` will raise `KeyError` as '2012-12-31 23:59' has the same resolution as the index and there is no column with such name:

```
In [103]: dft_minute.loc['2011-12-31 23:59']
Out[103]:
a   1
b   4
Name: 2011-12-31 23:59:00, dtype: int64
```

Note also that `DateTimeIndex` resolution cannot be less precise than day.

```
In [104]: series_monthly = pd.Series([1, 2, 3],
                           pd.DatetimeIndex(['2011-12',
                                            '2012-01',
                                            '2012-02']))

In [105]: series_monthly.index.resolution
Out[105]: 'day'

In [106]: series_monthly['2011-12'] # returns Series
Out[106]:
2011-12-01 1
dtype: int64
```
19.6.3 Exact Indexing

As discussed in previous section, indexing a `DatetimeIndex` with a partial string depends on the “accuracy” of the period, in other words how specific the interval is in relation to the resolution of the index. In contrast, indexing with `Timestamp` or `datetime` objects is exact, because the objects have exact meaning. These also follow the semantics of including both endpoints.

These `Timestamp` and `datetime` objects have exact hours, minutes, and seconds, even though they were not explicitly specified (they are 0).

```python
dft[datetime(2013, 1, 1):datetime(2013, 2, 28)]
```

```
  A
2013-01-01  00:00:00  0.176444
2013-01-01  00:01:00  0.403310
2013-01-01  00:02:00 -0.154951
2013-01-01  00:03:00  0.301624
2013-01-01  00:04:00 -2.179861
2013-01-01  00:05:00 -1.369849
2013-01-01  00:06:00 -0.954208
... ... ...
2013-02-27 23:54:00  0.897051
2013-02-27 23:55:00 -0.309230
2013-02-27 23:56:00  1.944713
2013-02-27 23:57:00  0.369265
2013-02-27 23:58:00  0.053071
2013-02-27 23:59:00 -0.019734
2013-02-28  00:00:00  1.388189

[83521 rows x 1 columns]
```

With no defaults.

```python
dft[datetime(2013, 1, 1, 10, 12, 0):datetime(2013, 2, 28, 10, 12, 0)]
```

```
  A
2013-01-01 10:12:00 -0.246733
2013-01-01 10:13:00 -1.429225
2013-01-01 10:14:00 -1.265339
2013-01-01 10:15:00  0.710986
2013-01-01 10:16:00 -0.818200
2013-01-01 10:17:00  0.543542
2013-01-01 10:18:00  1.577713
... ... ...
2013-02-28 10:06:00  0.311249
2013-02-28 10:07:00  2.366080
2013-02-28 10:08:00 -0.490372
2013-02-28 10:09:00  0.373340
2013-02-28 10:10:00  0.638442
2013-02-28 10:11:00  1.330135
2013-02-28 10:12:00 -0.945450

[83521 rows x 1 columns]
```
19.6.4 Truncating & Fancy Indexing

A `truncate()` convenience function is provided that is similar to slicing. Note that `truncate` assumes a 0 value for any unspecified date component in a `DatetimeIndex` in contrast to slicing which returns any partially matching dates:

```
In [109]: rng2 = pd.date_range('2011-01-01', '2012-01-01', freq='W')

In [110]: ts2 = pd.Series(np.random.randn(len(rng2)), index=rng2)

In [111]: ts2.truncate(before='2011-11', after='2011-12')
Out[111]:
         2011-11-06   -0.773743
         2011-11-13    0.247216
         2011-11-20    0.591308
         2011-11-27    2.228500
Freq: W-SUN, dtype: float64

In [112]: ts2['2011-11':'2011-12']
Out[112]:
         2011-11-06   -0.773743
         2011-11-13    0.247216
         2011-11-20    0.591308
         2011-11-27    2.228500
         2011-12-04    0.838769
         2011-12-11    0.658538
         2011-12-18    0.567353
         2011-12-25  -1.076735
Freq: W-SUN, dtype: float64
```

Even complicated fancy indexing that breaks the `DatetimeIndex` frequency regularity will result in a `DatetimeIndex`, although frequency is lost:

```
In [113]: ts2[[0, 2, 6]].index
Out[113]: DatetimeIndex([2011-01-02, 2011-01-16, 2011-02-13], dtype='datetime64[ns]', freq=None)
```

19.7 Time/Date Components

There are several time/date properties that one can access from `Timestamp` or a collection of timestamps like a `DatetimeIndex`.
<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>year</td>
<td>The year of the datetime</td>
</tr>
<tr>
<td>month</td>
<td>The month of the datetime</td>
</tr>
<tr>
<td>day</td>
<td>The days of the datetime</td>
</tr>
<tr>
<td>hour</td>
<td>The hour of the datetime</td>
</tr>
<tr>
<td>minute</td>
<td>The minutes of the datetime</td>
</tr>
<tr>
<td>second</td>
<td>The seconds of the datetime</td>
</tr>
<tr>
<td>microsecond</td>
<td>The microseconds of the datetime</td>
</tr>
<tr>
<td>nanosecond</td>
<td>The nanoseconds of the datetime</td>
</tr>
<tr>
<td>date</td>
<td>Returns datetime.date (does not contain timezone information)</td>
</tr>
<tr>
<td>time</td>
<td>Returns datetime.time (does not contain timezone information)</td>
</tr>
<tr>
<td>dayofyear</td>
<td>The ordinal day of year</td>
</tr>
<tr>
<td>weekofyear</td>
<td>The week ordinal of the year</td>
</tr>
<tr>
<td>week</td>
<td>The week ordinal of the year</td>
</tr>
<tr>
<td>dayofweek</td>
<td>The number of the day of the week with Monday=0, Sunday=6</td>
</tr>
<tr>
<td>weekday</td>
<td>The number of the day of the week with Monday=0, Sunday=6</td>
</tr>
<tr>
<td>weekday_name</td>
<td>The name of the day in a week (ex: Friday)</td>
</tr>
<tr>
<td>quarter</td>
<td>Quarter of the date: Jan-Mar = 1, Apr-Jun = 2, etc.</td>
</tr>
<tr>
<td>days_in_month</td>
<td>The number of days in the month of the datetime</td>
</tr>
<tr>
<td>is_month_start</td>
<td>Logical indicating if first day of month (defined by frequency)</td>
</tr>
<tr>
<td>is_month_end</td>
<td>Logical indicating if last day of month (defined by frequency)</td>
</tr>
<tr>
<td>is_quarter_start</td>
<td>Logical indicating if first day of quarter (defined by frequency)</td>
</tr>
<tr>
<td>is_quarter_end</td>
<td>Logical indicating if last day of quarter (defined by frequency)</td>
</tr>
<tr>
<td>is_year_start</td>
<td>Logical indicating if first day of year (defined by frequency)</td>
</tr>
<tr>
<td>is_year_end</td>
<td>Logical indicating if last day of year (defined by frequency)</td>
</tr>
<tr>
<td>is_leap_year</td>
<td>Logical indicating if the date belongs to a leap year</td>
</tr>
</tbody>
</table>

Furthermore, if you have a Series with datetimelike values, then you can access these properties via the .dt accessor, as detailed in the section on .dt accessors.

### 19.8 DateOffset Objects

In the preceding examples, we created DatetimeIndex objects at various frequencies by passing in frequency strings like ‘M’, ‘W’, and ‘BM’ to the freq keyword. Under the hood, these frequency strings are being translated into an instance of DateOffset, which represents a regular frequency increment. Specific offset logic like “month”, “business day”, or “one hour” is represented in its various subclasses.

<table>
<thead>
<tr>
<th>Class name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DateOffset</td>
<td>Generic offset class, defaults to 1 calendar day</td>
</tr>
<tr>
<td>BDay</td>
<td>business day (weekday)</td>
</tr>
<tr>
<td>CDay</td>
<td>custom business day</td>
</tr>
<tr>
<td>Week</td>
<td>one week, optionally anchored on a day of the week</td>
</tr>
<tr>
<td>WeekOfMonth</td>
<td>the x-th day of the y-th week of each month</td>
</tr>
<tr>
<td>LastWeekOfMonth</td>
<td>the x-th day of the last week of each month</td>
</tr>
<tr>
<td>MonthEnd</td>
<td>calendar month end</td>
</tr>
<tr>
<td>MonthBegin</td>
<td>calendar month begin</td>
</tr>
<tr>
<td>BMonthEnd</td>
<td>business month end</td>
</tr>
<tr>
<td>BMonthBegin</td>
<td>business month begin</td>
</tr>
<tr>
<td>CBMonthEnd</td>
<td>custom business month end</td>
</tr>
</tbody>
</table>

Continued on next page
### Table 1 – continued from previous page

<table>
<thead>
<tr>
<th>Class name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBMonthBegin</td>
<td>custom business month begin</td>
</tr>
<tr>
<td>SemiMonthEnd</td>
<td>15th (or other day_of_month) and calendar month end</td>
</tr>
<tr>
<td>SemiMonthBegin</td>
<td>15th (or other day_of_month) and calendar month begin</td>
</tr>
<tr>
<td>QuarterEnd</td>
<td>calendar quarter end</td>
</tr>
<tr>
<td>QuarterBegin</td>
<td>calendar quarter begin</td>
</tr>
<tr>
<td>BQuarterEnd</td>
<td>business quarter end</td>
</tr>
<tr>
<td>BQuarterBegin</td>
<td>business quarter begin</td>
</tr>
<tr>
<td>FY5253Quarter</td>
<td>retail (aka 52-53 week) quarter</td>
</tr>
<tr>
<td>YearEnd</td>
<td>calendar year end</td>
</tr>
<tr>
<td>YearBegin</td>
<td>calendar year begin</td>
</tr>
<tr>
<td>BYearEnd</td>
<td>business year end</td>
</tr>
<tr>
<td>BYearBegin</td>
<td>business year begin</td>
</tr>
<tr>
<td>FY5253</td>
<td>retail (aka 52-53 week) year</td>
</tr>
<tr>
<td>BusinessHour</td>
<td>business hour</td>
</tr>
<tr>
<td>CustomBusinessHour</td>
<td>custom business hour</td>
</tr>
<tr>
<td>Hour</td>
<td>one hour</td>
</tr>
<tr>
<td>Minute</td>
<td>one minute</td>
</tr>
<tr>
<td>Second</td>
<td>one second</td>
</tr>
<tr>
<td>Milli</td>
<td>one millisecond</td>
</tr>
<tr>
<td>Micro</td>
<td>one microsecond</td>
</tr>
<tr>
<td>Nano</td>
<td>one nanosecond</td>
</tr>
</tbody>
</table>

The basic `DateOffset` takes the same arguments as `dateutil.relativedelta`, which works as follows:

```python
In [114]: d = datetime(2008, 8, 18, 9, 0)
In [115]: d + relativedelta(months=4, days=5)
Out[115]: datetime.datetime(2008, 12, 23, 9, 0)
```

We could have done the same thing with `DateOffset`:

```python
In [116]: from pandas.tseries.offsets import *
In [117]: d + DateOffset(months=4, days=5)
Out[117]: Timestamp('2008-12-23 09:00:00')
```

The key features of a `DateOffset` object are:

- It can be added / subtracted to/from a datetime object to obtain a shifted date.
- It can be multiplied by an integer (positive or negative) so that the increment will be applied multiple times.
- It has `rollforward()` and `rollback()` methods for moving a date forward or backward to the next or previous “offset date”.

Subclasses of `DateOffset` define the `apply` function which dictates custom date increment logic, such as adding business days:

```python
class BDay(DateOffset):
    """DateOffset increments between business days""
    def apply(self, other):
        ...
```

19.8. DateOffset Objects
The `rollforward` and `rollback` methods do exactly what you would expect:

```python
In [120]: d = datetime.datetime(2008, 8, 18, 9, 0)
In [121]: offset = BMonthEnd()
In [122]: offset.rollforward(d)
Out[122]: Timestamp('2008-08-29 09:00:00')
In [123]: offset.rollback(d)
Out[123]: Timestamp('2008-07-31 09:00:00')
```

It’s definitely worth exploring the `pandas.tseries.offsets` module and the various docstrings for the classes. These operations (`apply`, `rollforward` and `rollback`) preserve time (hour, minute, etc) information by default. To reset time, use `normalize=True` when creating the offset instance. If `normalize=True`, the result is normalized after the function is applied.

```python
In [124]: day = Day()
In [125]: day.apply(pd.Timestamp('2014-01-01 09:00'))
Out[125]: Timestamp('2014-01-02 09:00:00')
In [126]: day = Day(normalize=True)
In [127]: day.apply(pd.Timestamp('2014-01-01 09:00'))
Out[127]: Timestamp('2014-01-02 00:00:00')
In [128]: hour = Hour()
In [129]: hour.apply(pd.Timestamp('2014-01-01 22:00'))
Out[129]: Timestamp('2014-01-01 23:00:00')
In [130]: hour = Hour(normalize=True)
In [131]: hour.apply(pd.Timestamp('2014-01-01 22:00'))
Out[131]: Timestamp('2014-01-01 00:00:00')
In [132]: hour.apply(pd.Timestamp('2014-01-01 23:00'))
Out[132]: Timestamp('2014-01-01 00:00:00')
```

### 19.8.1 Parametric Offsets

Some of the offsets can be “parameterized” when created to result in different behaviors. For example, the `Week` offset for generating weekly data accepts a `weekday` parameter which results in the generated dates always lying on a particular day of the week:

```python
In [133]: d = datetime.datetime(2008, 8, 18, 9, 0)
```

(continues on next page)
In [134]: d + Week()
Out[134]: Timestamp('2008-08-25 09:00:00')

In [135]: d + Week(weekday=4)
Out[135]: Timestamp('2008-08-22 09:00:00')

In [136]: (d + Week(weekday=4)).weekday()
Out[136]: 4

In [137]: d - Week()
Out[137]: Timestamp('2008-08-11 09:00:00')

The normalize option will be effective for addition and subtraction.

In [138]: d + Week(normalize=True)
Out[138]: Timestamp('2008-08-25 00:00:00')

In [139]: d - Week(normalize=True)
Out[139]: Timestamp('2008-08-11 00:00:00')

Another example is parameterizing YearEnd with the specific ending month:

In [140]: d + YearEnd()
Out[140]: Timestamp('2008-12-31 09:00:00')

In [141]: d + YearEnd(month=6)
Out[141]: Timestamp('2009-06-30 09:00:00')

19.8.2 Using Offsets with Series / DatetimeIndex

Offsets can be used with either a Series or DatetimeIndex to apply the offset to each element.

In [142]: rng = pd.date_range('2012-01-01', '2012-01-03')
In [143]: s = pd.Series(rng)
In [144]: rng
Out[144]: DatetimeIndex(['2012-01-01', '2012-01-02', '2012-01-03'], dtype='datetime64[ns]', freq='D')
In [145]: rng + DateOffset(months=2)
Out[145]: DatetimeIndex(['2012-03-01', '2012-03-02', '2012-03-03'], dtype='datetime64[ns]', freq='D')
In [146]: s + DateOffset(months=2)
Out[146]:
0 2012-03-01
1 2012-03-02

(continues on next page)
If the offset class maps directly to a `Timedelta` (Day, Hour, Minute, Second, Micro, Milli, Nano) it can be used exactly like a `Timedelta` - see the `Timedelta` section for more examples.

```
In [148]: s - Day(2)
Out[148]:
0  2011-12-30
1  2011-12-31
2  2012-01-01
dtype: datetime64[ns]
```

```
In [149]: td = s - pd.Series(pd.date_range('2011-12-29', '2011-12-31'))
In [150]: td
Out[150]:
0   3 days
1   3 days
2   3 days
dtype: timedelta64[ns]
```

```
In [151]: td + Minute(15)
Out[151]:
0 3 days 00:15:00
1 3 days 00:15:00
2 3 days 00:15:00
dtype: timedelta64[ns]
```

Note that some offsets (such as `BQuarterEnd`) do not have a vectorized implementation. They can still be used but may calculate significantly slower and will show a `PerformanceWarning`

```
In [152]: rng + BQuarterEnd()
Out[152]: DatetimeIndex(['2012-03-30', '2012-03-30', '2012-03-30'], dtype='datetime64[ns]', freq='D')
```

### 19.8.3 Custom Business Days

The `CDay` or `CustomBusinessDay` class provides a parametric `BusinessDay` class which can be used to create customized business day calendars which account for local holidays and local weekend conventions.

As an interesting example, let’s look at Egypt where a Friday-Saturday weekend is observed.

```
In [153]: from pandas.tseries.offsets import CustomBusinessDay
In [154]: weekmask_egypt = 'Sun Mon Tue Wed Thu'
```

(continues on next page)
# They also observe International Workers' Day so let's
# add that for a couple of years
In [155]: holidays = ['2012-05-01', datetime(2013, 5, 1), np.datetime64('2014-05-01')]

In [156]: bday_egypt = CustomBusinessDay(holidays=holidays, weekmask=weekmask_egypt)

In [157]: dt = datetime(2013, 4, 30)

In [158]: dt + 2 * bday_egypt
Out[158]: Timestamp('2013-05-05 00:00:00')

Let's map to the weekday names:

In [159]: dts = pd.date_range(dt, periods=5, freq=bday_egypt)

In [160]: pd.Series(dts.weekday, dts).map(pd.Series('Mon Tue Wed Thu Fri Sat'.split()))
Out[160]:
2013-04-30 Tue
2013-05-02 Thu
2013-05-05 Sun
2013-05-06 Mon
2013-05-07 Tue
Freq: C, dtype: object

Holiday calendars can be used to provide the list of holidays. See the holiday calendar section for more information.

In [161]: from pandas.tseries.holiday import USFederalHolidayCalendar

In [162]: bday_us = CustomBusinessDay(calendar=USFederalHolidayCalendar())

# Friday before MLK Day
In [163]: dt = datetime(2014, 1, 17)

# Tuesday after MLK Day (Monday is skipped because it's a holiday)
In [164]: dt + bday_us
Out[164]: Timestamp('2014-01-21 00:00:00')

Monthly offsets that respect a certain holiday calendar can be defined in the usual way.

In [165]: from pandas.tseries.offsets import CustomBusinessMonthBegin

In [166]: bmth_us = CustomBusinessMonthBegin(calendar=USFederalHolidayCalendar())

# Skip new years
In [167]: dt = datetime(2013, 12, 17)

In [168]: dt + bmth_us
Out[168]: Timestamp('2014-01-02 00:00:00')

# Define date index with custom offset
In [169]: pd.DatetimeIndex(start='20100101',end='20120101',freq=bmth_us)

Note: The frequency string ‘C’ is used to indicate that a CustomBusinessDay DateOffset is used, it is important to note that since CustomBusinessDay is a parameterised type, instances of CustomBusinessDay may differ and this is not detectable from the ‘C’ frequency string. The user therefore needs to ensure that the ‘C’ frequency string is used consistently within the user’s application.

19.8.4 Business Hour

The BusinessHour class provides a business hour representation on BusinessDay, allowing to use specific start and end times.

By default, BusinessHour uses 9:00 - 17:00 as business hours. Adding BusinessHour will increment Timestamp by hourly frequency. If target Timestamp is out of business hours, move to the next business hour then increment it. If the result exceeds the business hours end, the remaining hours are added to the next business day.

```
In [170]: bh = BusinessHour()

In [171]: bh
Out[171]: <BusinessHour: BH=09:00-17:00>

# 2014-08-01 is Friday
In [172]: pd.Timestamp('2014-08-01 10:00').weekday()
Out[172]: 4

In [173]: pd.Timestamp('2014-08-01 10:00') + bh
Out[173]: Timestamp('2014-08-01 11:00:00')

# Below example is the same as: pd.Timestamp('2014-08-01 09:00') + bh
In [174]: pd.Timestamp('2014-08-01 08:00') + bh
Out[174]: Timestamp('2014-08-01 10:00:00')

# If the result is on the end time, move to the next business day
In [175]: pd.Timestamp('2014-08-01 16:00') + bh
Out[175]: Timestamp('2014-08-04 09:00:00')

# Remainings are added to the next day
In [176]: pd.Timestamp('2014-08-01 16:30') + bh
Out[176]: Timestamp('2014-08-04 09:30:00')

# Adding 2 business hours
In [177]: pd.Timestamp('2014-08-01 10:00') + BusinessHour(2)
Out[177]: Timestamp('2014-08-01 12:00:00')

# Subtracting 3 business hours
```
You can also specify start and end time by keywords. The argument must be a str with an hour:minute representation or a datetime.time instance. Specifying seconds, microseconds and nanoseconds as business hour results in ValueError.

Passing start time later than end represents midnight business hour. In this case, business hour exceeds midnight and overlap to the next day. Valid business hours are distinguished by whether it started from valid BusinessDay.

Applying BusinessHour.rollforward and rollback to out of business hours results in the next business hour start or previous day’s end. Different from other offsets, BusinessHour.rollforward may output different results from apply by definition.

This is because one day’s business hour end is equal to next day’s business hour start. For example, under the default business hours (9:00 - 17:00), there is no gap (0 minutes) between 2014-08-01 17:00 and 2014-08-04 00:00.

19.8. DateOffset Objects

959
09:00.

```python
# This adjusts a Timestamp to business hour edge
In [190]: BusinessHour().rollback(pd.Timestamp('2014-08-02 15:00'))
Out[190]: Timestamp('2014-08-01 17:00:00')

In [191]: BusinessHour().rollforward(pd.Timestamp('2014-08-02 15:00'))
Out[191]: Timestamp('2014-08-04 09:00:00')

# It is the same as BusinessHour().apply(pd.Timestamp('2014-08-01 17:00')).
# And it is the same as BusinessHour().apply(pd.Timestamp('2014-08-04 09:00'))
In [192]: BusinessHour().apply(pd.Timestamp('2014-08-02 15:00'))
→ Timestamp('2014-08-04 10:00:00')

# BusinessDay results (for reference)
In [193]: BusinessHour().rollforward(pd.Timestamp('2014-08-02'))
→ Timestamp('2014-08-04 09:00:00')

# It is the same as BusinessDay().apply(pd.Timestamp('2014-08-01'))
# The result is the same as rollforwrd because BusinessDay never overlap.
In [194]: BusinessHour().apply(pd.Timestamp('2014-08-02'))
→ Timestamp('2014-08-04 10:00:00')
```

BusinessHour regards Saturday and Sunday as holidays. To use arbitrary holidays, you can use CustomBusinessHour offset, as explained in the following subsection.

### 19.8.5 Custom Business Hour

New in version 0.18.1.

The CustomBusinessHour is a mixture of BusinessHour and CustomBusinessDay which allows you to specify arbitrary holidays. CustomBusinessHour works as the same as BusinessHour except that it skips specified custom holidays.

```python
In [195]: from pandas.tseries.holiday import USFederalHolidayCalendar
In [196]: bhour_us = CustomBusinessHour(calendar=USFederalHolidayCalendar())

# Friday before MLK Day
In [197]: dt = datetime(2014, 1, 17, 15)

In [198]: dt + bhour_us
Out[198]: Timestamp('2014-01-17 16:00:00')

# Tuesday after MLK Day (Monday is skipped because it's a holiday)
In [199]: dt + bhour_us * 2
Out[199]: Timestamp('2014-01-21 09:00:00')

You can use keyword arguments supported by either BusinessHour and CustomBusinessDay.

In [200]: bhour_mon = CustomBusinessHour(start='10:00', weekmask='Tue Wed Thu Fri')

# Monday is skipped because it's a holiday, business hour starts from 10:00
```

(continues on next page)
19.8.6 Offset Aliases

A number of string aliases are given to useful common time series frequencies. We will refer to these aliases as offset aliases.

<table>
<thead>
<tr>
<th>Alias</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>business day frequency</td>
</tr>
<tr>
<td>C</td>
<td>custom business day frequency</td>
</tr>
<tr>
<td>D</td>
<td>calendar day frequency</td>
</tr>
<tr>
<td>W</td>
<td>weekly frequency</td>
</tr>
<tr>
<td>M</td>
<td>month end frequency</td>
</tr>
<tr>
<td>SM</td>
<td>semi-month end frequency (15th and end of month)</td>
</tr>
<tr>
<td>BM</td>
<td>business month end frequency</td>
</tr>
<tr>
<td>CBM</td>
<td>custom business month end frequency</td>
</tr>
<tr>
<td>MS</td>
<td>month start frequency</td>
</tr>
<tr>
<td>SMS</td>
<td>semi-month start frequency (1st and 15th)</td>
</tr>
<tr>
<td>BMS</td>
<td>business month start frequency</td>
</tr>
<tr>
<td>CBMS</td>
<td>custom business month start frequency</td>
</tr>
<tr>
<td>Q</td>
<td>quarter end frequency</td>
</tr>
<tr>
<td>BQ</td>
<td>business quarter end frequency</td>
</tr>
<tr>
<td>QS</td>
<td>quarter start frequency</td>
</tr>
<tr>
<td>BQS</td>
<td>business quarter start frequency</td>
</tr>
<tr>
<td>A, Y</td>
<td>year end frequency</td>
</tr>
<tr>
<td>BA, BY</td>
<td>business year end frequency</td>
</tr>
<tr>
<td>AS, YS</td>
<td>year start frequency</td>
</tr>
<tr>
<td>BAS, BYS</td>
<td>business year start frequency</td>
</tr>
<tr>
<td>BH</td>
<td>business hour frequency</td>
</tr>
<tr>
<td>H</td>
<td>hourly frequency</td>
</tr>
<tr>
<td>T, min</td>
<td>minutely frequency</td>
</tr>
<tr>
<td>S</td>
<td>secondly frequency</td>
</tr>
<tr>
<td>L, ms</td>
<td>milliseconds</td>
</tr>
<tr>
<td>U, us</td>
<td>microseconds</td>
</tr>
<tr>
<td>N</td>
<td>nanoseconds</td>
</tr>
</tbody>
</table>

19.8.7 Combining Aliases

As we have seen previously, the alias and the offset instance are fungible in most functions:
You can combine together day and intraday offsets:

```python
In [204]: pd.date_range(start, periods=10, freq='2h20min')
Out[204]:
```
datetime64[ns], freq='140T')
```

```python
In [205]: pd.date_range(start, periods=10, freq='1D10U')
```

<table>
<thead>
<tr>
<th>Alias</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-SUN</td>
<td>weekly frequency (Sundays). Same as ‘W’</td>
</tr>
<tr>
<td>W-MON</td>
<td>weekly frequency (Mondays)</td>
</tr>
<tr>
<td>W-TUE</td>
<td>weekly frequency (Tuesdays)</td>
</tr>
<tr>
<td>W-WED</td>
<td>weekly frequency (Wednesdays)</td>
</tr>
<tr>
<td>W-THU</td>
<td>weekly frequency (Thursdays)</td>
</tr>
<tr>
<td>W-FRI</td>
<td>weekly frequency (Fridays)</td>
</tr>
<tr>
<td>W-SAT</td>
<td>weekly frequency (Saturdays)</td>
</tr>
<tr>
<td>(B)Q(S)-DEC</td>
<td>quarterly frequency, year ends in December. Same as ‘Q’</td>
</tr>
<tr>
<td>(B)Q(S)-JAN</td>
<td>quarterly frequency, year ends in January</td>
</tr>
<tr>
<td>(B)Q(S)-FEB</td>
<td>quarterly frequency, year ends in February</td>
</tr>
<tr>
<td>(B)Q(S)-MAR</td>
<td>quarterly frequency, year ends in March</td>
</tr>
<tr>
<td>(B)Q(S)-APR</td>
<td>quarterly frequency, year ends in April</td>
</tr>
<tr>
<td>(B)Q(S)-MAY</td>
<td>quarterly frequency, year ends in May</td>
</tr>
<tr>
<td>(B)Q(S)-JUN</td>
<td>quarterly frequency, year ends in June</td>
</tr>
</tbody>
</table>
### Table 2 – continued from previous page

<table>
<thead>
<tr>
<th>Alias</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(B)Q(S)-JUL</td>
<td>quarterly frequency, year ends in July</td>
</tr>
<tr>
<td>(B)Q(S)-AUG</td>
<td>quarterly frequency, year ends in August</td>
</tr>
<tr>
<td>(B)Q(S)-SEP</td>
<td>quarterly frequency, year ends in September</td>
</tr>
<tr>
<td>(B)Q(S)-OCT</td>
<td>quarterly frequency, year ends in October</td>
</tr>
<tr>
<td>(B)Q(S)-NOV</td>
<td>quarterly frequency, year ends in November</td>
</tr>
<tr>
<td>(B)A(S)-DEC</td>
<td>annual frequency, anchored end of December. Same as ‘A’</td>
</tr>
<tr>
<td>(B)A(S)-JAN</td>
<td>annual frequency, anchored end of January</td>
</tr>
<tr>
<td>(B)A(S)-FEB</td>
<td>annual frequency, anchored end of February</td>
</tr>
<tr>
<td>(B)A(S)-MAR</td>
<td>annual frequency, anchored end of March</td>
</tr>
<tr>
<td>(B)A(S)-APR</td>
<td>annual frequency, anchored end of April</td>
</tr>
<tr>
<td>(B)A(S)-MAY</td>
<td>annual frequency, anchored end of May</td>
</tr>
<tr>
<td>(B)A(S)-JUN</td>
<td>annual frequency, anchored end of June</td>
</tr>
<tr>
<td>(B)A(S)-JUL</td>
<td>annual frequency, anchored end of July</td>
</tr>
<tr>
<td>(B)A(S)-AUG</td>
<td>annual frequency, anchored end of August</td>
</tr>
<tr>
<td>(B)A(S)-SEP</td>
<td>annual frequency, anchored end of September</td>
</tr>
<tr>
<td>(B)A(S)-OCT</td>
<td>annual frequency, anchored end of October</td>
</tr>
<tr>
<td>(B)A(S)-NOV</td>
<td>annual frequency, anchored end of November</td>
</tr>
</tbody>
</table>

These can be used as arguments to `date_range`, `bdelta_range`, constructors for `DatetimeIndex`, as well as various other timeseries-related functions in pandas.

#### 19.8.9 Anchored Offset Semantics

For those offsets that are anchored to the start or end of specific frequency (`MonthEnd`, `MonthBegin`, `WeekEnd`, etc), the following rules apply to rolling forward and backwards.

When \( n \) is not 0, if the given date is not on an anchor point, it snapped to the next(previous) anchor point, and moved \( |n|-1 \) additional steps forwards or backwards.

```python
In [206]: pd.Timestamp('2014-01-02') + MonthBegin(n=1)
Out[206]: Timestamp('2014-02-01 00:00:00')

In [207]: pd.Timestamp('2014-01-02') + MonthEnd(n=1)
Out[207]: Timestamp('2014-01-31 00:00:00')
```

(continues on next page)
In [208]: pd.Timestamp('2014-01-02') - MonthBegin(n=1)
→ Timestamp('2014-01-01 00:00:00')

Out[208]:

In [209]: pd.Timestamp('2014-01-02') - MonthEnd(n=1)
→ Timestamp('2013-12-31 00:00:00')

In [210]: pd.Timestamp('2014-01-02') + MonthBegin(n=4)
→ Timestamp('2014-05-01 00:00:00')

In [211]: pd.Timestamp('2014-01-02') - MonthBegin(n=4)
→ Timestamp('2013-10-01 00:00:00')

If the given date is on an anchor point, it is moved $|n|$ points forwards or backwards.

In [212]: pd.Timestamp('2014-01-01') + MonthBegin(n=1)
Out[212]: Timestamp('2014-02-01 00:00:00')

In [213]: pd.Timestamp('2014-01-31') + MonthEnd(n=1)
→ Timestamp('2014-02-28 00:00:00')

In [214]: pd.Timestamp('2014-01-01') - MonthBegin(n=1)
→ Timestamp('2013-12-01 00:00:00')

In [215]: pd.Timestamp('2014-01-31') - MonthEnd(n=1)
→ Timestamp('2013-12-31 00:00:00')

In [216]: pd.Timestamp('2014-01-01') + MonthBegin(n=4)
→ Timestamp('2014-05-01 00:00:00')

In [217]: pd.Timestamp('2014-01-31') - MonthBegin(n=4)
→ Timestamp('2013-10-01 00:00:00')

For the case when $n=0$, the date is not moved if on an anchor point, otherwise it is rolled forward to the next anchor point.

In [218]: pd.Timestamp('2014-01-02') + MonthBegin(n=0)
Out[218]: Timestamp('2014-02-01 00:00:00')

In [219]: pd.Timestamp('2014-01-02') + MonthEnd(n=0)
→ Timestamp('2014-01-31 00:00:00')

In [220]: pd.Timestamp('2014-01-01') + MonthBegin(n=0)
→ Timestamp('2014-01-01 00:00:00')

In [221]: pd.Timestamp('2014-01-31') + MonthEnd(n=0)
→ Timestamp('2014-01-31 00:00:00')
19.8.10 Holidays / Holiday Calendars

Holidays and calendars provide a simple way to define holiday rules to be used with CustomBusinessDay or in other analysis that requires a predefined set of holidays. The AbstractHolidayCalendar class provides all the necessary methods to return a list of holidays and only rules need to be defined in a specific holiday calendar class. Furthermore, the start_date and end_date class attributes determine over what date range holidays are generated. These should be overwritten on the AbstractHolidayCalendar class to have the range apply to all calendar subclasses. USFederalHolidayCalendar is the only calendar that exists and primarily serves as an example for developing other calendars.

For holidays that occur on fixed dates (e.g., US Memorial Day or July 4th) an observance rule determines when that holiday is observed if it falls on a weekend or some other non-observed day. Defined observance rules are:

<table>
<thead>
<tr>
<th>Rule</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>nearest_workday</td>
<td>move Saturday to Friday and Sunday to Monday</td>
</tr>
<tr>
<td>sunday_to_monday</td>
<td>move Sunday to following Monday</td>
</tr>
<tr>
<td>next_monday_or_tuesday</td>
<td>Saturday to Monday and Sunday/Monday to Tuesday</td>
</tr>
<tr>
<td>previous_friday</td>
<td>move Saturday and Sunday to previous Friday</td>
</tr>
<tr>
<td>next_monday</td>
<td>move Saturday and Sunday to following Monday</td>
</tr>
</tbody>
</table>

An example of how holidays and holiday calendars are defined:

```python
In [222]: from pandas.tseries.holiday import Holiday, USMemorialDay, AbstractHolidayCalendar, nearest_workday, MO

In [223]: class ExampleCalendar(AbstractHolidayCalendar):
   ....:     rules = [
   ....:         USMemorialDay,
   ....:         Holiday('July 4th', month=7, day=4, observance=nearest_workday),
   ....:         Holiday('Columbus Day', month=10, day=1, offset=DateOffset(weekday=MO(2))), # same as 2*Week(weekday=2)
   ....:     ]

In [224]: cal = ExampleCalendar()

In [225]: cal.holidays(datetime(2012, 1, 1), datetime(2012, 12, 31))
```

Using this calendar, creating an index or doing offset arithmetic skips weekends and holidays (i.e., Memorial Day/July 4th). For example, the below defines a custom business day offset using the ExampleCalendar. Like any other offset, it can be used to create a DatetimeIndex or added to datetime or Timestamp objects.

```python
In [226]: from pandas.tseries.offsets import CDay

In [227]: pd.DatetimeIndex(start='7/1/2012', end='7/10/2012', freq=CDay(calendar=cal)).to_pydatetime()
```

(continues on next page)
Ranges are defined by the `start_date` and `end_date` class attributes of `AbstractHolidayCalendar`. The defaults are shown below.

```
In [233]: AbstractHolidayCalendar.start_date
Out[233]: Timestamp('1970-01-01 00:00:00')
In [234]: AbstractHolidayCalendar.end_date
Out[234]: Timestamp('2030-12-31 00:00:00')
```

These dates can be overwritten by setting the attributes as datetime/Timestamp/string.

```
In [235]: AbstractHolidayCalendar.start_date = datetime(2012, 1, 1)
In [236]: AbstractHolidayCalendar.end_date = datetime(2012, 12, 31)
In [237]: cal.holidays()
Out[237]: DatetimeIndex(['2012-05-28', '2012-07-04', '2012-10-08'], dtype='datetime64[ns]', freq=None)
```

Every calendar class is accessible by name using the `get_calendar` function which returns a holiday class instance. Any imported calendar class will automatically be available by this function. Also, `HolidayCalendarFactory` provides an easy interface to create calendars that are combinations of calendars or calendars with additional rules.

```
In [238]: from pandas.tseries.holiday import get_calendar, HolidayCalendarFactory,
           USLaborDay
In [239]: cal = get_calendar('ExampleCalendar')
In [240]: cal.rules
Out[240]: [Holiday: MemorialDay (month=5, day=31, offset=<DateOffset: weekday=MO(-1)>),
       Holiday: July 4th (month=7, day=4, observance=<function nearest_workday at 0x1c36e47158>),
       Holiday: Columbus Day (month=10, day=1, offset=<DateOffset: weekday=MO(+2)>)]
In [241]: new_cal = HolidayCalendarFactory('NewExampleCalendar', cal, USLaborDay)
```
19.9 Time Series-Related Instance Methods

19.9.1 Shifting / Lagging

One may want to *shift* or *lag* the values in a time series back and forward in time. The method for this is `shift()`, which is available on all of the pandas objects.

```python
In [243]: ts = ts[:5]
In [244]: ts.shift(1)
Out[244]:
2011-01-31   NaN
2011-02-28  -1.281247
2011-03-31  -0.727707
2011-04-29  -0.121306
2011-05-31  -0.097883
Freq: BM, dtype: float64
```

The `shift` method accepts an `freq` argument which can accept a `DateOffset` class or other `timedelta`-like object or also an `offset alias`:

```python
In [245]: ts.shift(5, freq=offsets.BDay())
Out[245]:
2011-02-07  -1.281247
2011-03-07  -0.727707
2011-04-07  -0.121306
2011-05-06  -0.097883
2011-06-07   0.695775
```

```python
In [246]: ts.shift(5, freq='BM')
Out[246]:
2011-06-30  -1.281247
2011-07-29  -0.727707
2011-08-31  -0.121306
2011-09-30  -0.097883
2011-10-31   0.695775
Freq: BM, dtype: float64
```

Rather than changing the alignment of the data and the index, `DataFrame` and `Series` objects also have a `tshift()` convenience method that changes all the dates in the index by a specified number of offsets:

```python
In [247]: ts.tshift(5, freq='D')
Out[247]:
(continues on next page)
```
2011-02-05  -1.281247
2011-03-05  -0.727707
2011-04-05  -0.121306
2011-05-04  -0.097883
2011-06-05   0.695775

dtype: float64

Note that with `tshift`, the leading entry is no longer NaN because the data is not being realigned.

## 19.9.2 Frequency Conversion

The primary function for changing frequencies is the `asfreq()` method. For a `DatetimeIndex`, this is basically just a thin, but convenient wrapper around `reindex()` which generates a `date_range` and calls `reindex`.

```
In [248]: dr = pd.date_range('1/1/2010', periods=3, freq=3 * offsets.BDay())
In [249]: ts = pd.Series(randn(3), index=dr)
In [250]: ts
Out[250]:
2010-01-01    0.155932
2010-01-06    1.486218
2010-01-11   -2.148675
Freq: 3B, dtype: float64
```

`asfreq` provides a further convenience so you can specify an interpolation method for any gaps that may appear after the frequency conversion.

```
In [252]: ts.asfreq(BDay(), method='pad')
Out[252]:
2010-01-01    0.155932
2010-01-04     NaN
2010-01-05     NaN
2010-01-06    1.486218
2010-01-07     NaN
2010-01-08     NaN
2010-01-11   -2.148675
Freq: B, dtype: float64
```

## 19.9.3 Filling Forward / Backward

Related to `asfreq` and `reindex` is `fillna()`, which is documented in the `missing data section`. 

968 Chapter 19. Time Series / Date functionality
19.9.4 Converting to Python Datetimes

DatetimeIndex can be converted to an array of Python native `datetime.datetime` objects using the `to_pydatetime` method.

19.10 Resampling

**Warning:** The interface to `.resample` has changed in 0.18.0 to be more groupby-like and hence more flexible. See the [whatsnew docs](#) for a comparison with prior versions.

Pandas has a simple, powerful, and efficient functionality for performing resampling operations during frequency conversion (e.g., converting secondly data into 5-minutely data). This is extremely common in, but not limited to, financial applications.

`.resample()` is a time-based groupby, followed by a reduction method on each of its groups. See some [cookbook examples](#) for some advanced strategies.

Starting in version 0.18.1, the `.resample()` function can be used directly from `DataFrameGroupBy` objects, see the [groupby docs](#).

**Note:** `.resample()` is similar to using a `rolling()` operation with a time-based offset, see a discussion [here](#).

19.10.1 Basics

```
In [253]: rng = pd.date_range('1/1/2012', periods=100, freq='S')
In [254]: ts = pd.Series(np.random.randint(0, 500, len(rng)), index=rng)
In [255]: ts.resample('5Min').sum()
Out[255]:
2012-01-01    25653
Freq: 5T, dtype: int64
```

The `resample` function is very flexible and allows you to specify many different parameters to control the frequency conversion and resampling operation.

Any function available via `dispatching` is available as a method of the returned object, including `sum`, `mean`, `std`, `sem`, `max`, `min`, `median`, `first`, `last`, `ohlc`:

```
In [256]: ts.resample('5Min').mean()
Out[256]:
2012-01-01    256.53
Freq: 5T, dtype: float64
In [257]: ts.resample('5Min').ohlc()
2012-01-01    296  496   6  449
open    high   low    close
Freq: 5T, dtype: int64
In [258]: ts.resample('5Min').max()
(continues on next page)
```
For downsampling, `closed` can be set to ‘left’ or ‘right’ to specify which end of the interval is closed:

```python
In [258]: ts.resample('5Min', closed='right').mean()
Out[258]:
2012-01-01 23:55:00 296.000000
2012-01-01 00:00:00 256.131313
Freq: 5T, dtype: float64
```

```python
In [259]: ts.resample('5Min', closed='left').mean()
```

```python
In [260]: ts.resample('5Min', label='left').mean()
Out[260]:
2012-01-01 256.53
Freq: 5T, dtype: float64
```

```python
In [261]: ts.resample('5Min', label='left', loffset='1s').mean()
```

```
Note: The default values for `label` and `closed` is ‘left’ for all frequency offsets except for ‘M’, ‘A’, ‘Q’, ‘BM’, ‘BA’, ‘BQ’, and ‘W’ which all have a default of ‘right’.
```
The `axis` parameter can be set to 0 or 1 and allows you to resample the specified axis for a DataFrame. `kind` can be set to ‘timestamp’ or ‘period’ to convert the resulting index to/from timestamp and time span representations. By default `resample` retains the input representation. `convention` can be set to ‘start’ or ‘end’ when resampling period data (detail below). It specifies how low frequency periods are converted to higher frequency periods.

### 19.10.2 Upsampling

For upsampling, you can specify a way to upsample and the `limit` parameter to interpolate over the gaps that are created:

```python
# from secondly to every 250 milliseconds
In [269]: ts[:2].resample('250L').asfreq()
Out[269]:
2012-01-01 00:00:00.000    296.0
2012-01-01 00:00:00.250      NaN
2012-01-01 00:00:00.500      NaN
2012-01-01 00:00:00.750      NaN
2012-01-01 00:00:01.000   199.0
Freq: 250L, dtype: float64
```

```python
In [270]: ts[:2].resample('250L').ffill()
Out[270]:
2012-01-01 00:00:00.000    296
2012-01-01 00:00:00.250    296
2012-01-01 00:00:00.500    296
2012-01-01 00:00:00.750    296
2012-01-01 00:00:01.000    199
Freq: 250L, dtype: int64
```
19.10.3 Sparse Resampling

Sparse timeseries are the ones where you have a lot fewer points relative to the amount of time you are looking to resample. Naively upsampling a sparse series can potentially generate lots of intermediate values. When you don't want to use a method to fill these values, e.g. `fill_method` is `None`, then intermediate values will be filled with `NaN`.

Since `resample` is a time-based groupby, the following is a method to efficiently resample only the groups that are not all `NaN`.

```
In [272]: rng = pd.date_range('2014-1-1', periods=100, freq='D') + pd.Timedelta('1s')
In [273]: ts = pd.Series(range(100), index=rng)
```

If we want to resample to the full range of the series:

```
In [274]: ts.resample('3T').sum()
```

We can instead only resample those groups where we have points as follows:

```
In [275]: from functools import partial
In [276]: from pandas.tseries.frequencies import to_offset
In [277]: def round(t, freq):
       ....:     freq = to_offset(freq)
       ....:     return pd.Timestamp(t.value // freq.delta.value) * freq.delta.value
```
19.10.4 Aggregation

Similar to the aggregating API, groupby API, and the window functions API, a Resampler can be selectively resampled.

Resampling a DataFrame, the default will be to act on all columns with the same function.

```python
In [279]: df = pd.DataFrame(np.random.randn(1000, 3),
                    index=pd.date_range('1/1/2012', freq='S', periods=1000),
                    columns=['A', 'B', 'C'])
In [280]: r = df.resample('3T')
In [281]: r.mean()
```

We can select a specific column or columns using standard getitem.

```python
In [282]: r['A'].mean()
```

(continues on next page)
Freq: 3T, Name: A, dtype: float64

In [283]: r[['A', 'B']].mean()

→

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-01-01 00:00:00</td>
<td>-0.038580</td>
<td>-0.085117</td>
</tr>
<tr>
<td>2012-01-01 00:03:00</td>
<td>0.052387</td>
<td>-0.061477</td>
</tr>
<tr>
<td>2012-01-01 00:06:00</td>
<td>0.121377</td>
<td>-0.010630</td>
</tr>
<tr>
<td>2012-01-01 00:09:00</td>
<td>-0.106814</td>
<td>-0.053819</td>
</tr>
<tr>
<td>2012-01-01 00:12:00</td>
<td>0.032560</td>
<td>0.080543</td>
</tr>
<tr>
<td>2012-01-01 00:15:00</td>
<td>0.060486</td>
<td>-0.057602</td>
</tr>
</tbody>
</table>

You can pass a list or dict of functions to do aggregation with, outputting a DataFrame:

In [284]: r['A'].agg([np.sum, np.mean, np.std])

Out[284]:

<table>
<thead>
<tr>
<th></th>
<th>sum</th>
<th>mean</th>
<th>std</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-01-01 00:00:00</td>
<td>-6.944481</td>
<td>-0.038580</td>
<td>0.985150</td>
</tr>
<tr>
<td>2012-01-01 00:03:00</td>
<td>9.429707</td>
<td>0.052387</td>
<td>1.078022</td>
</tr>
<tr>
<td>2012-01-01 00:06:00</td>
<td>21.847876</td>
<td>0.121377</td>
<td>0.996365</td>
</tr>
<tr>
<td>2012-01-01 00:09:00</td>
<td>-19.226593</td>
<td>-0.106814</td>
<td>0.914070</td>
</tr>
<tr>
<td>2012-01-01 00:12:00</td>
<td>5.860874</td>
<td>0.032560</td>
<td>1.100055</td>
</tr>
<tr>
<td>2012-01-01 00:15:00</td>
<td>6.048588</td>
<td>0.060486</td>
<td>1.001532</td>
</tr>
</tbody>
</table>

On a resampled DataFrame, you can pass a list of functions to apply to each column, which produces an aggregated result with a hierarchical index:

In [285]: r.agg([np.sum, np.mean])

Out[285]:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>sum</td>
<td>mean</td>
<td>sum</td>
</tr>
<tr>
<td>2012-01-01 00:00:00</td>
<td>-6.944481</td>
<td>-0.038580</td>
<td>-15.320993</td>
</tr>
<tr>
<td>2012-01-01 00:03:00</td>
<td>9.429707</td>
<td>0.052387</td>
<td>-11.065916</td>
</tr>
<tr>
<td>2012-01-01 00:06:00</td>
<td>21.847876</td>
<td>0.121377</td>
<td>-1.913420</td>
</tr>
<tr>
<td>2012-01-01 00:09:00</td>
<td>-19.226593</td>
<td>-0.106814</td>
<td>-9.687468</td>
</tr>
<tr>
<td>2012-01-01 00:12:00</td>
<td>5.860874</td>
<td>0.032560</td>
<td>14.497725</td>
</tr>
<tr>
<td>2012-01-01 00:15:00</td>
<td>6.048588</td>
<td>0.060486</td>
<td>-5.760208</td>
</tr>
</tbody>
</table>

By passing a dict to aggregate you can apply a different aggregation to the columns of a DataFrame:

In [286]: r.agg({'A' : np.sum, 'B' : lambda x: np.std(x, ddof=1)})

Out[286]:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-01-01 00:00:00</td>
<td>-6.944481</td>
<td>1.087752</td>
</tr>
<tr>
<td>2012-01-01 00:03:00</td>
<td>9.429707</td>
<td>1.014552</td>
</tr>
<tr>
<td>2012-01-01 00:06:00</td>
<td>21.847876</td>
<td>0.954588</td>
</tr>
<tr>
<td>2012-01-01 00:09:00</td>
<td>-19.226593</td>
<td>1.027990</td>
</tr>
<tr>
<td>2012-01-01 00:12:00</td>
<td>5.860874</td>
<td>1.021503</td>
</tr>
<tr>
<td>2012-01-01 00:15:00</td>
<td>6.048588</td>
<td>1.004984</td>
</tr>
</tbody>
</table>

The function names can also be strings. In order for a string to be valid it must be implemented on the resampled object:
In [287]: `r.agg({'A' : 'sum', 'B' : 'std'})`  
Out[287]:  
<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-01-01 00:00:00</td>
<td>-6.944481</td>
<td>1.087752</td>
<td></td>
</tr>
<tr>
<td>2012-01-01 00:03:00</td>
<td>9.429707</td>
<td>1.014552</td>
<td></td>
</tr>
<tr>
<td>2012-01-01 00:06:00</td>
<td>21.847876</td>
<td>0.954588</td>
<td></td>
</tr>
<tr>
<td>2012-01-01 00:09:00</td>
<td>-19.226593</td>
<td>1.027990</td>
<td></td>
</tr>
<tr>
<td>2012-01-01 00:12:00</td>
<td>5.860874</td>
<td>1.021503</td>
<td></td>
</tr>
<tr>
<td>2012-01-01 00:15:00</td>
<td>6.048588</td>
<td>1.004984</td>
<td></td>
</tr>
</tbody>
</table>

Furthermore, you can also specify multiple aggregation functions for each column separately.

In [288]: `r.agg({'A' : ['sum','std'], 'B' : ['mean','std'] })`  
Out[288]:  
<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>sum</td>
<td>std</td>
<td>mean</td>
<td>std</td>
</tr>
<tr>
<td>2012-01-01 00:00:00</td>
<td>-6.944481</td>
<td>0.985150</td>
<td>-0.085117</td>
<td>1.087752</td>
</tr>
<tr>
<td>2012-01-01 00:03:00</td>
<td>9.429707</td>
<td>1.078022</td>
<td>-0.061477</td>
<td>1.014552</td>
</tr>
<tr>
<td>2012-01-01 00:06:00</td>
<td>21.847876</td>
<td>0.996365</td>
<td>-0.010630</td>
<td>0.954588</td>
</tr>
<tr>
<td>2012-01-01 00:09:00</td>
<td>-19.226593</td>
<td>0.914070</td>
<td>-0.053819</td>
<td>1.027990</td>
</tr>
<tr>
<td>2012-01-01 00:12:00</td>
<td>5.860874</td>
<td>1.100055</td>
<td>0.080543</td>
<td>1.021503</td>
</tr>
<tr>
<td>2012-01-01 00:15:00</td>
<td>6.048588</td>
<td>1.001532</td>
<td>-0.057602</td>
<td>1.004984</td>
</tr>
</tbody>
</table>

If a DataFrame does not have a datetimelike index, but instead you want to resample based on datetimelike column in the frame, it can passed to the on keyword.

In [289]: df = pd.DataFrame({'date': pd.date_range('2015-01-01', freq='W', periods=5),  
                      'a': np.arange(5),  
                      index=pd.MultiIndex.from_arrays([  
                        [1,2,3,4,5],  
                        pd.date_range('2015-01-01', freq='W', periods=5)],  
                      names=['v','d']))

In [290]: df  
Out[290]:  
<table>
<thead>
<tr>
<th>date</th>
<th>a</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015-01-04</td>
<td>0</td>
</tr>
<tr>
<td>2015-01-11</td>
<td>1</td>
</tr>
<tr>
<td>2015-01-18</td>
<td>2</td>
</tr>
<tr>
<td>2015-01-25</td>
<td>3</td>
</tr>
<tr>
<td>2015-02-01</td>
<td>4</td>
</tr>
</tbody>
</table>

In [291]: df.resample('M', on='date').sum()  

<table>
<thead>
<tr>
<th>date</th>
<th>a</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015-01-31</td>
<td>6</td>
</tr>
<tr>
<td>2015-02-28</td>
<td>4</td>
</tr>
</tbody>
</table>

Similarly, if you instead want to resample by a datetimelike level of MultiIndex, its name or location can be passed to the level keyword.

In [292]: df.resample('M', level='d').sum()  

(continues on next page)
19.11 Time Span Representation

Regular intervals of time are represented by `Period` objects in pandas while sequences of `Period` objects are collected in a `PeriodIndex`, which can be created with the convenience function `period_range`.

19.11.1 Period

A `Period` represents a span of time (e.g., a day, a month, a quarter, etc). You can specify the span via `freq` keyword using a frequency alias like below. Because `freq` represents a span of `Period`, it cannot be negative like “-3D”.

```python
In [293]: pd.Period('2012', freq='A-DEC')
Out[293]: Period('2012', 'A-DEC')
In [294]: pd.Period('2012-1-1', freq='D')
Out[294]: Period('2012-01-01', 'D')
In [295]: pd.Period('2012-1-1 19:00', freq='H')
Out[295]: Period('2012-01-01 19:00', 'H')
In [296]: pd.Period('2012-1-1 19:00', freq='5H')
Out[296]: Period('2012-01-01 19:00', '5H')
```

Adding and subtracting integers from periods shifts the period by its own frequency. Arithmetic is not allowed between `Period` with different `freq` (span).

```python
In [297]: p = pd.Period('2012', freq='A-DEC')
In [298]: p + 1
Out[298]: Period('2013', 'A-DEC')
In [299]: p - 3
Out[299]: Period('2009', 'A-DEC')
In [300]: p = pd.Period('2012-01', freq='2M')
In [301]: p + 2
Out[301]: Period('2012-05', '2M')
In [302]: p - 1
Out[302]: Period('2011-11', '2M')
In [303]: p == pd.Period('2012-01', freq='3M')
```

---

IncompatibleFrequency

Traceback (most recent call last)

(continues on next page)
If `Period` `freq` is daily or higher (D, H, T, S, L, U, N), offsets and `timedelta`-like can be added if the result can have the same freq. Otherwise, `ValueError` will be raised.

```
In [304]: p = pd.Period('2014-07-01 09:00', freq='H')
In [305]: p + Hour(2)
Out[305]: Period('2014-07-01 11:00', 'H')
In [306]: p + timedelta(minutes=120)
Out[306]: Period('2014-07-01 11:00', 'H')
In [307]: p + np.timedelta64(7200, 's')
Out[307]: Period('2014-07-01 11:00', 'H')
```

If `Period` has other `freq`, only the same offsets can be added. Otherwise, `ValueError` will be raised.

```
In [308]: p = pd.Period('2014-07', freq='M')
In [309]: p + MonthEnd(3)
Out[309]: Period('2014-10', 'M')
```

Taking the difference of `Period` instances with the same frequency will return the number of frequency units between them:

```
Out[310]: 10
```

### 19.11.2 PeriodIndex and `period_range`

Regular sequences of `Period` objects can be collected in a `PeriodIndex`, which can be constructed using the `period_range` convenience function:

```
In [311]: prng = pd.period_range('1/1/2011', '1/1/2012', freq='M')
In [312]: prng
```

(continues on next page)
The `PeriodIndex` constructor can also be used directly:

```
In [313]: pd.PeriodIndex(['2011-1', '2011-2', '2011-3'], freq='M')
Out[313]: PeriodIndex(['2011-01', '2011-02', '2011-03'], dtype='period[M]', freq='M')
```

Passing multiplied frequency outputs a sequence of Period which has multiplied span.

```
In [314]: pd.PeriodIndex(start='2014-01', freq='3M', periods=4)  
```

If `start` or `end` are `Period` objects, they will be used as anchor endpoints for a `PeriodIndex` with frequency matching that of the `PeriodIndex` constructor.

```
In [315]: pd.PeriodIndex(start=pd.Period('2017Q1', freq='Q'),  
                      end=pd.Period('2017Q2', freq='Q'), freq='M')  
Out[315]: PeriodIndex(['2017-03', '2017-04', '2017-05', '2017-06'], dtype='period[M]', freq='M')
```

Just like `DatetimeIndex`, a `PeriodIndex` can also be used to index pandas objects:

```
In [316]: ps = pd.Series(np.random.randn(len(prng)), prng)  
In [317]: ps
Out[317]:
2011-01  0.258318
2011-02 -2.503700
2011-03 -0.303053
2011-04  0.270509
2011-05  1.004841
2011-06 -0.129044
2011-07 -1.406335
2011-08 -1.310412
2011-09  0.769439
2011-10 -0.542325
2011-11  2.010541
2011-12  1.001558
2012-01 -0.087453
Freq: M, dtype: float64
```

`PeriodIndex` supports addition and subtraction with the same rule as `Period`.

```
In [318]: idx = pd.period_range('2014-07-01 09:00', periods=5, freq='H')  
In [319]: idx
Out[319]:
PeriodIndex(['2014-07-01 09:00', '2014-07-01 10:00', '2014-07-01 11:00',  
             '2014-07-01 12:00', '2014-07-01 13:00'],  
            dtype='period[H]', freq='H')
```
In [320]: idx + Hour(2)

→ PeriodIndex(['2014-07-01 11:00', '2014-07-01 12:00', '2014-07-01 13:00',
               '2014-07-01 14:00', '2014-07-01 15:00'],
              dtype='period[H]', freq='H')

In [321]: idx = pd.period_range('2014-07', periods=5, freq='M')

In [322]: idx

Out[322]:
            dtype='period[M]', freq='M')

In [323]: idx + MonthEnd(3)

               dtype='period[M]', freq='M')

PeriodIndex has its own dtype named period, refer to Period Dtypes.

19.11.3 Period Dtypes

New in version 0.19.0.

PeriodIndex has a custom period dtype. This is a pandas extension dtype similar to the timezone aware dtype (datetime64[ns, tz]).

The period dtype holds the freq attribute and is represented with period[freq] like period[D] or period[M], using frequency strings.

In [324]: pi = pd.period_range('2016-01-01', periods=3, freq='M')

In [325]: pi

Out[325]:
PeriodIndex(['2016-01', '2016-02', '2016-03'],
            dtype='period[M]', freq='M')

In [326]: pi.dtype

→ period[M]

The period dtype can be used in .astype(...). It allows one to change the freq of a PeriodIndex like .asfreq() and convert a DatetimeIndex to PeriodIndex like to_period():

# change monthly freq to daily freq
In [327]: pi.astype('period[D]')

Out[327]:
PeriodIndex(['2016-01-31', '2016-02-29', '2016-03-31'],
            dtype='period[D]', freq='D')

# convert to DatetimeIndex
In [328]: pi.astype('datetime64[ns]')

→ DatetimeIndex(['2016-01-01', '2016-02-01', '2016-03-01'],
                dtype='datetime64[ns]',
                freq='MS')

# convert to PeriodIndex
In [329]: dti = pd.date_range('2011-01-01', freq='M', periods=3)
19.11.4 PeriodIndex Partial String Indexing

You can pass in dates and strings to Series and DataFrame with PeriodIndex, in the same manner as DatetimeIndex. For details, refer to *DatetimeIndex Partial String Indexing*.

In [332]: ps['2011-01']
Out[332]: 0.25831819727391592

In [333]: ps[datetime(2011, 12, 25):]
Out[333]:
2011-12 1.001558
2012-01 -0.087453
Freq: M, dtype: float64

In [334]: ps['10/31/2011':'12/31/2011']
Out[334]:
2011-10 -0.542325
2011-11 2.010541
2011-12 1.001558
Freq: M, dtype: float64

Passing a string representing a lower frequency than PeriodIndex returns partial sliced data.

In [335]: ps['2011']
Out[335]:
2011-01 0.258318
2011-02 -2.503700
2011-03 -0.303053
2011-04 0.270509
2011-05 1.004841
2011-06 -0.129044
2011-07 -1.406335
2011-08 -1.310412
2011-09 0.769439
2011-10 -0.542325
2011-11 2.010541
2011-12 1.001558
Freq: M, dtype: float64

In [336]: dfp = pd.DataFrame(np.random.randn(600,1),
                   columns=['A'],
                   index=pd.period_range('2013-01-01 9:00', periods=600,
                                           freq='T'))

(continues on next page)
As with `DatetimeIndex`, the endpoints will be included in the result. The example below slices data starting from 10:00 to 11:59.

```
In [339]: dfp['2013-01-01 10H':'2013-01-01 11H']
Out[339]:
     A
2013-01-01 10:00  -0.148998
2013-01-01 10:01   2.154810
2013-01-01 10:02  -1.605646
2013-01-01 10:03   0.021024
2013-01-01 10:04  -0.623737
2013-01-01 10:05   1.451612
2013-01-01 10:06   1.062463
...     ...
2013-01-01 11:53   0.273119
2013-01-01 11:54  -0.994071
2013-01-01 11:55  -1.222179
2013-01-01 11:56  -1.167118
2013-01-01 11:57   0.262822
2013-01-01 11:58  -0.283786
2013-01-01 11:59   1.190726
[60 rows x 1 columns]
```
19.11.5 Frequency Conversion and Resampling with PeriodIndex

The frequency of Period and PeriodIndex can be converted via the asfreq method. Let's start with the fiscal year 2011, ending in December:

```python
In [340]: p = pd.Period('2011', freq='A-DEC')
In [341]: p
Out[341]: Period('2011', 'A-DEC')
```

We can convert it to a monthly frequency. Using the how parameter, we can specify whether to return the starting or ending month:

```python
In [342]: p.asfreq('M', how='start')
Out[342]: Period('2011-01', 'M')
In [343]: p.asfreq('M', how='end')
Out[343]: Period('2011-12', 'M')
```

The shorthands 's' and 'e' are provided for convenience:

```python
In [344]: p.asfreq('M', 's')
Out[344]: Period('2011-01', 'M')
In [345]: p.asfreq('M', 'e')
Out[345]: Period('2011-12', 'M')
```

Converting to a “super-period” (e.g., annual frequency is a super-period of quarterly frequency) automatically returns the super-period that includes the input period:

```python
In [346]: p = pd.Period('2011-12', freq='A-NOV')
In [347]: p.asfreq('A-DEC')
Out[347]: Period('2012', 'A-DEC')
```

Note that since we converted to an annual frequency that ends the year in November, the monthly period of December 2011 is actually in the 2012 A-NOV period.

Period conversions with anchored frequencies are particularly useful for working with various quarterly data common to economics, business, and other fields. Many organizations define quarters relative to the month in which their fiscal year starts and ends. Thus, first quarter of 2011 could start in 2010 or a few months into 2011. Via anchored frequencies, pandas works for all quarterly frequencies Q-JAN through Q-DEC.

Q-DEC define regular calendar quarters:
Q-MAR defines fiscal year end in March:

```python
In [351]: p = pd.Period('2011Q4', freq='Q-MAR')
In [352]: p.asfreq('D', 's')
Out[352]: Period('2011-01-01', 'D')
In [353]: p.asfreq('D', 'e')
Out[353]: Period('2011-03-31', 'D')
```

## 19.12 Converting Between Representations

Timestamped data can be converted to PeriodIndex-ed data using `to_period` and vice-versa using `to_timestamp`:

```python
In [354]: rng = pd.date_range('1/1/2012', periods=5, freq='M')
In [355]: ts = pd.Series(np.random.randn(len(rng)), index=rng)
In [356]: ts
Out[356]:
2012-01-31   -0.898547
2012-02-29   -1.332247
2012-03-31   -0.741645
2012-04-30    0.094321
2012-05-31   -0.438813
Freq: M, dtype: float64

In [357]: ps = ts.to_period()
In [358]: ps
Out[358]:
2012-01    -0.898547
2012-02    -1.332247
2012-03    -0.741645
2012-04     0.094321
2012-05    -0.438813
Freq: M, dtype: float64

In [359]: ps.to_timestamp()
```

(continues on next page)
Remember that ‘s’ and ‘e’ can be used to return the timestamps at the start or end of the period:

```python
In [360]: ps.to_timestamp('D', how='s')
Out[360]:
2012-01-01 -0.898547
2012-02-01 -1.332247
2012-03-01 -0.741645
2012-04-01 0.094321
2012-05-01 -0.438813
Freq: MS, dtype: float64
```

Converting between period and timestamp enables some convenient arithmetic functions to be used. In the following example, we convert a quarterly frequency with year ending in November to 9am of the end of the month following the quarter end:

```python
In [361]: prng = pd.period_range('1990Q1', '2000Q4', freq='Q-NOV')
In [362]: ts = pd.Series(np.random.randn(len(prng)), prng)
In [363]: ts.index = (prng.asfreq('M', 'e') + 1).asfreq('H', 's') + 9
In [364]: ts.head()
Out[364]:
1990-03-01 09:00 -0.564874
1990-06-01 09:00 -1.426510
1990-09-01 09:00 1.295437
1990-12-01 09:00 1.124017
1991-03-01 09:00 0.840428
Freq: H, dtype: float64
```

### 19.13 Representing Out-of-Bounds Spans

If you have data that is outside of the Timestamp bounds, see Timestamp limitations, then you can use a PeriodIndex and/or Series of Periods to do computations.

```python
In [365]: span = pd.period_range('1215-01-01', '1381-01-01', freq='D')
In [366]: span
Out[366]:
PeriodIndex(['1215-01-01', '1215-01-02', '1215-01-03', '1215-01-04',
            '1215-01-05', '1215-01-06', '1215-01-07', '1215-01-08',
            '1215-01-09', '1215-01-10',
            ...]
1380-12-23', '1380-12-24', '1380-12-25', '1380-12-26',
            '1380-12-27', '1380-12-28', '1380-12-29', '1380-12-30',
            '1380-12-31', '1381-01-01'],
dtype='period[D]', length=60632, freq='D')
```

To convert from an int64 based YYYYMMDD representation.
In [367]: s = pd.Series([20121231, 20141130, 99991231])

In [368]: s
Out[368]:
0 20121231
1 20141130
2 99991231
dtype: int64

In [369]: def conv(x):
   .....:     return pd.Period(year = x // 10000, month = x//100 % 100, day = x%100,
   .....:     freq='D')
   .....:

In [370]: s.apply(conv)
Out[370]:
0 2012-12-31
1 2014-11-30
2 9999-12-31
dtype: object

In [371]: s.apply(conv)[2]
Out[371]: Period('9999-12-31', 'D')

These can easily be converted to a PeriodIndex:

In [372]: span = pd.PeriodIndex(s.apply(conv))

In [373]: span
Out[373]: PeriodIndex(['2012-12-31', '2014-11-30', '9999-12-31'],
dtype='period[D]', freq='D')

19.14 Time Zone Handling

Pandas provides rich support for working with timestamps in different time zones using pytz and dateutil libraries. dateutil currently is only supported for fixed offset and tzfile zones. The default library is pytz. Support for dateutil is provided for compatibility with other applications e.g. if you use dateutil in other Python packages.

19.14.1 Working with Time Zones

By default, pandas objects are time zone unaware:

In [374]: rng = pd.date_range('3/6/2012 00:00', periods=15, freq='D')

In [375]: rng.tz
Out[375]: None

To supply the time zone, you can use the tz keyword to date_range and other functions. Dateutil time zone strings are distinguished from pytz time zones by starting with dateutil/.

- In pytz you can find a list of common (and less common) time zones using from pytz import common_timezones, all_timezones.
- dateutil uses the OS timezones so there isn’t a fixed list available. For common zones, the names are the same as pytz.

```python
# pytz
In [367]: rng_pytz = pd.date_range('3/6/2012 00:00', periods=10, freq='D',
                             tz='Europe/London')

In [377]: rng_pytz.tz
Out[377]: <DstTzInfo 'Europe/London' LMT-1 day, 23:59:00 STD>

# dateutil
In [378]: rng_dateutil = pd.date_range('3/6/2012 00:00', periods=10, freq='D',
                                  tz='dateutil/Europe/London')

In [379]: rng_dateutil.tz
Out[379]: tzfile('/usr/share/zoneinfo/Europe/London')

# dateutil - utc special case
In [380]: rng_utc = pd.date_range('3/6/2012 00:00', periods=10, freq='D',
                             tz=dateutil.tz.tzutc())

In [381]: rng_utc.tz
Out[381]: tzutc()
```

Note that the UTC timezone is a special case in dateutil and should be constructed explicitly as an instance of `dateutil.tz.tzutc`. You can also construct other timezones explicitly first, which gives you more control over which time zone is used:

```python
# pytz
In [382]: tz_pytz = pytz.timezone('Europe/London')

In [383]: rng_pytz = pd.date_range('3/6/2012 00:00', periods=10, freq='D',
                               tz=tz_pytz)

In [384]: rng_pytz.tz == tz_pytz
Out[384]: True

# dateutil
In [385]: tz_dateutil = dateutil.tz.gettz('Europe/London')

In [386]: rng_dateutil = pd.date_range('3/6/2012 00:00', periods=10, freq='D',
                                   tz=tz_dateutil)

In [387]: rng_dateutil.tz == tz_dateutil
Out[387]: True
```

Timestamps, like Python’s `datetime.datetime` object can be either time zone naive or time zone aware. Naive time series and `DatetimeIndex` objects can be `localized` using `tz_localize`:

```python
In [388]: ts = pd.Series(np.random.randn(len(rng)), rng)

In [389]: ts_utc = ts.tz_localize('UTC')
```

(continues on next page)
In [390]: ts_utc
Out[390]:
2012-03-06 00:00:00+00:00  0.037206
2012-03-07 00:00:00+00:00  2.313998
2012-03-08 00:00:00+00:00  1.458296
2012-03-09 00:00:00+00:00  -0.620431
2012-03-10 00:00:00+00:00  -0.000111
2012-03-11 00:00:00+00:00  -0.342783
2012-03-12 00:00:00+00:00  -0.664322
2012-03-13 00:00:00+00:00  0.654814
2012-03-14 00:00:00+00:00  1.550680
2012-03-15 00:00:00+00:00  0.174511
2012-03-16 00:00:00+00:00  1.360491
2012-03-17 00:00:00+00:00  0.799737
2012-03-18 00:00:00+00:00  0.449149
2012-03-19 00:00:00+00:00  0.111346
2012-03-20 00:00:00+00:00  -0.435531
Freq: D, dtype: float64

Again, you can explicitly construct the timezone object first. You can use the `tz_convert` method to convert pandas objects to convert tz-aware data to another time zone:

In [391]: ts_utc.tz_convert('US/Eastern')
Out[391]:
2012-03-05 19:00:00-05:00  0.037206
2012-03-06 19:00:00-05:00  2.313998
2012-03-07 19:00:00-05:00  1.458296
2012-03-08 19:00:00-05:00  -0.620431
2012-03-09 19:00:00-05:00  -0.000111
2012-03-10 19:00:00-05:00  -0.342783
2012-03-11 20:00:00-04:00  -0.664322
2012-03-12 20:00:00-04:00  0.654814
2012-03-13 20:00:00-04:00  1.550680
2012-03-14 20:00:00-04:00  0.174511
2012-03-15 20:00:00-04:00  1.360491
2012-03-16 20:00:00-04:00  0.799737
2012-03-17 20:00:00-04:00  0.449149
2012-03-18 20:00:00-04:00  0.111346
2012-03-19 20:00:00-04:00  -0.435531
Freq: D, dtype: float64

**Warning:** Be wary of conversions between libraries. For some zones `pytz` and `dateutil` have different definitions of the zone. This is more of a problem for unusual time zones than for ‘standard’ zones like US/Eastern.

**Warning:** Be aware that a timezone definition across versions of timezone libraries may not be considered equal. This may cause problems when working with stored data that is localized using one version and operated on with a different version. See [here](#) for how to handle such a situation.

**Warning:** It is incorrect to pass a timezone directly into the `datetime.datetime` constructor (e.g., `datetime.datetime(2011, 1, 1, tz=timezone('US/Eastern'))`). Instead, the `datetime` needs
to be localized using the localize method on the timezone.

Under the hood, all timestamps are stored in UTC. Scalar values from a `DatetimeIndex` with a time zone will have their fields (day, hour, minute) localized to the time zone. However, timestamps with the same UTC value are still considered to be equal even if they are in different time zones:

```python
In [392]: rng_eastern = rng_utc.tz_convert('US/Eastern')
In [393]: rng_berlin = rng_utc.tz_convert('Europe/Berlin')
In [394]: rng_eastern[5]
Out[394]: Timestamp('2012-03-10 19:00:00-0500', tz='US/Eastern', freq='D')
In [395]: rng_berlin[5]  
   \-------------------------------------------------\Out[395]:<timestamp '2012-03-11 01:00:00+0100', tz='Europe/Berlin', freq='D'>
   \-------------------------------------------------\Out[396]:<true>
```

Like `Series`, `DataFrame`, and `DatetimeIndex`, `Timestamp`'s can be converted to other time zones using ``tz_convert``:

```python
In [397]: rng_eastern[5]  
   \-------------------------------------------------\Out[397]: Timestamp('2012-03-10 19:00:00-0500', tz='US/Eastern', freq='D')
In [398]: rng_berlin[5]  
   \-------------------------------------------------\Out[398]:<timestamp '2012-03-11 01:00:00+0100', tz='Europe/Berlin', freq='D'>
In [399]: rng_eastern[5].tz_convert('Europe/Berlin')  
   \-------------------------------------------------\Out[399]:<timestamp '2012-03-11 01:00:00+0100', tz='Europe/Berlin'>
```

Localization of `Timestamp` functions just like `DatetimeIndex` and `Series`:

```python
In [400]: rng[5]  
   \-------------------------------------------------\Out[400]: Timestamp('2012-03-11 00:00:00', tz=None, freq='D')
In [401]: rng[5].tz_localize('Asia/Shanghai')  
   \-------------------------------------------------\Out[401]:Timestamp('2012-03-11_00:00:00+0800', tz='Asia/Shanghai')
```

Operations between `Series` in different time zones will yield UTC `Series`, aligning the data on the UTC timestamps:

```python
In [402]: eastern = ts_utc.tz_convert('US/Eastern')
In [403]: berlin = ts_utc.tz_convert('Europe/Berlin')
In [404]: result = eastern + berlin
In [405]: result
   \-------------------------------------------------\Out[405]:  
   2012-03-06 00:00:00+00:00  0.074412
```

(continues on next page)
To remove timezone from tz-aware DatetimeIndex, use `tz_localize(None)` or `tz_convert(None)`.

`tz_localize(None)` will remove timezone holding local time representations. `tz_convert(None)` will remove timezone after converting to UTC time.
"2014-08-01 17:00:00", '2014-08-01 18:00:00',
'2014-08-01 19:00:00', '2014-08-01 20:00:00',
'2014-08-01 21:00:00', '2014-08-01 22:00:00'],
dtype='datetime64[ns]', freq='H')
# tz_convert(None) is identical with tz_convert('UTC').tz_localize(None)
In [411]: didx.tz_convert('UCT').tz_localize(None)

\[\ldots\]
Out[411]:
\[\ldots\]
ʻ2014-08-01 13:00:00', '2014-08-01 14:00:00',
'2014-08-01 15:00:00', '2014-08-01 16:00:00',
'2014-08-01 17:00:00', '2014-08-01 18:00:00',
'2014-08-01 19:00:00', '2014-08-01 20:00:00',
'2014-08-01 21:00:00', '2014-08-01 22:00:00'],
dtype='datetime64[ns]', freq='H')

19.14.2 Ambiguous Times when Localizing

In some cases, localize cannot determine the DST and non-DST hours when there are duplicates. This often happens when reading files or database records that simply duplicate the hours. Passing ambiguous='infer' into tz_localize will attempt to determine the right offset. Below the top example will fail as it contains ambiguous times and the bottom will infer the right offset.

In [412]: rng_hourly = pd.DatetimeIndex(['11/06/2011 00:00', '11/06/2011 01:00',
.....: '11/06/2011 01:00', '11/06/2011 02:00',
.....: '11/06/2011 03:00'])

This will fail as there are ambiguous times

In [2]: rng_hourly.tz_localize('US/Eastern')
AmbiguousTimeError: Cannot infer dst time from Timestamp('2011-11-06 01:00:00'), try_
→using the 'ambiguous' argument

In [413]: rng_hourly_eastern = rng_hourly.tz_localize('US/Eastern', ambiguous='infer')
In [414]: rng_hourly_eastern.tolist()
Out[414]:
[Timestamp('2011-11-06 00:00:00-0400', tz='US/Eastern'),
Timestamp('2011-11-06 01:00:00-0400', tz='US/Eastern'),
Timestamp('2011-11-06 01:00:00-0500', tz='US/Eastern'),
Timestamp('2011-11-06 02:00:00-0500', tz='US/Eastern'),
Timestamp('2011-11-06 03:00:00-0500', tz='US/Eastern')]

In addition to ‘infer’, there are several other arguments supported. Passing an array-like of bools or 0s/1s where True represents a DST hour and False a non-DST hour, allows for distinguishing more than one DST transition (e.g., if you have multiple records in a database each with their own DST transition). Or passing ‘NaT’ will fill in transition times with not-a-time values. These methods are available in the DatetimeIndex constructor as well as tz_localize.

In [415]: rng_hourly_dst = np.array([1, 1, 0, 0, 0])
In [416]: rng_hourly.tz_localize('US/Eastern', ambiguous=rng_hourly_dst).tolist()
Out[416]:
[Timestamp('2011-11-06 00:00:00-0400', tz='US/Eastern'),
 Timestamp('2011-11-06 01:00:00-0400', tz='US/Eastern'),
 Timestamp('2011-11-06 01:00:00-0500', tz='US/Eastern'),
 Timestamp('2011-11-06 02:00:00-0500', tz='US/Eastern'),
 Timestamp('2011-11-06 03:00:00-0500', tz='US/Eastern')]

In [417]:
rng_hourly.tz_localize('US/Eastern', ambiguous='NaT').tolist()

→
[Timestamp('2011-11-06 00:00:00-0400', tz='US/Eastern'),
 NaT,
 NaT,
 Timestamp('2011-11-06 02:00:00-0500', tz='US/Eastern'),
 Timestamp('2011-11-06 03:00:00-0500', tz='US/Eastern')]

In [418]:
didx = pd.DatetimeIndex(start='2014-08-01 09:00', freq='H', periods=10, tz='US/Eastern')

In [419]:
didx
Out[419]:
DatetimeIndex(['2014-08-01 09:00:00-04:00', '2014-08-01 10:00:00-04:00',
 '2014-08-01 11:00:00-04:00', '2014-08-01 12:00:00-04:00',
 '2014-08-01 13:00:00-04:00', '2014-08-01 14:00:00-04:00',
 '2014-08-01 15:00:00-04:00', '2014-08-01 16:00:00-04:00',
 '2014-08-01 17:00:00-04:00', '2014-08-01 18:00:00-04:00'],
 dtype='datetime64[ns, US/Eastern]', freq='H')

In [420]:
didx.tz_localize(None)

→
DatetimeIndex(['2014-08-01 09:00:00', '2014-08-01 10:00:00',
 '2014-08-01 11:00:00', '2014-08-01 12:00:00',
 '2014-08-01 13:00:00', '2014-08-01 14:00:00',
 '2014-08-01 15:00:00', '2014-08-01 16:00:00',
 '2014-08-01 17:00:00', '2014-08-01 18:00:00'],
 dtype='datetime64[ns]', freq='H')

In [421]:
didx.tz_convert(None)

→
DatetimeIndex(['2014-08-01 13:00:00', '2014-08-01 14:00:00',
 '2014-08-01 15:00:00', '2014-08-01 16:00:00',
 '2014-08-01 17:00:00', '2014-08-01 18:00:00'],
 dtype='datetime64[ns]', freq='H')

# tz_convert(None) is identical with tz_convert('UTC').tz_localize(None)

In [422]:
didx.tz_convert('UTC').tz_localize(None)

→
DatetimeIndex(['2014-08-01 13:00:00', '2014-08-01 14:00:00',
 '2014-08-01 15:00:00', '2014-08-01 16:00:00',
 '2014-08-01 17:00:00', '2014-08-01 18:00:00'],
 dtype='datetime64[ns]', freq='H')

19.14. Time Zone Handling
19.14.3 TZ Aware Dtypes

Series/DatetimeIndex with a timezone naive value are represented with a dtype of \texttt{datetime64[ns]}.

\begin{verbatim}
In [423]: s_naive = pd.Series(pd.date_range('20130101', periods=3))

In [424]: s_naive
Out[424]:
0  2013-01-01
1  2013-01-02
2  2013-01-03
dtype: datetime64[ns]
\end{verbatim}

Series/DatetimeIndex with a timezone aware value are represented with a dtype of \texttt{datetime64[ns, tz]}.

\begin{verbatim}
In [425]: s_aware = pd.Series(pd.date_range('20130101', periods=3, tz='US/Eastern'))

In [426]: s_aware
Out[426]:
0  2013-01-01 00:00:00-05:00
1  2013-01-02 00:00:00-05:00
2  2013-01-03 00:00:00-05:00
dtype: datetime64[ns, US/Eastern]
\end{verbatim}

Both of these Series can be manipulated via the \texttt{.dt} accessor, see \texttt{here}.

For example, to localize and convert a naive stamp to timezone aware.

\begin{verbatim}
In [427]: s_naive.dt.tz_localize('UTC').dt.tz_convert('US/Eastern')
Out[427]:
0  2012-12-31 19:00:00-05:00
1  2013-01-01 19:00:00-05:00
2  2013-01-02 19:00:00-05:00
dtype: datetime64[ns, US/Eastern]
\end{verbatim}

Further more you can \texttt{.astype(...)} timezone aware (and naive). This operation is effectively a localize AND convert on a naive stamp, and a convert on an aware stamp.

\begin{verbatim}
# localize and convert a naive timezone
In [428]: s_naive.astype('datetime64[ns, US/Eastern]')
Out[428]:
0  2012-12-31 19:00:00-05:00
1  2013-01-01 19:00:00-05:00
2  2013-01-02 19:00:00-05:00
dtype: datetime64[ns, US/Eastern]

# make an aware tz naive
In [429]: s_aware.astype('datetime64[ns]')
\end{verbatim}

(continues on next page)
# convert to a new timezone
In [430]: s_aware.astype('datetime64[ns, CET]')

→
0   2013-01-01 06:00:00+01:00
1   2013-01-02 06:00:00+01:00
2   2013-01-03 06:00:00+01:00
dtype: datetime64[ns, CET]

Note: Using the `.values` accessor on a Series, returns an NumPy array of the data. These values are converted to UTC, as NumPy does not currently support timezones (even though it is printing in the local timezone!).

In [431]: s_naive.values
Out[431]:
array(['2013-01-01T00:00:00.000000000', '2013-01-02T00:00:00.000000000',
       '2013-01-03T00:00.000000000'], dtype='datetime64[ns]')

In [432]: s_aware.values
Out[432]:
array(['2013-01-01T05:00:00.000000000', '2013-01-02T05:00:00.000000000',
       '2013-01-03T05:00.000000000'], dtype='datetime64[ns]')

Further note that once converted to a NumPy array these would lose the tz tenor.

In [433]: pd.Series(s_aware.values)
Out[433]:
0   2013-01-01 05:00:00
1   2013-01-02 05:00:00
2   2013-01-03 05:00:00
dtype: datetime64[ns]

However, these can be easily converted:

In [434]: pd.Series(s_aware.values).dt.tz_localize('UTC').dt.tz_convert('US/Eastern')
Out[434]:
0   2013-01-01 00:00:00-05:00
1   2013-01-02 00:00:00-05:00
2   2013-01-03 00:00:00-05:00
dtype: datetime64[ns, US/Eastern]
Timedeltas are differences in times, expressed in difference units, e.g. days, hours, minutes, seconds. They can be both positive and negative.

Timedelta is a subclass of datetime.timedelta, and behaves in a similar manner, but allows compatibility with np.timedelta64 types as well as a host of custom representation, parsing, and attributes.

20.1 Parsing

You can construct a Timedelta scalar through various arguments:

```python
# strings
In [1]: pd.Timedelta('1 days')
Out[1]: Timedelta('1 days 00:00:00')

In [2]: pd.Timedelta('1 days 00:00:00')
Out[2]: Timedelta('1 days 00:00:00')

In [3]: pd.Timedelta('1 days 2 hours')
Out[3]: Timedelta('1 days 02:00:00')

In [4]: pd.Timedelta('-1 days 2 min 3us')
Out[4]: Timedelta('-2 days +23:57:59.999997')

# like datetime.timedelta
# note: these MUST be specified as keyword arguments
In [5]: pd.Timedelta(days=1, seconds=1)
Out[5]: Timedelta('1 days 00:00:01')

# integers with a unit
In [6]: pd.Timedelta(1, unit='d')
Out[6]: Timedelta('1 days 00:00:00')

# from a datetime.timedelta/np.timedelta64
In [7]: pd.Timedelta(datetime.timedelta(days=1, seconds=1))
Out[7]: Timedelta('1 days 00:00:01')

In [8]: pd.Timedelta(np.timedelta64(1, 'ms'))
```

(continues on next page)
# negative Timedeltas have this string repr
# to be more consistent with datetime.timedelta conventions
In [9]: pd.Timedelta('-1us')
Out[9]: Timedelta('-1 days +23:59:59.999999')

# a NaT
In [10]: pd.Timedelta('nan')
Out[10]: NaT

In [11]: pd.Timedelta('nat')
Out[11]: NaT

# ISO 8601 Duration strings
In [12]: pd.Timedelta('P0DT0H1M0S')
Out[12]: Timedelta('0 days 00:01:00')

In [13]: pd.Timedelta('P0DT0H0M0.000000123S')
Out[13]: Timedelta('0 days 00:00:00.000000')

New in version 0.23.0: Added constructor for ISO 8601 Duration strings

DateOffsets (Day, Hour, Minute, Second, Milli, Micro, Nano) can also be used in construction.

In [14]: pd.Timedelta(Second(2))
Out[14]: Timedelta('0 days 00:00:02')

Further, operations among the scalars yield another scalar Timedelta.

In [15]: pd.Timedelta(Day(2)) + pd.Timedelta(Second(2)) + pd.Timedelta('00:00:00.000123')
Out[15]: Timedelta('2 days 00:00:02.000123')

## 20.1.1 to_timedelta

Using the top-level `pd.to_timedelta`, you can convert a scalar, array, list, or Series from a recognized timedelta format/value into a Timedelta type. It will construct Series if the input is a Series, a scalar if the input is scalar-like, otherwise it will output a TimedeltaIndex.

You can parse a single string to a Timedelta:

In [16]: pd.to_timedelta('1 days 06:05:01.00003')
Out[16]: Timedelta('1 days 06:05:01.000030')

In [17]: pd.to_timedelta('15.Sus')
Out[17]: Timedelta('0 days 00:00:00.000015')

or a list/array of strings:
In [18]: pd.to_timedelta(['1 days 06:05:01.00003', '15.5us', 'nan'])
Out[18]: TimedeltaIndex(['1 days 06:05:01.000030', '0 days 00:00:00.000015', NaT],
                  dtype='timedelta64[ns]', freq=None)

The unit keyword argument specifies the unit of the Timedelta:

In [19]: pd.to_timedelta(np.arange(5), unit='s')
Out[19]: TimedeltaIndex(['00:00:00', '00:00:01', '00:00:02', '00:00:03', '00:00:04'],
                       dtype='timedelta64[ns]', freq=None)
In [20]: pd.to_timedelta(np.arange(5), unit='d')
Out[20]: TimedeltaIndex(['0 days', '1 days', '2 days', '3 days', '4 days'], dtype=
                       'timedelta64[ns]', freq=None)

20.1.2 Timedelta limitations

Pandas represents Timedeltas in nanosecond resolution using 64 bit integers. As such, the 64 bit integer limits determine the Timedelta limits.

In [21]: pd.Timedelta.min
Out[21]: Timedelta('-106752 days +00:12:43.145224')
In [22]: pd.Timedelta.max
Out[22]: Timedelta('106751 days 23:47:16.854775')

20.2 Operations

You can operate on Series/DataFrames and construct timedelta64[ns] Series through subtraction operations on datetime64[ns] Series, or Timestamps.

In [23]: s = pd.Series(pd.date_range('2012-1-1', periods=3, freq='D'))
In [24]: td = pd.Series([ pd.Timedelta(days=i) for i in range(3) ])
In [25]: df = pd.DataFrame(dict(A = s, B = td))
In [26]: df
Out[26]:
   A         B
0 2012-01-01 0 days
1 2012-01-02 1 days
2 2012-01-03 2 days
In [27]: df['C'] = df['A'] + df['B']
In [28]: df
Out[28]:
   A         B         C
0 2012-01-01 0 days 2012-01-01
1 2012-01-02 1 days 2012-01-03
2 2012-01-03 2 days 2012-01-05

(continues on next page)
In [29]: df.dtypes
A datetime64[ns]
B timedelta64[ns]
C datetime64[ns]
dtype: object

In [30]: s - s.max()
0  -2 days
1  -1 days
2   0 days
dtype: timedelta64[ns]

In [31]: s - datetime.datetime(2011, 1, 1, 3, 5)
0 364 days 20:55:00
1 365 days 20:55:00
2 366 days 20:55:00
dtype: timedelta64[ns]

In [32]: s + datetime.timedelta(minutes=5)
0 2012-01-01 00:05:00
1 2012-01-02 00:05:00
2 2012-01-03 00:05:00
dtype: datetime64[ns]

In [33]: s + Minute(5)
0 2012-01-01 00:05:00
1 2012-01-02 00:05:00
2 2012-01-03 00:05:00
dtype: datetime64[ns]

In [34]: s + Minute(5) + Milli(5)
0 2012-01-01 00:05:00.005
1 2012-01-02 00:05:00.005
2 2012-01-03 00:05:00.005
dtype: datetime64[ns]

Operations with scalars from a timedelta64[ns] series:

In [35]: y = s - s[0]

In [36]: y
Out[36]:
0   0 days
1  1 days
Series of timedeltas with NaT values are supported:

```python
In [37]: y = s - s.shift()

In [38]: y
Out[38]:
0   NaT
1   1 days
2   1 days
dtype: timedelta64[ns]
```

Elements can be set to NaT using `np.nan` analogously to datetimes:

```python
In [39]: y[1] = np.nan

In [40]: y
Out[40]:
0   NaT
1   NaT
2   1 days
dtype: timedelta64[ns]
```

Operands can also appear in a reversed order (a singular object operated with a Series):

```python
In [41]: s.max() - s

Out[41]:
0   2 days
1   1 days
2   0 days
dtype: timedelta64[ns]

In [42]: datetime.datetime(2011, 1, 1, 3, 5) - s
   \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[42]:
0   -365 days +03:05:00
1   -366 days +03:05:00
2   -367 days +03:05:00
dtype: timedelta64[ns]

In [43]: datetime.timedelta(minutes=5) + s
   \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\n
In [43]:
```

min, max and the corresponding `idxmin`, `idxmax` operations are supported on frames:

```python
In [44]: A = s - pd.Timestamp('20120101') - pd.Timedelta('00:05:05')

In [45]: B = s - pd.Series(pd.date_range('2012-1-2', periods=3, freq='D'))

In [46]: df = pd.DataFrame(dict(A=A, B=B))
```

(continues on next page)
min, max, idxmin, idxmax operations are supported on Series as well. A scalar result will be a Timedelta.

You can fillna on timedeltas. Integers will be interpreted as seconds. You can pass a timedelta to get a particular value.
0 0 days
1 0 days
2 1 days
dtype: timedelta64[ns]

In [57]: y.fillna(10)
\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\:\\(continues from previous page)

You can also negate, multiply and use abs on Timedeltas:

In [59]: td1 = pd.Timedelta('-1 days 2 hours 3 seconds')

In [60]: td1
Out[60]: Timedelta('-2 days +21:59:57')

In [61]: -1 * td1
Out[61]: Timedelta('1 days 02:00:03')

In [62]: - td1
Out[62]: Timedelta('1 days 02:00:03')

In [63]: abs(td1)
Out[63]: Timedelta('1 days 02:00:03')

20.3 Reductions

Numeric reduction operation for timedelta64[ns] will return Timedelta objects. As usual NaT are skipped during evaluation.

In [64]: y2 = pd.Series(pd.to_timedelta(['-1 days +00:00:05', 'nat', '-1 days +00:00:05', '1 days']))

In [65]: y2
Out[65]:
0  -1 days +00:00:05
1  NaT
2  -1 days +00:00:05
3   1 days 00:00:00
dtype: timedelta64[ns]
In [66]: y2.mean()
→Timedelta('-1 days +16:00:03.333333')

In [67]: y2.median()
→Timedelta('-1 days +00:00:05')

In [68]: y2.quantile(.1)
→Timedelta('-1 days +00:00:05')

In [69]: y2.sum()
→Timedelta('-1 days +00:00:10')

20.4 Frequency Conversion

Timedelta Series, TimedeltaIndex, and Timedelta scalars can be converted to other ‘frequencies’ by dividing
by another timedelta, or by astyping to a specific timedelta type. These operations yield Series and propagate NaT -> nan. Note that division by the NumPy scalar is true division, while astyping is equivalent of floor division.

In [70]: td = pd.Series(pd.date_range('20130101', periods=4)) - pd.Series(pd.date_range('20121201', periods=4))

In [71]: td[2] += datetime.timedelta(minutes=5, seconds=3)

In [72]: td[3] = np.nan

In [73]: td
Out[73]:
0  31 days 00:00:00
1  31 days 00:00:00
2  31 days 00:05:03
3    NaT
dtype: timedelta64[ns]

# to days
In [74]: td / np.timedelta64(1, 'D')
→
0   31.000000
1   31.000000
2   31.003507
3  NaN
dtype: float64

In [75]: td.astype('timedelta64[D]')
→
0  31.0
1  31.0
2  31.0

(continues on next page)
3     NaN
dtype: float64

# to seconds
In [76]: td / np.timedelta64(1, 's')

→
0   2678400.0
1   2678400.0
2   2678703.0
3     NaN
dtype: float64

In [77]: td.astype('timedelta64[ns]')

→
0   2678400.0
1   2678400.0
2   2678703.0
3     NaN
dtype: float64

# to months (these are constant months)
In [78]: td / np.timedelta64(1, 'M')

→
0  1.018501
1  1.018501
2  1.018617
3   NaT
dtype: float64

Dividing or multiplying a timedelta64[ns] Series by an integer or integer Series yields another
timedelta64[ns] dtypes Series.

In [79]: td * -1
Out[79]:
0   -31 days +00:00:00
1   -31 days +00:00:00
2   -32 days +23:54:57
3      NaT
dtype: timedelta64[ns]

In [80]: td * pd.Series([1, 2, 3, 4])

→
0   31 days 00:00:00
1   62 days 00:00:00
2   93 days 00:15:09
3      NaT
dtype: timedelta64[ns]

Rounded division (floor-division) of a timedelta64[ns] Series by a scalar Timedelta gives a series of integers.

In [81]: td // pd.Timedelta(days=3, hours=4)
Out[81]:

(continues on next page)
The mod (%) and divmod operations are defined for `Timedelta` when operating with another timedelta-like or with a numeric argument.

```python
In [83]: pd.Timedelta(hours=37) % datetime.timedelta(hours=2)
Out[83]: Timedelta('0 days 01:00:00')
```

# divmod against a timedelta-like returns a pair (int, Timedelta)

```python
In [84]: divmod(datetime.timedelta(hours=2), pd.Timedelta(minutes=11))
Out[84]: (10, Timedelta('0 days 00:10:00'))
```

# divmod against a numeric returns a pair (Timedelta, Timedelta)

```python
In [85]: divmod(pd.Timedelta(hours=25), 8640000000000)
```

### 20.5 Attributes

You can access various components of the `Timedelta` or `TimedeltaIndex` directly using the attributes `days, seconds, microseconds, nanoseconds`. These are identical to the values returned by `datetime.timedelta`, in that, for example, the `.seconds` attribute represents the number of seconds $\geq 0$ and $< 1$ day. These are signed according to whether the `Timedelta` is signed.

These operations can also be directly accessed via the `.dt` property of the `Series` as well.

**Note:** Note that the attributes are NOT the displayed values of the `Timedelta`. Use `.components` to retrieve the displayed values.

For a `Series`:

```python
In [86]: td.dt.days
Out[86]:
```

```python
0 31.0
1 31.0
2 31.0
3 NaN
dtype: float64
```

```python
In [87]: td.dt.seconds
```

(continues on next page)
You can access the value of the fields for a scalar Timedelta directly.

```python
In [88]: tds = pd.Timedelta('31 days 5 min 3 sec')
In [89]: tds.days
Out[89]: 31
In [90]: tds.seconds
Out[90]: 303
In [91]: (-tds).seconds
Out[91]: 86097
```

You can use the `.components` property to access a reduced form of the timedelta. This returns a DataFrame indexed similarly to the Series. These are the displayed values of the Timedelta.

```python
In [92]: tds.components
Out[92]:
    days  hours  minutes  seconds  milliseconds  microseconds  nanoseconds
0  31.0      0.0       0.0       0.0             0.0             0.0       0.0
1  31.0      0.0       0.0       0.0             0.0             0.0       0.0
2  31.0      0.0       5.0       3.0             0.0             0.0       0.0
3  NaN       NaN       NaN       NaN             NaN             NaN       NaN
In [93]: tds.components.seconds
Out[93]:
    0  0.0  1  0.0  2  3.0  3  NaN
Name: seconds, dtype: float64
```

You can convert a Timedelta to an ISO 8601 Duration string with the `.isoformat` method.

New in version 0.20.0.

```python
In [94]: pd.Timedelta(days=6, minutes=50, seconds=3, milliseconds=10, microseconds=10, nanoseconds=12).isoformat()
Out[94]: 'P6DT0H50M3.010010012S'
```

### 20.6 TimedeltaIndex

To generate an index with time delta, you can use either the `TimedeltaIndex` or the `timedelta_range()` constructor.
Using TimedeltaIndex you can pass string-like, Timedelta, timedelta, or np.timedelta64 objects. Passing np.nan/pd.NaT/nat will represent missing values.

```
In [95]: pd.TimedeltaIndex(['1 days', '1 days, 00:00:05',
                          ....:'2 days 00:00:02']),
       dtype='timedelta64[ns]', freq=None)
```

## 20.6.1 Generating Ranges of Time Deltas

Similar to `date_range()`, you can construct regular ranges of a TimedeltaIndex using `timedelta_range()`. The default frequency for `timedelta_range` is calendar day:

```
In [96]: pd.timedelta_range(start='1 days', periods=5)
Out[96]: TimedeltaIndex(['1 days', '2 days', '3 days', '4 days', '5 days'],
                     dtype='timedelta64[ns]', freq='D')
```

Various combinations of `start`, `end`, and `periods` can be used with `timedelta_range`:

```
In [97]: pd.timedelta_range(start='1 days', end='5 days')
Out[97]: TimedeltaIndex(['1 days', '2 days', '3 days', '4 days', '5 days'],
                       dtype='timedelta64[ns]', freq='D')
```

```
In [98]: pd.timedelta_range(end='10 days', periods=4)
Out[98]: TimedeltaIndex(['7 days', '8 days', '9 days', '10 days'],
                        dtype='timedelta64[ns]', freq='D')
```

The `freq` parameter can passed a variety of `frequency aliases`:

```
In [99]: pd.timedelta_range(start='1 days', end='2 days', freq='30T')
Out[99]: TimedeltaIndex(['1 days 00:00:00', '1 days 00:30:00', '1 days 01:00:00',
                        '1 days 01:30:00', '1 days 02:00:00', '1 days 02:30:00',
                        '1 days 03:00:00', '1 days 03:30:00', '1 days 04:00:00',
                        '1 days 04:30:00', '1 days 05:00:00', '1 days 05:30:00',
                        '1 days 06:00:00', '1 days 06:30:00', '1 days 07:00:00',
                        '1 days 07:30:00', '1 days 08:00:00', '1 days 08:30:00',
                        '1 days 09:00:00', '1 days 09:30:00', '1 days 10:00:00',
                        '1 days 10:30:00', '1 days 11:00:00', '1 days 11:30:00',
                        '1 days 12:00:00', '1 days 12:30:00', '1 days 13:00:00',
                        '1 days 13:30:00', '1 days 14:00:00', '1 days 14:30:00',
                        '1 days 15:00:00', '1 days 15:30:00', '1 days 16:00:00',
                        '1 days 16:30:00', '1 days 17:00:00', '1 days 17:30:00',
                        '1 days 18:00:00', '1 days 18:30:00', '1 days 19:00:00',
                        '1 days 19:30:00', '1 days 20:00:00', '1 days 20:30:00',
                        '1 days 21:00:00', '1 days 21:30:00', '1 days 22:00:00',
                        '1 days 22:30:00', '1 days 23:00:00', '1 days 23:30:00',
                        '2 days 00:00:00'],
                       dtype='timedelta64[ns]', freq='30T')
```

```
In [100]: pd.timedelta_range(start='1 days', periods=5, freq='2D5H')
(continues on next page)
Out[100]:
 TimedeltaIndex(['1 days 00:00:00', '3 days 05:00:00', '5 days 10:00:00',
     '7 days 15:00:00', '9 days 20:00:00'],
    dtype='timedelta64[ns]', freq='53H')

New in version 0.23.0.

Specifying start, end, and periods will generate a range of evenly spaced timedeltas from start to end inclusively, with periods number of elements in the resulting TimedeltaIndex:

In [101]: pd.timedelta_range('0 days', '4 days', periods=5)
Out[101]: TimedeltaIndex(['0 days', '1 days', '2 days', '3 days', '4 days'],
    dtype='timedelta64[ns]', freq=None)

In [102]: pd.timedelta_range('0 days', '4 days', periods=10)
    
Out[102]:
 TimedeltaIndex(['0 days 00:00:00', '0 days 10:40:00', '0 days 21:20:00',
     '1 days 08:00:00', '1 days 18:40:00', '2 days 05:20:00',
     '2 days 16:00:00', '3 days 02:40:00', '3 days 13:20:00',
     '4 days 00:00:00'],
    dtype='timedelta64[ns]', freq=None)

20.6.2 Using the TimedeltaIndex

Similarly to other of the datetime-like indices, DatetimeIndex and PeriodIndex, you can use TimedeltaIndex as the index of pandas objects.

In [103]: s = pd.Series(np.arange(100),
    index=pd.timedelta_range('1 days', periods=100, freq='h'))

In [104]: s
Out[104]:
1 days 00:00:00    0
1 days 01:00:00    1
1 days 02:00:00    2
1 days 03:00:00    3
1 days 04:00:00    4
1 days 05:00:00    5
1 days 06:00:00    6
   ..
4 days 21:00:00   93
4 days 22:00:00   94
4 days 23:00:00   95
5 days 00:00:00   96
5 days 01:00:00   97
5 days 02:00:00   98
5 days 03:00:00   99
Freq: H, Length: 100, dtype: int64

Selections work similarly, with coercion on string-likes and slices:
In [105]: s['1 day':'2 day']
Out[105]:
1 days 00:00:00  0
1 days 01:00:00  1
1 days 02:00:00  2
1 days 03:00:00  3
1 days 04:00:00  4
1 days 05:00:00  5
1 days 06:00:00  6
    ...
2 days 17:00:00 41
2 days 18:00:00 42
2 days 19:00:00 43
2 days 20:00:00 44
2 days 21:00:00 45
2 days 22:00:00 46
2 days 23:00:00 47
Freq: H, Length: 48, dtype: int64

In [106]: s['1 day 01:00:00']

In [107]: s[pd.Timedelta('1 day 1h')]

Furthermore you can use partial string selection and the range will be inferred:

In [108]: s['1 day':'1 day 5 hours']
Out[108]:
1 days 00:00:00 0
1 days 01:00:00 1
1 days 02:00:00 2
1 days 03:00:00 3
1 days 04:00:00 4
1 days 05:00:00 5
Freq: H, Length: 5, dtype: int64

20.6.3 Operations

Finally, the combination of TimedeltaIndex with DatetimeIndex allow certain combination operations that are NaT preserving:

In [109]: tdi = pd.TimedeltaIndex(['1 days', pd.NaT, '2 days'])

In [110]: tdi.tolist()
Out[110]: [Timedelta('1 days 00:00:00'), NaT, Timedelta('2 days 00:00:00')]

In [111]: dti = pd.date_range('20130101', periods=3)

In [112]: dti.tolist()
Out[112]: [Timestamp('2013-01-01 00:00:00', freq='D'),
          Timestamp('2013-01-02 00:00:00', freq='D'),
          Timestamp('2013-01-03 00:00:00', freq='D')]
In [113]: (dti + tdi).tolist()
Out[113]: [Timestamp('2013-01-02 00:00:00'), NaT, Timestamp('2013-01-05 00:00:00')]

In [114]: (dti - tdi).tolist()
Out[114]: [Timestamp('2012-12-31 00:00:00'), NaT, Timestamp('2013-01-01 00:00:00')]

20.6.4 Conversions

Similarly to frequency conversion on a Series above, you can convert these indices to yield another Index.

In [115]: tdi / np.timedelta64(1,'s')
Out[115]: Float64Index([86400.0, nan, 172800.0], dtype='float64')

In [116]: tdi.astype('timedelta64[s]')
Out[116]: Float64Index([86400.0, nan, 172800.0], dtype='float64')

Scalars type ops work as well. These can potentially return a different type of index.

# adding or timedelta and date -> datelike
In [117]: tdi + pd.Timestamp('20130101')
Out[117]: DatetimeIndex(['2013-01-02', 'NaT', '2013-01-03'], dtype='datetime64[ns]', freq=None)

# subtraction of a date and a timedelta -> datelike
# note that trying to subtract a date from a Timedelta will raise an exception
In [118]: (pd.Timestamp('20130101') - tdi).tolist()
Out[118]: [Timestamp('2012-12-31 00:00:00'), NaT, Timestamp('2012-12-30 00:00:00')]

# timedelta + timedelta -> timedelta
In [119]: tdi + pd.Timedelta('10 days')
Out[119]: TimedeltaIndex(['11 days', NaT, '12 days'], dtype='timedelta64[ns]', freq=None)

# division can result in a Timedelta if the divisor is an integer
In [120]: tdi / 2
Out[120]: TimedeltaIndex(['0 days 12:00:00', NaT, '1 days 00:00:00'], dtype='timedelta64[ns]', freq=None)

# or a Float64Index if the divisor is a Timedelta
In [121]: tdi / tdi[0]
Out[121]: Float64Index([1.0, nan, 2.0], dtype='float64')

20.7 Resampling

Similar to timeseries resampling, we can resample with a TimedeltaIndex.
In [122]: s.resample('D').mean()
Out[122]:
1 days  11.5
2 days  35.5
3 days  59.5
4 days  83.5
5 days  97.5
Freq: D, dtype: float64
CATEGORICAL DATA

This is an introduction to pandas categorical data type, including a short comparison with R’s factor.

Categoricals are a pandas data type corresponding to categorical variables in statistics. A categorical variable takes on a limited, and usually fixed, number of possible values (categories, levels in R). Examples are gender, social class, blood type, country affiliation, observation time or rating via Likert scales.

In contrast to statistical categorical variables, categorical data might have an order (e.g. ‘strongly agree’ vs ‘agree’ or ‘first observation’ vs. ‘second observation’), but numerical operations (additions, divisions, . . .) are not possible.

All values of categorical data are either in categories or np.nan. Order is defined by the order of categories, not lexical order of the values. Internally, the data structure consists of a categories array and an integer array of codes which point to the real value in the categories array.

The categorical data type is useful in the following cases:

• A string variable consisting of only a few different values. Converting such a string variable to a categorical variable will save some memory, see here.
• The lexical order of a variable is not the same as the logical order (“one”, “two”, “three”). By converting to a categorical and specifying an order on the categories, sorting and min/max will use the logical order instead of the lexical order, see here.
• As a signal to other Python libraries that this column should be treated as a categorical variable (e.g. to use suitable statistical methods or plot types).

See also the API docs on categoricals.

21.1 Object Creation

21.1.1 Series Creation

Categorical Series or columns in a DataFrame can be created in several ways:

By specifying dtype="category" when constructing a Series:

In [1]: s = pd.Series(["a","b","c","a"], dtype="category")

In [2]: s
Out[2]:
0  a
1  b
2  c
3  a

(continues on next page)
By converting an existing Series or column to a **category** dtype:

```
In [3]: df = pd.DataFrame({"A": ["a", "b", "c", "a"]})
In [4]: df["B"] = df["A"].astype('category')
In [5]: df
```

```
   A   B
0  a   a
1  b   b
2  c   c
3  a   a
```

By using special functions, such as `cut()`, which groups data into discrete bins. See the *example on tiling* in the docs.

```
In [6]: df = pd.DataFrame({'value': np.random.randint(0, 100, 20)})
In [7]: labels = ["{0} - {1}".format(i, i + 9) for i in range(0, 100, 10)]
In [8]: df['group'] = pd.cut(df.value, range(0, 105, 10), right=False, labels=labels)
In [9]: df.head(10)
```

```
   value group
0   65  60 - 69
1   49  40 - 49
2   56  50 - 59
3   43  40 - 49
4   43  40 - 49
5   91  90 - 99
6   32  30 - 39
7   87  80 - 89
8   36  30 - 39
9    8   0 - 9
```

By passing a `pandas.Categorical` object to a Series or assigning it to a DataFrame.

```
In [10]: raw_cat = pd.Categorical(["a", "b", "c", "a"], categories=["b", "c", "d"], ordered=False)
In [11]: s = pd.Series(raw_cat)
In [12]: s
```

```
0   NaN
1     b
2     c
3   NaN
dtype: category
Categories (3, object): [b, c, d]
```
In [13]: df = pd.DataFrame({'A': ['a', 'b', 'c', 'a']})
In [14]: df['B'] = raw_cat
In [15]: df
Out[15]:
   A  B
0  a  NaN
1  b  b
2  c  c
3  a  NaN

Categorical data has a specific category dtype:

In [16]: df.dtypes
Out[16]:
A  object
B  category
dtype: object

### 21.1.2 DataFrame Creation

Similar to the previous section where a single column was converted to categorical, all columns in a DataFrame can be batch converted to categorical either during or after construction.

This can be done during construction by specifying dtype="category" in the DataFrame constructor:

In [17]: df = pd.DataFrame({'A': list('abca'), 'B': list('bccd')}, dtype="category")
In [18]: df.dtypes
Out[18]:
A  category
B  category
dtype: object

Note that the categories present in each column differ; the conversion is done column by column, so only labels present in a given column are categories:

In [19]: df['A']
Out[19]:
   0  a
   1  b
   2  c
   3  a
Name: A, dtype: category
Categories (3, object): [a, b, c]

In [20]: df['B']
Out[20]:
   0  b
   1  c
   2  c
   3  d

(continues on next page)
New in version 0.23.0.

Analogously, all columns in an existing DataFrame can be batch converted using `DataFrame.astype()`:

```
In [21]: df = pd.DataFrame({'A': list('abca'), 'B': list('bccd'))
In [22]: df_cat = df.astype('category')
In [23]: df_cat.dtypes
Out[23]:
A category
B category
dtype: object
```

This conversion is likewise done column by column:

```
In [24]: df_cat['A']
Out[24]:
0  a
1  b
2  c
3  a
Name: A, dtype: category
Categories (3, object): [a, b, c]
In [25]: df_cat['B']
Out[25]:
0  b
1  c
2  c
3  d
Name: B, dtype: category
Categories (3, object): [b, c, d]
```

### 21.1.3 Controlling Behavior

In the examples above where we passed `dtype='category'`, we used the default behavior:

1. Categories are inferred from the data.
2. Categories are unordered.

To control those behaviors, instead of passing `dtype='category'`, use an instance of `CategoricalDtype`.

```
In [26]: from pandas.api.types import CategoricalDtype
In [27]: s = pd.Series(['a', 'b', 'c', 'a'])
In [28]: cat_type = CategoricalDtype(categories=['b', 'c', 'd'], ordered=True)
```

(continues on next page)
Similarly, a CategoricalDtype can be used with a DataFrame to ensure that categories are consistent among all columns.

```
In [31]: df = pd.DataFrame({'A': list('abca'), 'B': list('bccd'))

In [32]: cat_type = CategoricalDtype(categories=list('abcd'), ordered=True)

In [33]: df_cat = df.astype(cat_type)

In [34]: df_cat['A']
Out[34]:
0  a
1  b
2  c
3  a
Name: A, dtype: category
Categories (4, object): [a < b < c < d]

In [35]: df_cat['B']

0  b
1  c
2  c
3  d
Name: B, dtype: category
Categories (4, object): [a < b < c < d]
```

**Note:** To perform table-wise conversion, where all labels in the entire DataFrame are used as categories for each column, the categories parameter can be determined programmatically by categories = pd.unique(df.values.ravel()).

If you already have codes and categories, you can use the from_codes() constructor to save the factorize step during normal constructor mode:

```
In [36]: splitter = np.random.choice([0,1], 5, p=[0.5,0.5])

In [37]: s = pd.Series(pd.Categorical.from_codes(splitter, categories=['train', 'test →']))
```
21.1.4 Regaining Original Data

To get back to the original Series or NumPy array, use `Series.astype(original_dtype)` or `np.asarray(categorical)`:

```python
In [38]: s = pd.Series(['a', 'b', 'c', 'a'])

In [39]: s
Out[39]:
0  a
1  b
2  c
3  a
dtype: object

In [40]: s2 = s.astype('category')

In [41]: s2
Out[41]:
0  a
1  b
2  c
3  a
dtype: category
Categories (3, object): [a, b, c]

In [42]: s2.astype(str)
Out[42]:
0  a
1  b
2  c
3  a
dtype: object

In [43]: np.asarray(s2)
Out[43]:
array(['a', 'b', 'c', 'a'], dtype=object)
```

**Note:** In contrast to R’s `factor` function, categorical data is not converting input values to strings; categories will end up the same data type as the original values.

**Note:** In contrast to R’s `factor` function, there is currently no way to assign/change labels at creation time. Use `categories` to change the categories after creation time.

21.2 CategoricalDtype

Changed in version 0.21.0.

A categorical’s type is fully described by

1. `categories`: a sequence of unique values and no missing values
2. ordered: a boolean

This information can be stored in a `CategoricalDtype`. The `categories` argument is optional, which implies that the actual categories should be inferred from whatever is present in the data when the `pandas.Categorical` is created. The categories are assumed to be unordered by default.

```python
In [44]: from pandas.api.types import CategoricalDtype

In [45]: CategoricalDtype([ 'a', 'b', 'c' ])
Out[45]: CategoricalDtype(categories=['a', 'b', 'c'], ordered=None)

In [46]: CategoricalDtype([ 'a', 'b', 'c' ], ordered=True)
CategoricalDtype(categories=['a', 'b', 'c'], ordered=True)

In [47]: CategoricalDtype()
CategoricalDtype(categories=None, ordered=None)
```

A `CategoricalDtype` can be used in any place pandas expects a `dtype`. For example `pandas.read_csv()`, `pandas.DataFrame.astype()`, or in the `Series` constructor.

**Note:** As a convenience, you can use the string 'category' in place of a `CategoricalDtype` when you want the default behavior of the categories being unordered, and equal to the set values present in the array. In other words, `dtype='category'` is equivalent to `dtype=CategoricalDtype()`.

### 21.2.1 Equality Semantics

Two instances of `CategoricalDtype` compare equal whenever they have the same categories and order. When comparing two unordered categoricals, the order of the categories is not considered.

```python
In [48]: c1 = CategoricalDtype([ 'a', 'b', 'c' ], ordered=False)
# Equal, since order is not considered when ordered=False
In [49]: c1 == CategoricalDtype([ 'b', 'c', 'a' ], ordered=False)
Out[49]: True

# Unequal, since the second CategoricalDtype is ordered
In [50]: c1 == CategoricalDtype([ 'a', 'b', 'c' ], ordered=True)
Out[50]: False
```

All instances of `CategoricalDtype` compare equal to the string 'category'.

```python
In [51]: c1 == 'category'
Out[51]: True
```

**Warning:** Since `dtype='category'` is essentially `CategoricalDtype(None, False)`, and since all instances `CategoricalDtype` compare equal to 'category', all instances of `CategoricalDtype` compare equal to a `CategoricalDtype(None, False), regardless of categories or ordered.
21.3 Description

Using `describe()` on categorical data will produce similar output to a `Series` or `DataFrame` of type `string`.

```python
In [52]: cat = pd.Categorical(["a", "c", "c", np.nan], categories=["b", "a", "c"])
In [53]: df = pd.DataFrame({"cat": cat, "s": ["a", "c", "c", np.nan]})
In [54]: df.describe()
Out[54]:
   cat  s
  count 3 3
  unique 2 2
     top  c  c
    freq 2 2
```

```python
In [55]: df["cat"].describe()
Out[55]:
       count 3
       unique 2
         top  c
         freq 2
Name: cat, dtype: object
```

21.4 Working with categories

Categorical data has a `categories` and an `ordered` property, which list their possible values and whether the ordering matters or not. These properties are exposed as `s.cat.categories` and `s.cat.ordered`. If you don’t manually specify categories and ordering, they are inferred from the passed arguments.

```python
In [56]: s = pd.Series(["a", "b", "c", "a"], dtype="category")
In [57]: s.cat.categories
Out[57]: Index(["a", "b", "c"], dtype='object')
In [58]: s.cat.ordered
Out[58]: False
```

It’s also possible to pass in the categories in a specific order:

```python
In [59]: s = pd.Series(pd.Categorical(["a", "b", "c", "a"], categories=["c","b","a"]))
In [60]: s.cat.categories
Out[60]: Index(["c", "b", "a"], dtype='object')
In [61]: s.cat.ordered
Out[61]: False
```

**Note:** New categorical data are **not** automatically ordered. You must explicitly pass `ordered=True` to indicate an ordered `Categorical`.
Note: The result of `unique()` is not always the same as `Series.cat.categories`, because `Series.unique()` has a couple of guarantees, namely that it returns categories in the order of appearance, and it only includes values that are actually present.

```
In [62]: s = pd.Series(list('babc')).astype(CategoricalDtype(list('abcd')))

In [63]: s
Out[63]:
0   b
1   a
2   b
3   c
dtype: category
Categories (4, object): [a, b, c, d]

# categories
In [64]: s.cat.categories
Out[64]:
[\ldots]

# uniques
In [65]: s.unique()
Out[65]:
[b, a, c]
Categories (3, object): [b, a, c]
```

### 21.4.1 Renaming categories

Renaming categories is done by assigning new values to the `Series.cat.categories` property or by using the `rename_categories()` method:

```
In [66]: s = pd.Series(['a','b','c','a'], dtype='category')

In [67]: s
Out[67]:
0   a
1   b
2   c
3   a
dtype: category
Categories (3, object): [a, b, c]

In [68]: s.cat.categories = ['Group %s' % g for g in s.cat.categories]

In [69]: s
Out[69]:
0  Group a
1  Group b
2  Group c
3  Group a
dtype: category
Categories (3, object): [Group a, Group b, Group c]
```

(continues on next page)
In [70]: s.cat.rename_categories([1,2,3])

→
0 1
1 2
2 3
3 1
dtype: category
Categories (3, int64): [1, 2, 3]

In [71]: s

→
0 Group a
1 Group b
2 Group c
3 Group a
dtype: category
Categories (3, object): [Group a, Group b, Group c]

# You can also pass a dict-like object to map the renaming
In [72]: s.cat.rename_categories({1: 'x', 2: 'y', 3: 'z'})

→
0 Group a
1 Group b
2 Group c
3 Group a
dtype: category
Categories (3, object): [Group a, Group b, Group c]

In [73]: s

→
0 Group a
1 Group b
2 Group c
3 Group a
dtype: category
Categories (3, object): [Group a, Group b, Group c]

Note: In contrast to R’s `factor`, categorical data can have categories of other types than string.

Note: Be aware that assigning new categories is an inplace operation, while most other operations under `Series.cat` per default return a new `Series` of dtype `category`.

Categories must be unique or a `ValueError` is raised:

In [74]: try:
   ....:     s.cat.categories = [1,1,1]
   ....: except ValueError as e:
   ....:     print("ValueError: " + str(e))
ValueError: Categorical categories must be unique

Categories must also not be NaN or a ValueError is raised:

```python
In [75]: try:
   ....: s.cat.categories = [1,2,np.nan]
   ....: except ValueError as e:
   ....:     print("ValueError: " + str(e))
   ....:
ValueError: Categorical categories cannot be null
```

### 21.4.2 Appending new categories

Appending categories can be done by using the `add_categories()` method:

```python
In [76]: s = s.cat.add_categories([4])
In [77]: s.cat.categories
Out[77]: Index(["Group a", 'Group b', 'Group c', 4], dtype='object')
```

```python
In [78]: s
\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\Out[78]:
0  Group a
1  Group b
2  Group c
3  Group a
dtype: category
Categories (4, object): [Group a, Group b, Group c, 4]
```

### 21.4.3 Removing categories

Removing categories can be done by using the `remove_categories()` method. Values which are removed are replaced by `np.nan`:

```python
In [79]: s = s.cat.remove_categories([4])
In [80]: s
Out[80]:
0  Group a
1  Group b
2  Group c
3  Group a
dtype: category
Categories (3, object): [Group a, Group b, Group c]
```

### 21.4.4 Removing unused categories

Removing unused categories can also be done:

```python
In [81]: s = pd.Series(pd.Categorical(['a','b','a'], categories=['a','b','c','d']))
```

(continues on next page)
21.4.5 Setting categories

If you want to do remove and add new categories in one step (which has some speed advantage), or simply set the categories to a predefined scale, use `set_categories()`.

```python
In [84]: s = pd.Series(['one', 'two', 'four', '-'], dtype='category')
In [85]: s
Out[85]:
0   one
1   two
2   four
3   -
dtype: category
Categories (4, object): [-, four, one, two]
In [86]: s = s.cat.set_categories(['one', 'two', 'three', 'four'])
In [87]: s
Out[87]:
0   one
1   two
2   four
3  NaN
```

**Note:** Be aware that `Categorical.set_categories()` cannot know whether some category is omitted intentionally or because it is misspelled or (under Python3) due to a type difference (e.g., NumPy S1 dtype and Python strings). This can result in surprising behaviour!
### 21.5 Sorting and Order

If categorical data is ordered (s.cat.ordered == True), then the order of the categories has a meaning and certain operations are possible. If the categorical is unordered, .min()/.max() will raise a TypeError.

In [88]: s = pd.Series(pd.Categorical(["a","b","c","a"], ordered=False))
In [89]: s.sort_values(inplace=True)
In [90]: s = pd.Series(["a","b","c","a"]).astype(
    ....:     CategoricalDtype(ordered=True)
    ....: )
    ....:
In [91]: s.sort_values(inplace=True)

In [92]: s
Out[92]:
0  a
3  a
1  b
2  c
dtype: category
Categories (3, object): [a < b < c]

In [93]: s.min(), s.max()
\n→('a', 'c')

You can set categorical data to be ordered by using as_ordered() or unordered by using as_unordered(). These will by default return a new object.

In [94]: s.cat.as_ordered()
Out[94]:
0  a
3  a
1  b
2  c
dtype: category
Categories (3, object): [a < b < c]

In [95]: s.cat.as_unordered()
\n→
0  a
3  a
1  b
2  c
dtype: category
Categories (3, object): [a, b, c]

Sorting will use the order defined by categories, not any lexical order present on the data type. This is even true for strings and numeric data:

In [96]: s = pd.Series([1,2,3,1], dtype="category")
In [97]: s = s.cat.set_categories([2,3,1], ordered=True)
21.5.1 Reordering

Reordering the categories is possible via the `Categorical.reorder_categories()` and the `Categorical.set_categories()` methods. For `Categorical.reorder_categories()`, all old categories must be included in the new categories and no new categories are allowed. This will necessarily make the sort order the same as the categories order.
In [107]: s.min(), s.max()
→(2, 1)

Note: Note the difference between assigning new categories and reordering the categories: the first renames categories and therefore the individual values in the Series, but if the first position was sorted last, the renamed value will still be sorted last. Reordering means that the way values are sorted is different afterwards, but not that individual values in the Series are changed.

Note: If the Categorical is not ordered, Series.min() and Series.max() will raise TypeError. Numeric operations like +, -, *, / and operations based on them (e.g. Series.median(), which would need to compute the mean between two values if the length of an array is even) do not work and raise a TypeError.

21.5.2 Multi Column Sorting

A categorical dtyped column will participate in a multi-column sort in a similar manner to other columns. The ordering of the categorical is determined by the categories of that column.

In [108]: dfs = pd.DataFrame({'A' : pd.Categorical(list('bbeebbaa'), categories=['e', 'a', 'b'], ordered=True), 'B' : [1,2,1,2,2,1,2,1] })
.....:
In [109]: dfs.sort_values(by=['A', 'B'])
Out[109]:
A   B
2   e 1
3   e 2
7   a 1
6   a 2
0   b 1
5   b 1
1   b 2
4   b 2

Reordering the categories changes a future sort.

In [110]: dfs['A'] = dfs['A'].cat.reorder_categories(['a','b','e'])
In [111]: dfs.sort_values(by=['A', 'B'])
Out[111]:
A   B
7   a 1
6   a 2
0   b 1
5   b 1
1   b 2
4   b 2
2   e 1
3   e 2
21.6 Comparisons

Comparing categorical data with other objects is possible in three cases:

- Comparing equality (== and !=) to a list-like object (list, Series, array, ...) of the same length as the categorical data.

- All comparisons (==, !=, >, >=, <, and <=) of categorical data to another categorical Series, when ordered==True and the categories are the same.

- All comparisons of a categorical data to a scalar.

All other comparisons, especially “non-equality” comparisons of two categoricals with different categories or a categorical with any list-like object, will raise a TypeError.

**Note:** Any “non-equality” comparisons of categorical data with a Series, np.array, list or categorical data with different categories or ordering will raise a TypeError because custom categories ordering could be interpreted in two ways: one with taking into account the ordering and one without.

```python
In [112]: cat = pd.Series([1,2,3]).astype(CategoricalDtype([3, 2, 1], ordered=True))
   ....:     ...
   ....:

In [113]: cat_base = pd.Series([2,2,2]).astype(CategoricalDtype([3, 2, 1], ordered=True))
   ....:     ...
   ....:

In [114]: cat_base2 = pd.Series([2,2,2]).astype(CategoricalDtype(ordered=True))
   ....:     ...
   ....:

In [115]: cat
Out[115]:
0 1
1 2
2 3
dtype: category
Categories (3, int64): [3 < 2 < 1]

In [116]: cat_base
...
0 2
1 2
2 2
dtype: category
Categories (3, int64): [3 < 2 < 1]

In [117]: cat_base2
...
0 2
1 2
```

(continues on next page)
Comparing to a categorical with the same categories and ordering or to a scalar works:

```python
In [118]: cat > cat_base
Out[118]:
0   True
1   False
2   False
dtype: bool

In [119]: cat > 2
Out[119]:
0   True
1   False
2   False
dtype: bool
```

Equality comparisons work with any list-like object of same length and scalars:

```python
In [120]: cat == cat_base
Out[120]:
0   False
1   True
2   False
dtype: bool

In [121]: cat == np.array([1,2,3])
Out[121]:
0   True
1   True
2   True
dtype: bool

In [122]: cat == 2
Out[122]:
0   False
1   True
2   False
dtype: bool
```

This doesn’t work because the categories are not the same:

```python
In [123]: try:
    ....:    cat > cat_base2
    ....: except TypeError as e:
    ....:      print("TypeError: " + str(e))
(...)
```

If you want to do a “non-equality” comparison of a categorical series with a list-like object which is not categorical data, you need to be explicit and convert the categorical data back to the original values:
```python
In [124]: base = np.array([1,2,3])

In [125]: try:
       ...:     cat > base
       ...: except TypeError as e:
       ...:     print(f"TypeError: {e}")
...
TypeError: Cannot compare a Categorical for op __gt__ with type <class 'numpy.ndarray'>.
If you want to compare values, use 'np.asarray(cat) <op> other'.

In [126]: np.asarray(cat) > base
Out[126]: array([False, False, False], dtype=bool)
```

When you compare two unordered categoricals with the same categories, the order is not considered:

```python
In [127]: c1 = pd.Categorical(['a', 'b'], categories=['a', 'b'], ordered=False)
In [128]: c2 = pd.Categorical(['a', 'b'], categories=['b', 'a'], ordered=False)
In [129]: c1 == c2
Out[129]: array([ True, True], dtype=bool)
```

## 21.7 Operations

Apart from `Series.min()`, `Series.max()` and `Series.mode()`, the following operations are possible with categorical data:

Series methods like `Series.value_counts()` will use all categories, even if some categories are not present in the data:

```python
In [130]: s = pd.Series(pd.Categorical(['a', 'b', 'c', 'c'], categories=['c', 'a', 'b', 'd']))
In [131]: s.value_counts()
Out[131]:
   c    2
   b    1
   a    1
   d    0
dtype: int64
```

Groupby will also show “unused” categories:

```python
In [132]: cats = pd.Categorical(['a', 'b', 'b', 'b', 'c', 'c', 'c'], categories=['a', 'b', 'c', 'd'])
In [133]: df = pd.DataFrame({'cats':cats, 'values':[1,2,2,3,4,5]})
In [134]: df.groupby("cats").mean()
Out[134]:
   values
cats  
   a    1.0
   b    2.3
   c    3.0
   d    nan
```

(continues on next page)
In [135]: cats2 = pd.Categorical(['a','a','b','b'], categories=['a','b','c'])

In [136]: df2 = pd.DataFrame({'cats':cats2, 'B':['c','d','c','d'], 'values':[1,2,3,4]})

In [137]: df2.groupby(['cats','B']).mean()

Out[137]:

<table>
<thead>
<tr>
<th>cats</th>
<th>B</th>
<th>values</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>c</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>d</td>
<td>2.0</td>
</tr>
<tr>
<td>b</td>
<td>c</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>d</td>
<td>4.0</td>
</tr>
<tr>
<td>c</td>
<td>c</td>
<td>NaN</td>
</tr>
<tr>
<td></td>
<td>d</td>
<td>NaN</td>
</tr>
</tbody>
</table>

Pivot tables:

In [138]: raw_cat = pd.Categorical(['a','a','b','b'], categories=['a','b','c'])

In [139]: df = pd.DataFrame({'A':raw_cat, 'B':['c','d','c','d'], 'values':[1,2,3,4]})

In [140]: pd.pivot_table(df, values='values', index=['A', 'B'])

Out[140]:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a</td>
<td>c</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>c</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d</td>
<td>4</td>
</tr>
</tbody>
</table>

### 21.8 Data munging

The optimized pandas data access methods `.loc`, `.iloc`, `.at`, and `.iat`, work as normal. The only difference is the return type (for getting) and that only values already in `categories` can be assigned.

#### 21.8.1 Getting

If the slicing operation returns either a `DataFrame` or a column of type `Series`, the category dtype is preserved.

In [141]: idx = pd.Index(['h', 'i', 'j', 'k', 'l', 'm', 'n',])

In [142]: cats = pd.Series(['a','b','b','b','c','c','c'], dtype='category', index=idx)

In [143]: values = [1,2,2,2,3,4,5]

In [144]: df = pd.DataFrame({'cats':cats, 'values':values}, index=idx)

In [145]: df.iloc[2:4,:]

Out[145]:

(continues on next page)
An example where the category type is not preserved is if you take one single row: the resulting Series is of dtype object:

```python
# get the complete "h" row as a Series
In [149]: df.loc["h", :]
Out[149]:
cats  a
values 1
Name: h, dtype: object
```

Returning a single item from categorical data will also return the value, not a categorical of length “1”.

```python
In [150]: df.iat[0,0]
Out[150]: 'a'
```

```python
In [151]: df["cats"].cat.categories = ["x","y","z"]
```

```python
In [152]: df.at["h","cats"] # returns a string
Out[152]: 'x'
```

Note: The is in contrast to R’s `factor` function, where `factor(c(1,2,3))[1]` returns a single value `factor`. To get a single value Series of type `category`, you pass in a list with a single value:

```python
In [153]: df.loc["h","cats"]
Out[153]:
h  x
```

(continues on next page)
Name: cats, dtype: category
Categories (3, object): [x, y, z]

## 21.8.2 String and datetime accessors

The accessors `.dt` and `.str` will work if the `s.cat.categories` are of an appropriate type:

```python
In [154]: str_s = pd.Series(list('aabb'))
In [155]: str_cat = str_s.astype('category')
In [156]: str_cat
Out[156]:
0 a
1 a
2 b
3 b
dtype: category
Categories (2, object): [a, b]
In [157]: str_cat.str.contains("a")
Out[157]:
0   True
1   True
2  False
3  False
dtype: bool
In [158]: date_s = pd.Series(pd.date_range('1/1/2015', periods=5))
In [159]: date_cat = date_s.astype('category')
In [160]: date_cat
Out[160]:
0  2015-01-01
1  2015-01-02
2  2015-01-03
3  2015-01-04
4  2015-01-05
dtype: category
In [161]: date_cat.dt.day
Out[161]:
0    1
1    2
2    3
3    4
4    5
dtype: int64
```

**Note:** The returned `Series` (or DataFrame) is of the same type as if you used the `.str.<method>` /.dt. method.
<method> on a Series of that type (and not of type category!).

That means, that the returned values from methods and properties on the accessors of a Series and the returned values from methods and properties on the accessors of this Series transformed to one of type category will be equal:

```
In [162]: ret_s = str_s.str.contains("a")
In [163]: ret_cat = str_cat.str.contains("a")
In [164]: ret_s.dtype == ret_cat.dtype
Out[164]: True
```

```
In [165]: ret_s == ret_cat

Out[165]:
0   True
1   True
2   True
3   True
dtype: bool
```

**Note:** The work is done on the categories and then a new Series is constructed. This has some performance implication if you have a Series of type string, where lots of elements are repeated (i.e. the number of unique elements in the Series is a lot smaller than the length of the Series). In this case it can be faster to convert the original Series to one of type category and use .str.<method> or .dt.<property> on that.

### 21.8.3 Setting

Setting values in a categorical column (or Series) works as long as the value is included in the categories:

```
In [166]: idx = pd.Index(["h", "i", "j", "k", "l", "m", "n"])  
In [167]: cats = pd.Categorical(["a", "a", "a", "a", "a", "a", "a"], categories=["a", "b"])  
In [168]: values = [1, 1, 1, 1, 1, 1, 1]  
In [169]: df = pd.DataFrame({"cats":cats,"values":values}, index=idx)  
In [170]: df.iloc[2:4, :].iloc = [["b", 2], ["b", 2]]
```

```
In [171]: df
Out[171]:
    cats values
   h   a   1
   i   a   1
   j   b   2
   k   b   2
   l   a   1
   m   a   1
   n   a   1
```

```
In [172]: try:
      .....: df.iloc[2:4, :].iloc = [["c", 3], ["c", 3]]
```

(continues on next page)
Setting values by assigning categorical data will also check that the categories match:

```python
In [173]: df.loc["j":"k","cats"] = pd.Categorical(["a","a"], categories=["a","b"])
In [174]: df
Out[174]:
     cats
   h  a  1
   i  a  1
   j  a  2
   k  a  2
   l  a  1
   m  a  1
   n  a  1
In [175]: try:
     .....: df.loc["j":"k","cats"] = pd.Categorical(["b","b"], categories=["a","b","c"])
     .....: except ValueError as e:
     .....:     print("ValueError: " + str(e))
     .....:
ValueError: Cannot setitem on a Categorical with a new category, set the categories first
```

Assigning a Categorical to parts of a column of other types will use the values:

```python
In [176]: df = pd.DataFrame({"a":[1,1,1,1,1], "b":["a","a","a","a","a"]})
In [177]: df.loc[1:2,"a"] = pd.Categorical(["b","b"], categories=["a","b"])
In [178]: df.loc[2:3,"b"] = pd.Categorical(["b","b"], categories=["a","b"])
In [179]: df
Out[179]:
   a  b
0  1  a
1  2  b
2  3  b
3  4  a
In [180]: df.dtypes
Out[180]:
   a  object
   b  object
dtype: object
```

21.8. Data munging
21.8.4 Merging

You can concat two DataFrames containing categorical data together, but the categories of these categoricals need to be the same:

```python
In [181]: cat = pd.Series(["a","b"], dtype=\"category\")
In [182]: vals = [1,2]
In [183]: df = pd.DataFrame({"cats":cat, "vals":vals})
In [184]: res = pd.concat([df,df])
In [185]: res
Out[185]:
   cats vals
0   a    1
1   b    2
0   a    1
1   b    2
```

In this case the categories are not the same, and therefore an error is raised:

```python
In [186]: res.dtypes
```

```python
Out[186]:
cats category
vals int64
dtype: object
```

The same applies to `df.append(df_different)`.
See also the section on *merge dtypes* for notes about preserving merge dtypes and performance.

21.8.5 Unioning

New in version 0.19.0.

If you want to combine categoricals that do not necessarily have the same categories, the `union_categoricals()` function will combine a list-like of categoricals. The new categories will be the union of the categories being combined.

```python
In [190]: from pandas.api.types import union_categoricals
In [191]: a = pd.Categorical(["b", "c"],
In [192]: b = pd.Categorical(["a", "b"])
In [193]: union_categoricals([a, b])
```
By default, the resulting categories will be ordered as they appear in the data. If you want the categories to be lexsorted, use `sort_categories=True` argument.

```python
In [194]: union_categoricals([a, b], sort_categories=True)
Out[194]:
[b, c, a, b]
Categories (3, object): [a, b, c]
```

`union_categoricals` also works with the “easy” case of combining two categoricals of the same categories and order information (e.g. what you could also append for).

```python
In [195]: a = pd.Categorical(["a", "b"], ordered=True)
In [196]: b = pd.Categorical(["a", "b", "a"], ordered=True)
In [197]: union_categoricals([a, b])
Out[197]:
[a, b, a, b, a]
Categories (2, object): [a < b]
```

The below raises `TypeError` because the categories are ordered and not identical.

```python
In [1]: a = pd.Categorical(["a", "b"], ordered=True)
In [2]: b = pd.Categorical(["a", "b", "c"], ordered=True)
In [3]: union_categoricals([a, b])
Out[3]:
TypeError: to union ordered Categoricals, all categories must be the same
```

New in version 0.20.0.

Ordered categoricals with different categories or orderings can be combined by using the `ignore_ordered=True` argument.

```python
In [198]: a = pd.Categorical(["a", "b", "c"], ordered=True)
In [199]: b = pd.Categorical(["c", "b", "a"], ordered=True)
In [200]: union_categoricals([a, b], ignore_order=True)
Out[200]:
[a, b, c, c, b, a]
Categories (3, object): [a, b, c]
```

`union_categoricals()` also works with a `CategoricalIndex`, or `Series` containing categorical data, but note that the resulting array will always be a plain `Categorical`:

```python
In [201]: a = pd.Series(["b", "c"], dtype='category')
In [202]: b = pd.Series(["a", "b"], dtype='category')
In [203]: union_categoricals([a, b])
Out[203]:
[b, c, a, b]
Categories (3, object): [b, c, a]
```
**Note:** `union_categoricals` may recode the integer codes for categories when combining categoricals. This is likely what you want, but if you are relying on the exact numbering of the categories, be aware.

```python
In [204]: c1 = pd.Categorical(['b', 'c'])
In [205]: c2 = pd.Categorical(['a', 'b'])
In [206]: c1
Out[206]:
\[b, c\]
Categories (2, object): [b, c]

# "b" is coded to 0
In [207]: c1.codes
Out[207]: array([0, 1], dtype=int8)
In [208]: c2
\[a, b\]
Categories (2, object): [a, b]

# "b" is coded to 1
In [209]: c2.codes
Out[209]: array([0, 1], dtype=int8)
In [210]: c = union_categoricals([c1, c2])
In [211]: c
Out[211]:
\[b, c, a, b\]
Categories (3, object): [b, c, a]

# "b" is coded to 0 throughout, same as c1, different from c2
In [212]: c.codes
Out[212]: array([0, 1, 2, 0], dtype=int8)
```

21.8.6 Concatenation

This section describes concatenations specific to `category` dtype. See *Concatenating objects* for general description.

By default, `Series` or `DataFrame` concatenation which contains the same categories results in `category` dtype, otherwise results in `object` dtype. Use `.astype` or `union_categoricals` to get `category` result.

```python
# same categories
In [213]: s1 = pd.Series(['a', 'b'], dtype='category')
In [214]: s2 = pd.Series(['a', 'b', 'a'], dtype='category')
In [215]: pd.concat([s1, s2])
Out[215]:
0    a
Name: 0, dtype: category
```

(continues on next page)
1 a
0 b
1 a
2 a
dtype: category
Categories (2, object): [a, b]

# different categories
In [216]: s3 = pd.Series(['b', 'c'], dtype='category')

In [217]: pd.concat([s1, s3])
Out[217]:
0 a
1 b
0 b
1 c
dtype: object

In [218]: pd.concat([s1, s3]).astype('category')
Out[218]:
0 a
1 b
0 b
1 c
dtype: category
Categories (3, object): [a, b, c]

In [219]: union_categoricals([s1.values, s3.values])

→ [a, b, b, c]
Categories (3, object): [a, b, c]

Following table summarizes the results of Categoricals related concatenations.

<table>
<thead>
<tr>
<th>arg1</th>
<th>arg2</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>category</td>
<td>category (identical categories)</td>
<td>category</td>
</tr>
<tr>
<td>category</td>
<td>category (different categories, both not ordered)</td>
<td>object (dtype is inferred)</td>
</tr>
<tr>
<td>category</td>
<td>category (different categories, either one is ordered)</td>
<td>object (dtype is inferred)</td>
</tr>
<tr>
<td>category</td>
<td>not category</td>
<td>object (dtype is inferred)</td>
</tr>
</tbody>
</table>

21.9 Getting Data In/Out

You can write data that contains category dtypes to a HDFStore. See here for an example and caveats.

It is also possible to write data to and reading data from Stata format files. See here for an example and caveats.

Writing to a CSV file will convert the data, effectively removing any information about the categorical (categories and ordering). So if you read back the CSV file you have to convert the relevant columns back to category and assign the right categories and categories ordering.

In [220]: s = pd.Series(pd.Categorical(['a', 'b', 'b', 'a', 'a', 'd']))
# rename the categories

(continues on next page)
In [221]: s.cat.categories = ["very good", "good", "bad"]
 # reorder the categories and add missing categories
In [222]: s = s.cat.set_categories(["very bad", "bad", "medium", "good", "very good"])
In [223]: df = pd.DataFrame({"cats":s, "vals":[1,2,3,4,5,6]})
In [224]: csv = StringIO()
In [225]: df.to_csv(csv)
In [226]: df2 = pd.read_csv(StringIO(csv.getvalue()))
In [227]: df2.dtypes
Out[227]:
<table>
<thead>
<tr>
<th></th>
<th>dtype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unnamed:</td>
<td>int64</td>
</tr>
<tr>
<td>cats</td>
<td>object</td>
</tr>
<tr>
<td>vals</td>
<td>int64</td>
</tr>
<tr>
<td>dtype:</td>
<td>object</td>
</tr>
</tbody>
</table>
In [228]: df2["cats"]

0  very good
1    good
2    good
3  very good
4  very good
5    bad
Name: cats, dtype: object

# Redo the category
In [229]: df2["cats"] = df2["cats"].astype("category")
In [230]: df2["cats"].cat.set_categories(["very bad", "bad", "medium", "good", "very good"],
   .....:     inplace=True)
   .....:
In [231]: df2.dtypes
Out[231]:
<table>
<thead>
<tr>
<th></th>
<th>dtype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unnamed:</td>
<td>int64</td>
</tr>
<tr>
<td>cats</td>
<td>category</td>
</tr>
<tr>
<td>vals</td>
<td>int64</td>
</tr>
<tr>
<td>dtype:</td>
<td>object</td>
</tr>
</tbody>
</table>
In [232]: df2["cats"]

0  very good
1    good
2    good
3  very good
4  very good
5    bad
Name: cats, dtype: category
Categories (5, object): [very bad, bad, medium, good, very good]
The same holds for writing to a SQL database with `to_sql`.

## 21.10 Missing Data

pandas primarily uses the value `np.nan` to represent missing data. It is by default not included in computations. See the *Missing Data section*.

Missing values should **not** be included in the Categorical’s *categories*, only in the *values*. Instead, it is understood that NaN is different, and is always a possibility. When working with the Categorical’s *codes*, missing values will always have a code of `-1`.

```python
In [233]: s = pd.Series(["a", "b", np.nan, "a"], dtype="category")

# only two categories
In [234]: s
Out[234]:
0    a
1    b
2  NaN
3    a
dtype: category
Categories (2, object): [a, b]

In [235]: s.cat.codes
Out[235]:
0  0
1  1
2 -1
3  0
dtype: int8
```

Methods for working with missing data, e.g. `isna()`, `fillna()`, `dropna()`, all work normally:

```python
In [236]: s = pd.Series(["a", "b", np.nan], dtype="category")

In [237]: s
Out[237]:
0    a
1    b
2  NaN
dtype: category
Categories (2, object): [a, b]

In [238]: pd.isna(s)
Out[238]:
0   False
1   False
2    True
dtype: bool

In [239]: s.fillna("a")
Out[239]:
0    a
```

(continues on next page)
21.11 Differences to R's \textit{factor}

The following differences to R's factor functions can be observed:

- R's \textit{levels} are named \textit{categories}.
- R's \textit{levels} are always of type string, while \textit{categories} in pandas can be of any dtype.
- It's not possible to specify labels at creation time. Use \texttt{s.cat.rename\_categories(new\_labels)} afterwards.
- In contrast to R's \textit{factor} function, using categorical data as the sole input to create a new categorical series will not remove unused categories but create a new categorical series which is equal to the passed in one!
- R allows for missing values to be included in its \textit{levels} (pandas' \textit{categories}). Pandas does not allow NaN categories, but missing values can still be in the \textit{values}.

21.12 Gotchas

21.12.1 Memory Usage

The memory usage of a \texttt{Categorical} is proportional to the number of categories plus the length of the data. In contrast, an \texttt{object} dtype is a constant times the length of the data.

\begin{Verbatim}
In [240]: s = pd.Series(['foo','bar']*1000)
# object dtype
In [241]: s.nbytes
Out[241]: 16000

# category dtype
In [242]: s.astype('category').nbytes
Out[242]: 2016
\end{Verbatim}

\textbf{Note:} If the number of categories approaches the length of the data, the \texttt{Categorical} will use nearly the same or more memory than an equivalent \texttt{object} dtype representation.

\begin{Verbatim}
In [243]: s = pd.Series(['foo%d' % i for i in range(2000)])
# object dtype
In [244]: s.nbytes
Out[244]: 16000

# category dtype
In [245]: s.astype('category').nbytes
Out[245]: 20000
\end{Verbatim}
21.12.2 Categorical is not a numpy array

Currently, categorical data and the underlying Categorical is implemented as a Python object and not as a low-level NumPy array dtype. This leads to some problems.

NumPy itself doesn’t know about the new dtype:

```python
In [246]: try:
    ......:   np.dtype("category")
    ......: except TypeError as e:
    ......:   print("TypeError: " + str(e))
    ......:
TypeError: data type "category" not understood

In [247]: dtype = pd.Categorical(["a"]).dtype

In [248]: try:
    ......:   np.dtype(dtype)
    ......: except TypeError as e:
    ......:   print("TypeError: " + str(e))
    ......:
TypeError: data type not understood
```

Dtype comparisons work:

```python
In [249]: dtype == np.str_
Out[249]: False

In [250]: np.str_ == dtype
```

To check if a Series contains Categorical data, use `hasattr(s, 'cat')`:

```python
In [251]: hasattr(pd.Series(['a'], dtype='category'), 'cat')
Out[251]: True

In [252]: hasattr(pd.Series(['a']), 'cat')
```

Using NumPy functions on a Series of type category should not work as Categoricals are not numeric data (even in the case that .categories is numeric).

```python
In [253]: s = pd.Series(pd.Categorical([1,2,3,4]))

In [254]: try:
    ......:   np.sum(s)
    ......: except TypeError as e:
    ......:   print("TypeError: " + str(e))
    ......:
TypeError: Categorical cannot perform the operation sum
```

Note: If such a function works, please file a bug at https://github.com/pandas-dev/pandas!
21.12.3 dtype in apply

Pandas currently does not preserve the dtype in apply functions: If you apply along rows you get a Series of object dtype (same as getting a row -> getting one element will return a basic type) and applying along columns will also convert to object.

In [255]: df = pd.DataFrame({"a":[1,2,3,4],
......: "b": ["a","b","c","d"],
......: "cats":pd.Categorical([1,2,3,2])})

In [256]: df.apply(lambda row: type(row["cats"]), axis=1)
Out[256]:
0 <class 'int'>
1 <class 'int'>
2 <class 'int'>
3 <class 'int'>
dtype: object

In [257]: df.apply(lambda col: col.dtype, axis=0)
Out[257]:
\_strings        int64
\cats            category
dtype: object

21.12.4 Categorical Index

CategoricalIndex is a type of index that is useful for supporting indexing with duplicates. This is a container around a Categorical and allows efficient indexing and storage of an index with a large number of duplicated elements. See the advanced indexing docs for a more detailed explanation.

Setting the index will create a CategoricalIndex:

In [258]: cats = pd.Categorical([1,2,3,4], categories=[4,2,3,1])

In [259]: strings = ["a","b","c","d"]

In [260]: values = [4,2,3,1]

In [261]: df = pd.DataFrame({"strings":strings, "values":values}, index=cats)

In [262]: df.index
Out[262]: CategoricalIndex([1, 2, 3, 4], categories=[4, 2, 3, 1], ordered=False, dtype='category')

# This now sorts by the categories order
In [263]: df.sort_index()
Out[263]:
\strings values
4  d  1
2  b  2
3  c  3
1  a  4
21.12.5 Side Effects

Constructing a Series from a Categorical will not copy the input Categorical. This means that changes to the Series will in most cases change the original Categorical:

```python
In [264]: cat = pd.Categorical([1,2,3,10], categories=[1,2,3,4,10])
In [265]: s = pd.Series(cat, name="cat")
In [266]: cat
Out[266]:
[1, 2, 3, 10]  Categories (5, int64): [1, 2, 3, 4, 10]
In [267]: s.iloc[0:2] = 10
In [268]: cat
Out[268]:
[10, 10, 3, 10]  Categories (5, int64): [1, 2, 3, 4, 10]
In [269]: df = pd.DataFrame(s)
In [270]: df["cat"].cat.categories = [1,2,3,4,5]
In [271]: cat
Out[271]:
[5, 5, 3, 5]  Categories (5, int64): [1, 2, 3, 4, 5]

Use `copy=True` to prevent such a behaviour or simply don’t reuse Categoricals:

```python
In [272]: cat = pd.Categorical([1,2,3,10], categories=[1,2,3,4,10])
In [273]: s = pd.Series(cat, name="cat", copy=True)
In [274]: cat
Out[274]:
[1, 2, 3, 10]  Categories (5, int64): [1, 2, 3, 4, 10]
In [275]: s.iloc[0:2] = 10
In [276]: cat
Out[276]:
[1, 2, 3, 10]  Categories (5, int64): [1, 2, 3, 4, 10]
```

Note: This also happens in some cases when you supply a NumPy array instead of a Categorical: using an int array (e.g. `np.array([1,2,3,4])`) will exhibit the same behavior, while using a string array (e.g. `np.array(["a","b","c","a"])`) will not.
We use the standard convention for referencing the matplotlib API:

```python
In [1]: import matplotlib.pyplot as plt
```

We provide the basics in pandas to easily create decent looking plots. See the ecosystem section for visualization libraries that go beyond the basics documented here.

**Note:** All calls to `np.random` are seeded with 123456.

### 22.1 Basic Plotting: plot

We will demonstrate the basics, see the cookbook for some advanced strategies.

The `plot` method on Series and DataFrame is just a simple wrapper around `plt.plot()`:

```python
In [2]: ts = pd.Series(np.random.randn(1000), index=pd.date_range('1/1/2000', periods=1000))
In [3]: ts = ts.cumsum()
In [4]: ts.plot()
Out[4]: <matplotlib.axes._subplots.AxesSubplot at 0x1c2e3b0ba8>
```
If the index consists of dates, it calls `gcf().autofmt_xdate()` to try to format the x-axis nicely as per above.

On DataFrame, `plot()` is a convenience to plot all of the columns with labels:

```python
In [5]: df = pd.DataFrame(np.random.randn(1000, 4), index=ts.index, columns=list('ABCD'))
In [6]: df = df.cumsum()
In [7]: plt.figure(); df.plot();
```
You can plot one column versus another using the `x` and `y` keywords in `plot()`:

```python
In [8]: df3 = pd.DataFrame(np.random.randn(1000, 2), columns=['B', 'C']).cumsum()
In [9]: df3['A'] = pd.Series(list(range(len(df))))
In [10]: df3.plot(x='A', y='B')
Out[10]: <matplotlib.axes._subplots.AxesSubplot at 0x1c38114e10>
```
22.2 Other Plots

Plotting methods allow for a handful of plot styles other than the default line plot. These methods can be provided as the kind keyword argument to `plot()`, and include:

- 'bar' or 'barh' for bar plots
- 'hist' for histogram
- 'box' for boxplot
- 'kde' or 'density' for density plots
- 'area' for area plots
- 'scatter' for scatter plots
- 'hexbin' for hexagonal bin plots
- 'pie' for pie plots

For example, a bar plot can be created the following way:
You can also create these other plots using the methods `DataFrame.plot.<kind>` instead of providing the `kind` keyword argument. This makes it easier to discover plot methods and the specific arguments they use:

```python
In [13]: df = pd.DataFrame()
In [14]: df.plot.<TAB>
    df.plot.area    df.plot.barh    df.plot.density    df.plot.hist    df.plot.line
    df.plot.scatter
    df.plot.bar    df.plot.box    df.plot.hexbin    df.plot.kde    df.plot.pie
```

In addition to these kinds, there are the `DataFrame.hist()`, and `DataFrame.boxplot()` methods, which use a separate interface.

Finally, there are several plotting functions in `pandas.plotting` that take a `Series` or `DataFrame` as an argument. These include:

- Scatter Matrix
- Andrews Curves
- Parallel Coordinates
- Lag Plot
• Autocorrelation Plot
• Bootstrap Plot
• RadViz

Plots may also be adorned with errorbars or tables.

22.2.1 Bar plots

For labeled, non-time series data, you may wish to produce a bar plot:

Calling a DataFrame’s `plot.bar()` method produces a multiple bar plot:

```
In [17]: df2 = pd.DataFrame(np.random.rand(10, 4), columns=['a', 'b', 'c', 'd'])
In [18]: df2.plot.bar();
```
To produce a stacked bar plot, pass `stacked=True`:

```python
In [19]: df2.plot.bar(stacked=True);
```
To get horizontal bar plots, use the `barh` method:

```python
In [20]: df2.plot.barh(stacked=True);
```
22.2.2 Histograms

Histograms can be drawn by using the `DataFrame.plot.hist()` and `Series.plot.hist()` methods.

```
In [21]: df4 = pd.DataFrame({'a': np.random.randn(1000) + 1, 'b': np.random.randn(1000),
                      'c': np.random.randn(1000) - 1}, columns=['a', 'b', 'c'])

In [22]: plt.figure();
In [23]: df4.plot.hist(alpha=0.5)
Out[23]: <matplotlib.axes._subplots.AxesSubplot at 0x1c36abc470>
```
A histogram can be stacked using `stacked=True`. Bin size can be changed using the `bins` keyword.

```python
In [24]: plt.figure();
In [25]: df4.plot.hist(stacked=True, bins=20)
Out[25]: <matplotlib.axes._subplots.AxesSubplot at 0x1c36ac4940>
```
You can pass other keywords supported by matplotlib `hist`. For example, horizontal and cumulative histograms can be drawn by `orientation='horizontal'` and `cumulative=True`.

```python
In [26]: plt.figure();

In [27]: df4['a'].plot.hist(orientation='horizontal', cumulative=True)
Out[27]: <matplotlib.axes._subplots.AxesSubplot at 0x1c369362b0>
```
See the `hist` method and the `matplotlib hist` documentation for more.

The existing interface `DataFrame.hist` to plot histogram still can be used.

```python
In [28]: plt.figure();

In [29]: df['A'].diff().hist()
Out[29]: <matplotlib.axes._subplots.AxesSubplot at 0x1c388ceeb8>
```
`DataFrame.hist()` plots the histograms of the columns on multiple subplots:

```python
In [30]: plt.figure()
Out[30]: <Figure size 640x480 with 0 Axes>

In [31]: df.diff().hist(color='k', alpha=0.5, bins=50)
```

22.2. Other Plots 1057
The `by` keyword can be specified to plot grouped histograms:

```python
In [32]: data = pd.Series(np.random.randn(1000))
In [33]: data.hist(by=np.random.randint(0, 4, 1000), figsize=(6, 4))
Out[33]:
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x1c36be2d30>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c2efde940>],
      [<matplotlib.axes._subplots.AxesSubplot object at 0x1c2f002e48>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c33d2c198>]],
      dtype=object)
```
22.2.3 Box Plots

Boxplot can be drawn calling :meth:`Series.plot.box` and :meth:`DataFrame.plot.box`, or :meth:`DataFrame.boxplot` to visualize the distribution of values within each column.

For instance, here is a boxplot representing five trials of 10 observations of a uniform random variable on [0,1).

```python
In [34]: df = pd.DataFrame(np.random.rand(10, 5), columns=['A', 'B', 'C', 'D', 'E'])
In [35]: df.plot.box()
Out[35]: <matplotlib.axes._subplots.AxesSubplot at 0x1c38838f98>
```
Boxplot can be colorized by passing `color` keyword. You can pass a `dict` whose keys are `boxes`, `whiskers`, `medians` and `caps`. If some keys are missing in the `dict`, default colors are used for the corresponding artists. Also, boxplot has `sym` keyword to specify fliers style.

When you pass other type of arguments via `color` keyword, it will be directly passed to matplotlib for all the `boxes`, `whiskers`, `medians` and `caps` colorization.

The colors are applied to every boxes to be drawn. If you want more complicated colorization, you can get each drawn artists by passing `return_type`.

```
In [36]: color = dict(boxes='DarkGreen', whiskers='DarkOrange',
               medians='DarkBlue', caps='Gray')

In [37]: df.plot.box(color=color, sym='r+')
Out[37]: <matplotlib.axes._subplots.AxesSubplot at 0x1c378c4198>
```
Also, you can pass other keywords supported by matplotlib boxplot. For example, horizontal and custom-positioned boxplot can be drawn by `vert=False` and `positions` keywords.

```python
In [38]: df.plot.box(vert=False, positions=[1, 4, 5, 6, 8])
Out[38]: <matplotlib.axes._subplots.AxesSubplot at 0x1c36a6ae10>
```
See the `boxplot` method and the `matplotlib` boxplot documentation for more.

The existing interface `DataFrame.boxplot` to plot boxplot still can be used.

```python
In [39]: df = pd.DataFrame(np.random.rand(10,5))
In [40]: plt.figure();
In [41]: bp = df.boxplot()
```
You can create a stratified boxplot using the `by` keyword argument to create groupings. For instance,

```python
In [42]: df = pd.DataFrame(np.random.rand(10,2), columns=['Col1', 'Col2'])
In [43]: df['X'] = pd.Series(['A','A','A','A','A','B','B','B','B','B'])
In [44]: plt.figure();
In [45]: bp = df.boxplot(by='X')
```
You can also pass a subset of columns to plot, as well as group by multiple columns:

```python
In [46]: df = pd.DataFrame(np.random.rand(10,3), columns=['Col1', 'Col2', 'Col3'])
In [47]: df['X'] = pd.Series(['A','A','A','A','A','B','B','B','B','B'])
In [48]: df['Y'] = pd.Series(['A','B','A','B','A','B','A','B','A','B'])
In [49]: plt.figure();
In [50]: bp = df.boxplot(column=['Col1','Col2'], by=['X','Y'])
```
Warning: The default changed from 'dict' to 'axes' in version 0.19.0.

In boxplot, the return type can be controlled by the return_type keyword. The valid choices are {"axes", "dict", "both", None}. Faceting, created by DataFrame.boxplot with the by keyword, will affect the output type as well:

<table>
<thead>
<tr>
<th>return_type=</th>
<th>Faceted</th>
<th>Output type</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>No</td>
<td>axes</td>
</tr>
<tr>
<td>None</td>
<td>Yes</td>
<td>2-D ndarray of axes</td>
</tr>
<tr>
<td>'axes'</td>
<td>No</td>
<td>axes</td>
</tr>
<tr>
<td>'axes'</td>
<td>Yes</td>
<td>Series of axes</td>
</tr>
<tr>
<td>'dict'</td>
<td>No</td>
<td>dict of artists</td>
</tr>
<tr>
<td>'dict'</td>
<td>Yes</td>
<td>Series of dicts of artists</td>
</tr>
<tr>
<td>'both'</td>
<td>No</td>
<td>namedtuple</td>
</tr>
<tr>
<td>'both'</td>
<td>Yes</td>
<td>Series of namedtuples</td>
</tr>
</tbody>
</table>

Groupby.boxplot always returns a Series of return_type.

In [51]: np.random.seed(1234)

In [52]: df_box = pd.DataFrame(np.random.randn(50, 2))
In [53]: df_box['g'] = np.random.choice(['A', 'B'], size=50)

In [54]: df_box.loc[df_box['g'] == 'B', 1] += 3

In [55]: bp = df_box.boxplot(by='g')

The subplots above are split by the numeric columns first, then the value of the \textit{g} column. Below the subplots are first split by the value of \textit{g}, then by the numeric columns.

In [56]: bp = df_box.groupby('g').boxplot()
22.2.4 Area Plot

You can create area plots with `Series.plot.area()` and `DataFrame.plot.area()`. Area plots are stacked by default. To produce stacked area plot, each column must be either all positive or all negative values.

When input data contains `NaN`, it will be automatically filled by 0. If you want to drop or fill by different values, use `dataframe.dropna()` or `dataframe.fillna()` before calling `plot`.

```
In [57]: df = pd.DataFrame(np.random.rand(10, 4), columns=['a', 'b', 'c', 'd'])
In [58]: df.plot.area();
```
To produce an unstacked plot, pass `stacked=False`. Alpha value is set to 0.5 unless otherwise specified:

```
In [59]: df.plot.area(stacked=False);
```
22.2.5 Scatter Plot

Scatter plot can be drawn by using the `DataFrame.plot.scatter()` method. Scatter plot requires numeric columns for the x and y axes. These can be specified by the x and y keywords.

```
In [60]: df = pd.DataFrame(np.random.rand(50, 4), columns=['a', 'b', 'c', 'd'])
In [61]: df.plot.scatter(x='a', y='b');
```
To plot multiple column groups in a single axes, repeat `plot` method specifying target `ax`. It is recommended to specify `color` and `label` keywords to distinguish each groups.

```
In [62]: ax = df.plot.scatter(x='a', y='b', color='DarkBlue', label='Group 1');
In [63]: df.plot.scatter(x='c', y='d', color='DarkGreen', label='Group 2', ax=ax);
```
The keyword `c` may be given as the name of a column to provide colors for each point:

```python
In [64]: df.plot.scatter(x='a', y='b', c='c', s=50);
```
You can pass other keywords supported by matplotlib `scatter`. The example below shows a bubble chart using a column of the DataFrame as the bubble size.

```python
In [65]: df.plot.scatter(x='a', y='b', s=df['c']*200);
```
See the `scatter` method and the matplotlib `scatter` documentation for more.

### 22.2.6 Hexagonal Bin Plot

You can create hexagonal bin plots with `DataFrame.plot.hexbin()`. Hexbin plots can be a useful alternative to scatter plots if your data are too dense to plot each point individually.

```python
In [66]: df = pd.DataFrame(np.random.randn(1000, 2), columns=['a', 'b'])
In [67]: df['b'] = df['b'] + np.arange(1000)
In [68]: df.plot.hexbin(x='a', y='b', gridsize=25)
Out[68]: <matplotlib.axes._subplots.AxesSubplot at 0x1c3d4c09b0>
```
A useful keyword argument is `gridsize`; it controls the number of hexagons in the x-direction, and defaults to 100. A larger `gridsize` means more, smaller bins.

By default, a histogram of the counts around each \((x, y)\) point is computed. You can specify alternative aggregations by passing values to the `C` and `reduce_C_function` arguments. `C` specifies the value at each \((x, y)\) point and `reduce_C_function` is a function of one argument that reduces all the values in a bin to a single number (e.g. `mean`, `max`, `sum`, `std`). In this example the positions are given by columns `a` and `b`, while the value is given by column `z`. The bins are aggregated with NumPy’s `max` function.

```python
In [69]: df = pd.DataFrame(np.random.randn(1000, 2), columns=['a', 'b'])
In [70]: df['b'] = df['b'] = df['b'] + np.arange(1000)
In [71]: df['z'] = np.random.uniform(0, 3, 1000)
In [72]: df.plot.hexbin(x='a', y='b', C='z', reduce_C_function=np.max,
                   gridsize=25)
```

```
Out[72]: <matplotlib.axes._subplots.AxesSubplot at 0x1c3d567dd8>
```
See the `hexbin` method and the matplotlib hexbin documentation for more.

### 22.2.7 Pie plot

You can create a pie plot with `DataFrame.plot.pie()` or `Series.plot.pie()`. If your data includes any `NaN`, they will be automatically filled with 0. A `ValueError` will be raised if there are any negative values in your data.

```python
In [73]: series = pd.Series(3 * np.random.rand(4), index=['a', 'b', 'c', 'd'], name='series')

In [74]: series.plot.pie(figsize=(6, 6))
Out[74]: <matplotlib.axes._subplots.AxesSubplot at 0x1c3d85c5f8>
```
For pie plots it’s best to use square figures, i.e. a figure aspect ratio 1. You can create the figure with equal width and height, or force the aspect ratio to be equal after plotting by calling `ax.set_aspect('equal')` on the returned `axes` object.

Note that pie plot with `DataFrame` requires that you either specify a target column by the `y` argument or `subplots=True`. When `y` is specified, pie plot of selected column will be drawn. If `subplots=True` is specified, pie plots for each column are drawn as subplots. A legend will be drawn in each pie plots by default; specify `legend=False` to hide it.

```
In [75]: df = pd.DataFrame(3 * np.random.rand(4, 2), index=['a', 'b', 'c', 'd'],
                     columns=['x', 'y'])

In [76]: df.plot.pie(subplots=True, figsize=(8, 4))
Out[76]:
array([<matplotlib.axes._subplots.AxesSubplot object at 0x1c3d8c5940>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c3da4bd30>], dtype=object)
```
You can use the `labels` and `colors` keywords to specify the labels and colors of each wedge.

**Warning:** Most pandas plots use the `label` and `color` arguments (note the lack of “s” on those). To be consistent with matplotlib.pyplot.pie() you must use `labels` and `colors`.

If you want to hide wedge labels, specify `labels=None`. If `fontsize` is specified, the value will be applied to wedge labels. Also, other keywords supported by matplotlib.pyplot.pie() can be used.

```python
In [77]: series.plot.pie(labels=['AA', 'BB', 'CC', 'DD'], colors=['r', 'g', 'b', 'c'],
   ....:                                  autopct='%.2f', fontsize=20, figsize=(6, 6))
   ....:
Out[77]: <matplotlib.axes._subplots.AxesSubplot at 0x121551ba8>
```
If you pass values whose sum total is less than 1.0, matplotlib draws a semicircle.

```
In [78]: series = pd.Series([0.1] * 4, index=['a', 'b', 'c', 'd'], name='series2')
In [79]: series.plot.pie(figsize=(6, 6))
Out[79]: <matplotlib.axes._subplots.AxesSubplot at 0x1c3d8b22b0>
```
See the matplotlib pie documentation for more.

22.3 Plotting with Missing Data

Pandas tries to be pragmatic about plotting DataFrame or Series that contain missing data. Missing values are dropped, left out, or filled depending on the plot type.
If any of these defaults are not what you want, or if you want to be explicit about how missing values are handled, consider using `fillna()` or `dropna()` before plotting.

## 22.4 Plotting Tools

These functions can be imported from `pandas.plotting` and take a `Series` or `DataFrame` as an argument.

### 22.4.1 Scatter Matrix Plot

You can create a scatter plot matrix using the `scatter_matrix` method in `pandas.plotting`:

```python
In [80]: from pandas.plotting import scatter_matrix

In [81]: df = pd.DataFrame(np.random.randn(1000, 4), columns=['a', 'b', 'c', 'd'])

In [82]: scatter_matrix(df, alpha=0.2, figsize=(6, 6), diagonal='kde')

Out[82]:
array([<matplotlib.axes._subplots.AxesSubplot object at 0x1c381e89e8>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c37c4da20>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c3781c898>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c376d50f0>],
      [<matplotlib.axes._subplots.AxesSubplot object at 0x1c33b56320>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c33b56518>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c2f046550>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c2bdcf780>],
      [<matplotlib.axes._subplots.AxesSubplot object at 0x1c370c6400>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c25a6a710>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c2f082a20>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c36ac3668>],
      [<matplotlib.axes._subplots.AxesSubplot object at 0x1c33c43cf8>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c37d01cc0>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c383a0358>,
       <matplotlib.axes._subplots.AxesSubplot object at 0x1c38115470>]),
<dtype=object>)
```
22.4.2 Density Plot

You can create density plots using the `Series.plot.kde()` and `DataFrame.plot.kde()` methods.

```
In [83]: ser = pd.Series(np.random.randn(1000))
In [84]: ser.plot.kde()
Out[84]: <matplotlib.axes._subplots.AxesSubplot at 0x1c3842c908>
```
22.4.3 Andrews Curves

Andrews curves allow one to plot multivariate data as a large number of curves that are created using the attributes of samples as coefficients for Fourier series, see the Wikipedia entry for more information. By coloring these curves differently for each class it is possible to visualize data clustering. Curves belonging to samples of the same class will usually be closer together and form larger structures.

Note: The “Iris” dataset is available here.

```python
In [85]: from pandas.plotting import andrews_curves

In [86]: data = pd.read_csv('data/iris.data')

In [87]: plt.figure()
Out[87]: <Figure size 640x480 with 0 Axes>

In [88]: andrews_curves(data, 'Name')
```

![Andrews Curves Diagram](image)
22.4.4 Parallel Coordinates

Parallel coordinates is a plotting technique for plotting multivariate data, see the Wikipedia entry for an introduction. Parallel coordinates allows one to see clusters in data and to estimate other statistics visually. Using parallel coordinates points are represented as connected line segments. Each vertical line represents one attribute. One set of connected line segments represents one data point. Points that tend to cluster will appear closer together.

```
In [89]: from pandas.plotting import parallel_coordinates

In [90]: data = pd.read_csv('data/iris.data')

In [91]: plt.figure()
Out[91]: <Figure size 640x480 with 0 Axes>

In [92]: parallel_coordinates(data, 'Name')
```

```
\\\\\\\\\\\\\\\\\\\\\\\\:\\\\\\\\\\\\\\\\\\\\\\\\\:\\\\\\\\\\\\\\\\\\\\\\\\\:\\\\\\\\\\\\\\\\\\\\\\\\\:\\\\\\\\\\\\\\\\\\\\\\\\\:\\\\\\\\\\\\\\\\\\\\\\\\\:Out[92]: <matplotlib.axes._subplots.AxesSubplot at 0x1c38e62b38>
```

22.4. Plotting Tools
22.4.5 Lag Plot

Lag plots are used to check if a data set or time series is random. Random data should not exhibit any structure in the lag plot. Non-random structure implies that the underlying data are not random. The `lag` argument may be passed, and when `lag=1` the plot is essentially `data[:-1] vs. data[1:]`.

```
In [93]: from pandas.plotting import lag_plot

In [94]: plt.figure()
Out[94]: <Figure size 640x480 with 0 Axes>

In [95]: data = pd.Series(0.1 * np.random.rand(1000) +
                      0.9 * np.sin(np.linspace(-99 * np.pi, 99 * np.pi, num=1000)))

In [96]: lag_plot(data)
Out[96]: <matplotlib.axes._subplots.AxesSubplot at 0x1c2b26e208>
```
22.4.6 Autocorrelation Plot

Autocorrelation plots are often used for checking randomness in time series. This is done by computing autocorrelations for data values at varying time lags. If time series is random, such autocorrelations should be near zero for any and all time-lag separations. If time series is non-random then one or more of the autocorrelations will be significantly non-zero. The horizontal lines displayed in the plot correspond to 95% and 99% confidence bands. The dashed line is 99% confidence band. See the Wikipedia entry for more about autocorrelation plots.

```
In [97]: from pandas.plotting import autocorrelation_plot

In [98]: plt.figure()
Out[98]: <Figure size 640x480 with 0 Axes>

In [99]: data = pd.Series(0.7 * np.random.rand(1000) +
.....:            0.3 * np.sin(np.linspace(-9 * np.pi, 9 * np.pi, num=1000)))
.....:

In [100]: autocorrelation_plot(data)
Out[100]: <matplotlib.axes._subplots.AxesSubplot at 0x1c37dd3588>
```
22.4.7 Bootstrap Plot

Bootstrap plots are used to visually assess the uncertainty of a statistic, such as mean, median, midrange, etc. A random subset of a specified size is selected from a data set, the statistic in question is computed for this subset and the process is repeated a specified number of times. Resulting plots and histograms are what constitutes the bootstrap plot.

In [101]: from pandas.plotting import bootstrap_plot
In [102]: data = pd.Series(np.random.rand(1000))
In [103]: bootstrap_plot(data, size=50, samples=500, color='grey')
Out[103]: <Figure size 640x480 with 6 Axes>
22.4.8 RadViz

RadViz is a way of visualizing multi-variate data. It is based on a simple spring tension minimization algorithm. Basically you set up a bunch of points in a plane. In our case they are equally spaced on a unit circle. Each point represents a single attribute. You then pretend that each sample in the data set is attached to each of these points by a spring, the stiffness of which is proportional to the numerical value of that attribute (they are normalized to unit interval). The point in the plane, where our sample settles to (where the forces acting on our sample are at an equilibrium) is where a dot representing our sample will be drawn. Depending on which class that sample belongs it will be colored differently. See the R package `Radviz` for more information.

Note: The “Iris” dataset is available here.

```
In [104]: from pandas.plotting import radviz

In [105]: data = pd.read_csv('data/iris.data')

In [106]: plt.figure()
Out[106]: <Figure size 640x480 with 0 Axes>

In [107]: radviz(data, 'Name')
```

---

22.4. Plotting Tools 1087
22.5 Plot Formatting

22.5.1 Setting the plot style

From version 1.5 and up, matplotlib offers a range of preconfigured plotting styles. Setting the style can be used to easily give plots the general look that you want. Setting the style is as easy as calling `matplotlib.style.use(my_plot_style)` before creating your plot. For example you could write `matplotlib.style.use('ggplot')` for ggplot-style plots.

You can see the various available style names at `matplotlib.style.available` and it's very easy to try them out.

22.5.2 General plot style arguments

Most plotting methods have a set of keyword arguments that control the layout and formatting of the returned plot:

```python
In [108]: plt.figure(); ts.plot(style='k--', label='Series');
```
For each kind of plot (e.g. line, bar, scatter) any additional arguments keywords are passed along to the corresponding matplotlib function (ax.plot(), ax.bar(), ax.scatter()). These can be used to control additional styling, beyond what pandas provides.

### 22.5.3 Controlling the Legend

You may set the `legend` argument to `False` to hide the legend, which is shown by default.

```
In [109]: df = pd.DataFrame(np.random.randn(1000, 4), index=ts.index, columns=list('ABCD'))
In [110]: df = df.cumsum()
In [111]: df.plot(legend=False)
```

Out[111]: <matplotlib.axes._subplots.AxesSubplot at 0x1c2a823fd0>
### 22.5.4 Scales

You may pass `logy` to get a log-scale Y axis.

```python
In [112]: ts = pd.Series(np.random.randn(1000), index=pd.date_range('1/1/2000', periods=1000))

In [113]: ts = np.exp(ts.cumsum())

In [114]: ts.plot(logy=True)
Out[114]: <matplotlib.axes._subplots.AxesSubplot at 0x1c2f026080>
```
22.5.5 Plotting on a Secondary Y-axis

To plot data on a secondary y-axis, use the `secondary_y` keyword:

```python
In [115]: df.A.plot()
Out[115]: <matplotlib.axes._subplots.AxesSubplot at 0x1c37e6c7f0>

In [116]: df.B.plot(secondary_y=True, style='g')
```

See also the `logx` and `loglog` keyword arguments.
To plot some columns in a DataFrame, give the column names to the `secondary_y` keyword:

```python
In [117]: plt.figure()
Out[117]: <Figure size 640x480 with 0 Axes>

In [118]: ax = df.plot(secondary_y=['A', 'B'])

In [119]: ax.set_ylabel('CD scale')
Out[119]: Text(0,0.5,'CD scale')

In [120]: ax.right_ax.set_ylabel('AB scale')
```

Out[120]: Text(0,0.5,'AB scale')
Note that the columns plotted on the secondary y-axis is automatically marked with “(right)” in the legend. To turn off the automatic marking, use the `mark_right=False` keyword:

```python
In [121]: plt.figure()
Out[121]: <Figure size 640x480 with 0 Axes>

In [122]: df.plot(secondary_y=['A', 'B'], mark_right=False)
```

22.5. Plot Formatting
22.5.6 Suppressing Tick Resolution Adjustment

pandas includes automatic tick resolution adjustment for regular frequency time-series data. For limited cases where pandas cannot infer the frequency information (e.g., in an externally created `twinx`), you can choose to suppress this behavior for alignment purposes.

Here is the default behavior, notice how the x-axis tick labeling is performed:

```python
In [123]: plt.figure()
Out[123]: <Figure size 640x480 with 0 Axes>

In [124]: df.A.plot()
```

```python
Out[124]: <matplotlib.axes._subplots.AxesSubplot at 0x1c31f58a58>
```
Using the `x_compat` parameter, you can suppress this behavior:

```
In [125]: plt.figure()
Out[125]: <Figure size 640x480 with 0 Axes>

In [126]: df.A.plot(x_compat=True)
```
If you have more than one plot that needs to be suppressed, the `use` method in `pandas.plotting.plot_params` can be used in a `with` statement:

```python
In [127]: plt.figure()
Out[127]: <Figure size 640x480 with 0 Axes>

In [128]: with pd.plotting.plot_params.use('x_compat', True):
    ....:     df.A.plot(color='r')
    ....:     df.B.plot(color='g')
    ....:     df.C.plot(color='b')
    ....:
```
22.5.7 Automatic Date Tick Adjustment

New in version 0.20.0.

TimedeltaIndex now uses the native matplotlib tick locator methods, it is useful to call the automatic date tick adjustment from matplotlib for figures whose ticklabels overlap.

See the autofmt_xdate method and the matplotlib documentation for more.

22.5.8 Subplots

Each Series in a DataFrame can be plotted on a different axis with the subplots keyword:

```python
In [129]: df.plot(subplots=True, figsize=(6, 6));
```
22.5.9 Using Layout and Targeting Multiple Axes

The layout of subplots can be specified by the `layout` keyword. It can accept `(rows, columns)`. The `layout` keyword can be used in `hist` and `boxplot` also. If the input is invalid, a `ValueError` will be raised.

The number of axes which can be contained by rows x columns specified by `layout` must be larger than the number of required subplots. If layout can contain more axes than required, blank axes are not drawn. Similar to a NumPy array’s `reshape` method, you can use `-1` for one dimension to automatically calculate the number of rows or columns needed, given the other.

```python
In [130]: df.plot(subplots=True, layout=(2, 3), figsize=(6, 6), sharex=False);
```
The above example is identical to using:

```
In [131]: df.plot(subplots=True, layout=(2, -1), figsize=(6, 6), sharex=False);
```

The required number of columns (3) is inferred from the number of series to plot and the given number of rows (2).

You can pass multiple axes created beforehand as list-like via `ax` keyword. This allows more complicated layouts. The passed axes must be the same number as the subplots being drawn.

When multiple axes are passed via the `ax` keyword, `layout`, `sharex` and `sharey` keywords don’t affect to the output. You should explicitly pass `sharex=False` and `sharey=False`, otherwise you will see a warning.

```
In [132]: fig, axes = plt.subplots(4, 4, figsize=(6, 6));

In [133]: plt.subplots_adjust(wspace=0.5, hspace=0.5);

In [134]: target1 = [axes[0][0], axes[1][1], axes[2][2], axes[3][3]]
```

(continues on next page)
Another option is passing an `ax` argument to `Series.plot()` to plot on a particular axis:

```python
In [138]: fig, axes = plt.subplots(nrows=2, ncols=2)
In [139]: df['A'].plot(ax=axes[0,0]); axes[0,0].set_title('A');
In [140]: df['B'].plot(ax=axes[0,1]); axes[0,1].set_title('B');
(continues on next page)
```
In [141]: df['C'].plot(ax=axes[1,0]); axes[1,0].set_title('C');
In [142]: df['D'].plot(ax=axes[1,1]); axes[1,1].set_title('D');

22.5.10 Plotting With Error Bars

Plotting with error bars is supported in `DataFrame.plot()` and `Series.plot()`.

Horizontal and vertical error bars can be supplied to the `xerr` and `yerr` keyword arguments to `plot()`. The error values can be specified using a variety of formats:

- As a `DataFrame` or `dict` of errors with column names matching the `columns` attribute of the plotting `DataFrame` or matching the `name` attribute of the `Series`.
- As a `str` indicating which of the columns of plotting `DataFrame` contain the error values.
- As raw values (`list`, `tuple`, or `np.ndarray`). Must be the same length as the plotting `DataFrame/Series`.

Asymmetrical error bars are also supported, however raw error values must be provided in this case. For a `M` length `Series`, a `Mx2` array should be provided indicating lower and upper (or left and right) errors. For a `MxN DataFrame`, asymmetrical errors should be in a `Mx2xN` array.

Here is an example of one way to easily plot group means with standard deviations from the raw data.
# Generate the data

```python
In [143]: ix3 = pd.MultiIndex.from_arrays([['a', 'a', 'a', 'a', 'b', 'b', 'b', 'b'], ['foo', 'foo', 'bar', 'bar', 'foo', 'foo', 'bar', 'bar']], names=['letter', 'word'])
```

```python
In [144]: df3 = pd.DataFrame({'data1': [3, 2, 4, 3, 2, 4, 3, 2], 'data2': [6, 5, 7, 5, 4, 5, 6, 5]}, index=ix3)
```

# Group by index labels and take the means and standard deviations for each group

```python
In [145]: gp3 = df3.groupby(level=('letter', 'word'))
```

```python
In [146]: means = gp3.mean()
In [147]: errors = gp3.std()
```

```
Out[148]:

<table>
<thead>
<tr>
<th>letter</th>
<th>word</th>
<th>data1</th>
<th>data2</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>bar</td>
<td>3.5</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>foo</td>
<td>2.5</td>
<td>5.5</td>
</tr>
<tr>
<td>b</td>
<td>bar</td>
<td>2.5</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>foo</td>
<td>3.0</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Out[149]:

```

<table>
<thead>
<tr>
<th>letter</th>
<th>word</th>
<th>data1</th>
<th>data2</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>bar</td>
<td>0.707107</td>
<td>1.414214</td>
</tr>
<tr>
<td></td>
<td>foo</td>
<td>0.707107</td>
<td>0.707107</td>
</tr>
<tr>
<td>b</td>
<td>bar</td>
<td>0.707107</td>
<td>0.707107</td>
</tr>
<tr>
<td></td>
<td>foo</td>
<td>1.414214</td>
<td>0.707107</td>
</tr>
</tbody>
</table>
```

# Plot

```python
In [150]: fig, ax = plt.subplots()
In [151]: means.plot.bar(yerr=errors, ax=ax)
```

```
Out[151]: <matplotlib.axes._subplots.AxesSubplot at 0x1c3f1fd208>
```
22.5.11 Plotting Tables

Plotting with matplotlib table is now supported in `DataFrame.plot()` and `Series.plot()` with a `table` keyword. The `table` keyword can accept `bool`, `DataFrame` or `Series`. The simple way to draw a table is to specify `table=True`. Data will be transposed to meet matplotlib's default layout.

```
In [152]: fig, ax = plt.subplots(1, 1)

In [153]: df = pd.DataFrame(np.random.rand(5, 3), columns=['a', 'b', 'c'])

In [154]: ax.get_xaxis().set_visible(False)  # Hide Ticks

In [155]: df.plot(table=True, ax=ax)
Out[155]: <matplotlib.axes._subplots.AxesSubplot at 0x1c3e719550>
```
Also, you can pass a different `DataFrame` or `Series` to the `table` keyword. The data will be drawn as displayed in print method (not transposed automatically). If required, it should be transposed manually as seen in the example below.

```python
In [156]: fig, ax = plt.subplots(1, 1)
In [157]: ax.get_xaxis().set_visible(False)  # Hide Ticks
In [158]: df.plot(table=np.round(df.T, 2), ax=ax)
Out[158]: <matplotlib.axes._subplots.AxesSubplot at 0x1c3e23f320>
```
There also exists a helper function `pandas.plotting.table`, which creates a table from `DataFrame` or `Series`, and adds it to an `matplotlib.Axes` instance. This function can accept keywords which the `matplotlib` table has.

```python
In [159]: from pandas.plotting import table

In [160]: fig, ax = plt.subplots(1, 1)

In [161]: table(ax, np.round(df.describe(), 2),
        loc='upper right', colWidths=[0.2, 0.2, 0.2])

Out[161]: <matplotlib.table.Table at 0x1c382b3630>

In [162]: df.plot(ax=ax, ylim=(0, 2), legend=None)
```

There also exists a helper function `pandas.plotting.table`, which creates a table from `DataFrame` or `Series`, and adds it to an `matplotlib.Axes` instance. This function can accept keywords which the `matplotlib` table has.

```python
In [159]: from pandas.plotting import table

In [160]: fig, ax = plt.subplots(1, 1)

In [161]: table(ax, np.round(df.describe(), 2),
        loc='upper right', colWidths=[0.2, 0.2, 0.2])

Out[161]: <matplotlib.table.Table at 0x1c382b3630>

In [162]: df.plot(ax=ax, ylim=(0, 2), legend=None)
```

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>a</code></td>
<td>0.13</td>
<td>0.9</td>
<td>0.45</td>
<td>0.54</td>
<td>0.13</td>
</tr>
<tr>
<td><code>b</code></td>
<td>0.97</td>
<td>0.38</td>
<td>0.84</td>
<td>0.37</td>
<td>0.86</td>
</tr>
</tbody>
</table>

22.5. Plot Formatting
**pandas**: powerful Python data analysis toolkit, Release 0.23.2

**22.5.12 Colormaps**

A potential issue when plotting a large number of columns is that it can be difficult to distinguish some series due to repetition in the default colors. To remedy this, `DataFrame` plotting supports the use of the `colormap` argument, which accepts either a Matplotlib colormap or a string that is a name of a colormap registered with Matplotlib. A visualization of the default matplotlib colormaps is available [here](#).

As matplotlib does not directly support colormaps for line-based plots, the colors are selected based on an even spacing determined by the number of columns in the `DataFrame`. There is no consideration made for background color, so some colormaps will produce lines that are not easily visible.

To use the cubehelix colormap, we can pass `colormap='cubehelix'`.

```python
In [163]: df = pd.DataFrame(np.random.randn(1000, 10), index=ts.index)
In [164]: df = df.cumsum()
In [165]: plt.figure()
Out[165]: <Figure size 640x480 with 0 Axes>
In [166]: df.plot(colormap='cubehelix')
```

Note: You can get table instances on the axes using `axes.tables` property for further decorations. See the matplotlib table documentation for more.
Alternatively, we can pass the colormap itself:

```python
In [167]: from matplotlib import cm

In [168]: plt.figure()
Out[168]: <Figure size 640x480 with 0 Axes>

In [169]: df.plot(colormap=cm.cubehelix)
```
Colormaps can also be used other plot types, like bar charts:

```
In [170]: dd = pd.DataFrame(np.random.randn(10, 10)).applymap(abs)
In [171]: dd = dd.cumsum()
In [172]: plt.figure()
Out[172]: <Figure size 640x480 with 0 Axes>
In [173]: dd.plot.bar(colormap='Greens')
```

```
Out[173]: <matplotlib.axes._subplots.AxesSubplot at 0x1c3e7c6b38>
```
Parallel coordinates charts:

```
In [174]: plt.figure()
Out[174]: <Figure size 640x480 with 0 Axes>

In [175]: parallel_coordinates(data, 'Name', colormap='gist_rainbow')
```

```
Out[175]: <matplotlib.axes._subplots.AxesSubplot at 0x1c3e3f3240>
```
Andrews curves charts:

```python
In [176]: plt.figure()
Out[176]: <Figure size 640x480 with 0 Axes>

In [177]: andrews_curves(data, 'Name', colormap='winter')
```

```
Out[177]: <matplotlib.axes._subplots.AxesSubplot at 0x1c3ded0080>
```
22.6 Plotting directly with matplotlib

In some situations it may still be preferable or necessary to prepare plots directly with matplotlib, for instance when a certain type of plot or customization is not (yet) supported by pandas. Series and DataFrame objects behave like arrays and can therefore be passed directly to matplotlib functions without explicit casts.

pandas also automatically registers formatters and locators that recognize date indices, thereby extending date and time support to practically all plot types available in matplotlib. Although this formatting does not provide the same level of refinement you would get when plotting via pandas, it can be faster when plotting a large number of points.

In [178]: price = pd.Series(np.random.randn(150).cumsum(),
       index=pd.date_range('2000-1-1', periods=150, freq='B'))

In [179]: ma = price.rolling(20).mean()

In [180]: mstd = price.rolling(20).std()

In [181]: plt.figure()
Out[181]: <Figure size 640x480 with 0 Axes>

In [182]: plt.plot(price.index, price, 'k')

(continues on next page)
22.7 Trellis plotting interface

**Warning:** The `rplot` trellis plotting interface has been removed. Please use external packages like `seaborn` for similar but more refined functionality and refer to our 0.18.1 documentation [here](#) for how to convert to using it.
**CHAPTER TWENTYTHREE**

**STYLING**

*New in version 0.17.1*

Provisional: This is a new feature and still under development. We’ll be adding features and possibly making breaking changes in future releases. We’d love to hear your feedback.

This document is written as a Jupyter Notebook, and can be viewed or downloaded here.

You can apply conditional formatting, the visual styling of a DataFrame depending on the data within, by using the `DataFrame.style` property. This is a property that returns a `Styler` object, which has useful methods for formatting and displaying DataFrames.

The styling is accomplished using CSS. You write “style functions” that take scalars, DataFrames or Series, and return like-indexed DataFrames or Series with CSS "attribute: value" pairs for the values. These functions can be incrementally passed to the `Styler` which collects the styles before rendering.

### 23.1 Building Styles

Pass your style functions into one of the following methods:

- **Styler.applymap:** elementwise
- **Styler.apply:** column-/row-/table-wise

Both of those methods take a function (and some other keyword arguments) and applies your function to the DataFrame in a certain way. `Styler.applymap` works through the DataFrame elementwise. `Styler.apply` passes each column or row into your DataFrame one-at-a-time or the entire table at once, depending on the axis keyword argument. For columnwise use `axis=0`, rowwise use `axis=1`, and for the entire table at once use `axis=None`.

For `Styler.applymap` your function should take a scalar and return a single string with the CSS attribute-value pair.

For `Styler.apply` your function should take a Series or DataFrame (depending on the axis parameter), and return a Series or DataFrame with an identical shape where each value is a string with a CSS attribute-value pair.

Let’s see some examples.

In [2]:
import pandas as pd
import numpy as np
np.random.seed(24)
df = pd.DataFrame({'A': np.linspace(1, 10, 10)})
df = pd.concat([df, pd.DataFrame(np.random.randn(10, 4), columns=list('BCDE'))],
               axis=1)
df.iloc[0, 2] = np.nan

Here’s a boring example of rendering a DataFrame, without any (visible) styles:
pandas: powerful Python data analysis toolkit, Release 0.23.2

In [3]: df.style

Out[3]: <pandas.io.formats.style.Styler at 0x1119c4f98>

Note: The DataFrame.style attribute is a property that returns a Styler object. Styler has a _repr_html_ method defined on it so they are rendered automatically. If you want the actual HTML back for further processing or for writing to file call the .render() method which returns a string.

The above output looks very similar to the standard DataFrame HTML representation. But we’ve done some work behind the scenes to attach CSS classes to each cell. We can view these by calling the .render method.

In [4]: df.style.highlight_null().render().split('\n')[:10]

Out[4]: ['<style type="text/css" >', '
  #T_2baa851c_80a0_11e8_ae45_186590cd1c87row0_col2 {', '
    background-color: red;', '
  }<style> ', '
  <table id="T_2baa851c_80a0_11e8_ae45_186590cd1c87" > ', '
    <thead> ', '
    <tr>', '
      <th class="blank level0"></th>', '
      <th class="col_heading level0 col0" >A</th> ', '
      <th class="col_heading level0 col1" >B</th>', '
      <th class="col_heading level0 col2" >C</th> '
  ']

The row0_col2 is the identifier for that particular cell. We’ve also prepended each row/column identifier with a UUID unique to each DataFrame so that the style from one doesn’t collide with the styling from another within the same notebook or page (you can set the uuid if you’d like to tie together the styling of two DataFrames).

When writing style functions, you take care of producing the CSS attribute / value pairs you want. Pandas matches those up with the CSS classes that identify each cell.

Let’s write a simple style function that will color negative numbers red and positive numbers black.

In [5]: def color_negative_red(val):
    
    """ Takes a scalar and returns a string with the css property 'color: red' for negative strings, black otherwise. """
    color = 'red' if val < 0 else 'black'
    return 'color: %s' % color

In this case, the cell’s style depends only on it’s own value. That means we should use the Styler.applymap method which works elementwise.

In [6]: s = df.style.applymap(color_negative_red)

Out[6]: <pandas.io.formats.style.Styler at 0x113d34048>

Notice the similarity with the standard df.applymap, which operates on DataFrames elementwise. We want you to be able to reuse your existing knowledge of how to interact with DataFrames.

Notice also that our function returned a string containing the CSS attribute and value, separated by a colon just like in a <style> tag. This will be a common theme.

Finally, the input shapes matched. Styler.applymap calls the function on each scalar input, and the function returns a scalar output.

Now suppose you wanted to highlight the maximum value in each column. We can’t use .applymap anymore since that operated elementwise. Instead, we’ll turn to .apply which operates columnwise (or rowwise using the axis keyword). Later on we’ll see that something like highlight_max is already defined on Styler so you wouldn’t need to write this yourself.
In [7]: ```python
def highlight_max(s):
    '''
    highlight the maximum in a Series yellow.
    '''
    is_max = s == s.max()
    return ['background-color: yellow' if v else '' for v in is_max]
```

In [8]: df.style.apply(highlight_max)

Out[8]: <pandas.io.formats.style.Styler at 0x113cec9e8>

In this case the input is a Series, one column at a time. Notice that the output shape of highlight_max matches the input shape, an array with \( \text{len}(s) \) items.

We encourage you to use method chains to build up a style piecewise, before finally rendering at the end of the chain.

In [9]: df.style.\
    applymap(color_negative_red).\
    apply(highlight_max)

Out[9]: <pandas.io.formats.style.Styler at 0x113cec160>

Above we used Styler.apply to pass in each column one at a time.

**Debugging Tip**: If you’re having trouble writing your style function, try just passing it into DataFrame.apply. Internally, Styler.apply uses DataFrame.apply so the result should be the same.

What if you wanted to highlight just the maximum value in the entire table? Use \( \text{.apply(function, axis=None)} \) to indicate that your function wants the entire table, not one column or row at a time. Let’s try that next.

We’ll rewrite our highlight-max to handle either Series (from \( \text{.apply(axis=0 or 1)} \)) or DataFrames (from \( \text{.apply(axis=None)} \)). We’ll also allow the color to be adjustable, to demonstrate that .apply and .applymap pass along keyword arguments.

In [10]: ```python
def highlight_max(data, color='yellow'):
    '''
    highlight the maximum in a Series or DataFrame
    '''
    attr = 'background-color: {}'.format(color)
    if data.ndim == 1:  # Series from .apply(axis=0) or axis=1
        is_max = data == data.max()
        return [attr if v else '' for v in is_max]
    else:  # from .apply(axis=None)
        is_max = data == data.max().max()
        return pd.DataFrame(np.where(is_max, attr, ''),
                           index=data.index, columns=data.columns)
```

When using Styler.apply(func, axis=None), the function must return a DataFrame with the same index and column labels.

In [11]: df.style.apply(highlight_max, color='darkorange', axis=None)

Out[11]: <pandas.io.formats.style.Styler at 0x113d214e0>

### 23.1.1 Building Styles Summary

Style functions should return strings with one or more CSS attribute: value delimited by semicolons. Use

- Styler.applymap(func) for elementwise styles
- Styler.apply(func, axis=0) for columnwise styles
- Styler.apply(func, axis=1) for rowwise styles
• Styler.apply(func, axis=None) for tablewise styles
And crucially the input and output shapes of func must match. If x is the input then func(x).shape == x.shape.

23.2 Finer Control: Slicing

Both Styler.apply, and Styler.applymap accept a subset keyword. This allows you to apply styles to specific rows or columns, without having to code that logic into your style function.
The value passed to subset behaves similar to slicing a DataFrame.
• A scalar is treated as a column label
• A list (or series or numpy array)
• A tuple is treated as (row_indexer, column_indexer)
Consider using pd.IndexSlice to construct the tuple for the last one.
In [12]: df.style.apply(highlight_max, subset=['B', 'C', 'D'])
Out[12]: <pandas.io.formats.style.Styler at 0x113d217b8>
For row and column slicing, any valid indexer to .loc will work.
In [13]: df.style.applymap(color_negative_red, subset=pd.IndexSlice[2:5, ['B', 'D']])
Out[13]: <pandas.io.formats.style.Styler at 0x113d21a20>
Only label-based slicing is supported right now, not positional.
If your style function uses a subset or axis keyword argument, consider wrapping your function in a
functools.partial, partialing out that keyword.
my_func2 = functools.partial(my_func, subset=42)

23.3 Finer Control: Display Values

We distinguish the display value from the actual value in Styler. To control the display value, the text is printed in each cell, use Styler.format. Cells can be formatted according to a format spec string or a callable that takes a single value and returns a string.
In [14]: df.style.format("{:.2%}"
Out[14]: <pandas.io.formats.style.Styler at 0x113d21dd8>
Use a dictionary to format specific columns.
In [15]: df.style.format({"B": "{:0<4.0f}", 'D': '{:+.2f}'})
Out[15]: <pandas.io.formats.style.Styler at 0x113d214a8>
Or pass in a callable (or dictionary of callables) for more flexible handling.
In [16]: df.style.format({"B": lambda x: "±{:.2f}".format(abs(x))})
Out[16]: <pandas.io.formats.style.Styler at 0x113d21b38>
23.4 Builtin Styles

Finally, we expect certain styling functions to be common enough that we’ve included a few “built-in” to the Styler, so you don’t have to write them yourself.

In [17]: df.style.highlight_null(null_color='red')
Out[17]: <pandas.io.formats.style.Styler at 0x113d216d8>

You can create “heatmaps” with the background_gradient method. These require matplotlib, and we’ll use Seaborn to get a nice colormap.

In [18]: import seaborn as sns

    cm = sns.light_palette("green", as_cmap=True)
    s = df.style.background_gradient(cmap=cm)

Out[18]: <pandas.io.formats.style.Styler at 0x113d21198>

Styler.background_gradient takes the keyword arguments low and high. Roughly speaking these extend the range of your data by low and high percent so that when we convert the colors, the colormap’s entire range isn’t used. This is useful so that you can actually read the text still.

In [19]: # Uses the full color range
    df.loc[:4].style.background_gradient(cmap='viridis')

Out[19]: <pandas.io.formats.style.Styler at 0x113d21a58>

In [20]: # Compress the color range
    (df.loc[:4]
     .style
     .background_gradient(cmap='viridis', low=.5, high=0)
     .highlight_null('red'))

Out[20]: <pandas.io.formats.style.Styler at 0x1a15a64908>

There’s also .highlight_min and .highlight_max.

In [21]: df.style.highlight_max(axis=0)
Out[21]: <pandas.io.formats.style.Styler at 0x113d215c0>

Use Styler.set_properties when the style doesn’t actually depend on the values.

In [22]: df.style.set_properties(**{'background-color': 'black',
    'color': 'lawngreen',
    'border-color': 'white'})

Out[22]: <pandas.io.formats.style.Styler at 0x1a15a64908>

23.4.1 Bar charts

You can include “bar charts” in your DataFrame.
In [23]: df.style.bar(subset=['A', 'B'], color='#d65f5f')
Out[23]: <pandas.io.formats.style.Styler at 0x1a15aea4e0>

New in version 0.20.0 is the ability to customize further the bar chart: You can now have the `df.style.bar` be centered on zero or midpoint value (in addition to the already existing way of having the min value at the left side of the cell), and you can pass a list of `[color_negative, color_positive]`.

Here’s how you can change the above with the new `align='mid'` option:

In [24]: df.style.bar(subset=['A', 'B'], align='mid', color=['#d65f5f', '#5fba7d'])
Out[24]: <pandas.io.formats.style.Styler at 0x1a15bbbe10>

The following example aims to give a highlight of the behavior of the new align options:

In [25]: import pandas as pd
import IPython.display import HTML

# Test series
test1 = pd.Series([-100,-60,-30,-20], name='All Negative')
test2 = pd.Series([10,20,50,100], name='All Positive')
test3 = pd.Series([-10,-5,0,90], name='Both Pos and Neg')

head = ""
<table>
  <thead>
    <th>Align</th>
    <th>All Negative</th>
    <th>All Positive</th>
    <th>Both Neg and Pos</th>
  </thead>
  <tbody>
    for align in aligns:
      row = "<tr><th>{}</th>".format(align)
      for serie in [test1,test2,test3]:
        s = serie.copy()
        s.name=''
        row += "<td>{}</td>".format(s.to_frame().style.bar(align=align,
          color=['#d65f5f', '#5fba7d'],
          width=100).render()) #testn['width']
      row += '</tr>'
      head += row

    HTML(head)
Out[25]: <IPython.core.display.HTML object>
23.5 Sharing Styles

Say you have a lovely style built up for a DataFrame, and now you want to apply the same style to a second DataFrame. Export the style with `df1.style.export`, and import it on the second DataFrame with `df1.style.set`.

```
In [26]: df2 = -df
   ...: style1 = df.style.applymap(color_negative_red)
   ...: style1

Out[26]: <pandas.io.formats.style.Styler at 0x1a15aea6d8>

In [27]: style2 = df2.style
   ...: style2.use(style1.export())
   ...: style2

Out[27]: <pandas.io.formats.style.Styler at 0x1a15be6978>
```

Notice that you’re able share the styles even though they’re data aware. The styles are re-evaluated on the new DataFrame they’ve been used upon.

23.6 Other Options

You’ve seen a few methods for data-driven styling. `Styler` also provides a few other options for styles that don’t depend on the data.

- precision
- captions
- table-wide styles
- hiding the index or columns

Each of these can be specified in two ways:

- A keyword argument to `Styler.__init__`
- A call to one of the `.set_` or `.hide_` methods, e.g. `.set_caption` or `.hide_columns`

The best method to use depends on the context. Use the `Styler` constructor when building many styled DataFrames that should all share the same properties. For interactive use, the `.set_` and `.hide_` methods are more convenient.

23.6.1 Precision

You can control the precision of floats using pandas’ regular `display.precision` option.

```
In [28]: with pd.option_context('display.precision', 2):
   ...:     html = (df.style
   ...:         .applymap(color_negative_red)
   ...:         .apply(highlight_max))
   ...:     html

Out[28]: <pandas.io.formats.style.Styler at 0x1a15aea518>
```

Or through a `set_precision` method.

```
In [29]: df.style
   ...:     .applymap(color_negative_red)
   ...:     .apply(highlight_max)
   ...:     .set_precision(2)
```
Setting the precision only affects the printed number; the full-precision values are always passed to your style functions. You can always use \texttt{df.round(2).style} if you'd prefer to round from the start.

### 23.6.2 Captions

Regular table captions can be added in a few ways.

\texttt{In [30]: df.style.set_caption('Colormaps, with a caption.')}\texttt{
.background_gradient(cmap=cm)}

\texttt{Out[30]: <pandas.io.formats.style.Styler at 0x1a15aea3c8>}

### 23.6.3 Table Styles

The next option you have are “table styles”. These are styles that apply to the table as a whole, but don’t look at the data. Certain sytling, including pseudo-selectors like :hover can only be used this way.

\texttt{In [31]: from IPython.display import HTML}

\begin{verbatim}
def hover(hover_color="#ffff99"):
    return dict(selector="tr:hover",
                props=[("background-color", "$s % hover_color")])

styles = [
    hover(),
    dict(selector="th", props=[("font-size", "150%"),
                                ("text-align", "center")]),
    dict(selector="caption", props=[("caption-side", "bottom")])
]

html = (df.style.set_table_styles(styles)
            .set_caption("Hover to highlight."))

Out[31]: <pandas.io.formats.style.Styler at 0x1a15bdfbe0>
\end{verbatim}

\texttt{table_styles} should be a list of dictionaries. Each dictionary should have the \texttt{selector} and \texttt{props} keys. The value for \texttt{selector} should be a valid CSS selector. Recall that all the styles are already attached to an \texttt{id}, unique to each \texttt{Styler}. This selector is in addition to that \texttt{id}. The value for \texttt{props} should be a list of tuples of ('attribute', 'value').

\texttt{table_styles} are extremely flexible, but not as fun to type out by hand. We hope to collect some useful ones either in pandas, or preferable in a new package that \textit{builds on top} the tools here.

### 23.6.4 Hiding the Index or Columns

The index can be hidden from rendering by calling \texttt{Styler.hide_index}. Columns can be hidden from rendering by calling \texttt{Styler.hide_columns} and passing in the name of a column, or a slice of columns.

\texttt{In [32]: df.style.hide_index()}

\texttt{Out[32]: <pandas.io.formats.style.Styler at 0x1a15aea4a8>}

\texttt{In [33]: df.style.hide_columns(['C','D'])}
23.6.5 CSS Classes

Certain CSS classes are attached to cells.

- Index and Column names include `index_name` and `level<k>` where `k` is its level in a MultiIndex
- Index label cells include
  - `row_heading`
  - `row<n>` where `n` is the numeric position of the row
- `level<k>` where `k` is the level in a MultiIndex
- Column label cells include
  - `col_heading`
  - `col<n>` where `n` is the numeric position of the column
- `level<k>` where `k` is the level in a MultiIndex
- Blank cells include `blank`
- Data cells include `data`

23.6.6 Limitations

- DataFrame only (use `Series.to_frame().style`)
- The index and columns must be unique
- No large repr, and performance isn’t great; this is intended for summary DataFrames
- You can only style the `values`, not the index or columns
- You can only apply styles, you can’t insert new HTML entities

Some of these will be addressed in the future.

23.6.7 Terms

- Style function: a function that’s passed into `Styler.apply` or `Styler.applymap` and returns values like `css attribute: value`
- Builtin style functions: style functions that are methods on `Styler`
- `table style`: a dictionary with the two keys `selector` and `props`. `selector` is the CSS selector that `props` will apply to. `props` is a list of `(attribute, value)` tuples. A list of table styles passed into `Styler`.

23.7 Fun stuff

Here are a few interesting examples.

`Styler` interacts pretty well with widgets. If you’re viewing this online instead of running the notebook yourself, you’re missing out on interactively adjusting the color palette.
In [34]: from IPython.html import widgets
@widgets.interact
def f(h_neg=(0, 359, 1), h_pos=(0, 359), s=(0., 99.9), l=(0., 99.9)):
    return df.style.background_gradient(
        cmap=sns.palettes.diverging_palette(h_neg=h_neg, h_pos=h_pos, s=s, l=l, as_cmap=True)
    )

In [35]: def magnify():
    return [dict(selector="th",
        props=[('font-size', '4pt')]),
    dict(selector="td",
        props=[('padding', '0em 0em')]),
    dict(selector="th:hover",
        props=[('font-size', '12pt')]),
    dict(selector="tr:hover td:hover",
        props=[('max-width', '200px'),
                ('font-size', '12pt')])
    ]

In [36]: np.random.seed(25)
cmap = cmap=sns.diverging_palette(5, 250, as_cmap=True)
bigdf = pd.DataFrame(np.random.randn(20, 25)).cumsum()

    bigdf.style.background_gradient(cmap, axis=1)\
       .set_properties(**{'max-width': '80px', 'font-size': '1pt'})\n       .set_caption("Hover to magnify")\n       .set_precision(2)\n       .set_table_styles(magnify())

Out[36]: <pandas.io.formats.style.Styler at 0x1a1d6d4978>

23.8 Export to Excel

New in version 0.20.0

Experimental: This is a new feature and still under development. We’ll be adding features and possibly making breaking changes in future releases. We’d love to hear your feedback.

Some support is available for exporting styled DataFrames to Excel worksheets using the OpenPyXL or XlsxWriter engines. CSS2.2 properties handled include:

- background-color
- border-style, border-width, border-color and their top, right, bottom, left variants
- color
- font-family
- font-style
- font-weight
- text-align
- text-decoration
• vertical-align
• white-space: nowrap

Only CSS2 named colors and hex colors of the form #rgb or #rrggbb are currently supported.

In [37]: df.style.\applymap(color_negative_red).\apply(highlight_max).\to_excel('styled.xlsx', engine='openpyxl')

A screenshot of the output:

![Excel spreadsheet with styled DataFrame](image)

**23.9 Extensibility**

The core of pandas is, and will remain, its “high-performance, easy-to-use data structures”. With that in mind, we hope that DataFrame.style accomplishes two goals

- Provide an API that is pleasing to use interactively and is “good enough” for many tasks
- Provide the foundations for dedicated libraries to build on

If you build a great library on top of this, let us know and we’ll link to it.

**23.9.1 Subclassing**

If the default template doesn’t quite suit your needs, you can subclass Styler and extend or override the template. We’ll show an example of extending the default template to insert a custom header before each table.

In [38]: from jinja2 import Environment, ChoiceLoader, FileSystemLoader
   from IPython.display import HTML
   from pandas.io.formats.style import Styler
This next cell writes the custom template. We extend the template `html.tpl`, which comes with pandas.

```python
In [40]: %
file templates/myhtml.tpl
{% extends "html.tpl" %}
{% block table %}
<h1>{{ table_title|default("My Table") }}</h1>
{{ super() }}
{% endblock table %}
```

Writing templates/myhtml.tpl

Now that we’ve created a template, we need to set up a subclass of `Styler` that knows about it.

```python
In [41]: class MyStyler(Styler):
    env = Environment(
        loader=ChoiceLoader([
            FileSystemLoader("templates"), # contains ours
            Styler.loader, # the default
        ])
    )
    template = env.get_template("myhtml.tpl")
```

Notice that we include the original loader in our environment’s loader. That’s because we extend the original template, so the Jinja environment needs to be able to find it.

Now we can use that custom styler. Its `__init__` takes a DataFrame.

```python
In [42]: MyStyler(df)
Out[42]: <__main__.MyStyler at 0x1a1d6d44e0>
```

Our custom template accepts a `table_title` keyword. We can provide the value in the `.render` method.

```python
In [43]: HTML(MyStyler(df).render(table_title="Extending Example"))
Out[43]: <IPython.core.display.HTML object>
```

For convenience, we provide the `Styler.from_custom_template` method that does the same as the custom subclass.

```python
In [44]: EasyStyler = Styler.from_custom_template("templates", "myhtml.tpl")
EasyStyler(df)
Out[44]: <pandas.io.formats.style.Styler.from_custom_template.<locals>.MyStyler at 0x1a1fd934e0>
```

Here’s the template structure:

```python
In [45]: with open("template_structure.html") as f:
    structure = f.read()

HTML(structure)
Out[45]: <IPython.core.display.HTML object>
```

See the template in the [GitHub repo](https://github.com/pandas-dev/pandas) for more details.
IO TOOLS (TEXT, CSV, HDF5, . . .)

The pandas I/O API is a set of top level reader functions accessed like `pandas.read_csv()` that generally return a pandas object. The corresponding writer functions are object methods that are accessed like `DataFrame.to_csv()`. Below is a table containing available readers and writers.

<table>
<thead>
<tr>
<th>Format Type</th>
<th>Data Description</th>
<th>Reader</th>
<th>Writer</th>
</tr>
</thead>
<tbody>
<tr>
<td>text</td>
<td>CSV</td>
<td>read_csv</td>
<td>to_csv</td>
</tr>
<tr>
<td>text</td>
<td>JSON</td>
<td>read_json</td>
<td>to_json</td>
</tr>
<tr>
<td>text</td>
<td>HTML</td>
<td>read_html</td>
<td>to_html</td>
</tr>
<tr>
<td>text</td>
<td>Local clipboard</td>
<td>read_clipboard</td>
<td>to_clipboard</td>
</tr>
<tr>
<td>binary</td>
<td>MS Excel</td>
<td>read_excel</td>
<td>to_excel</td>
</tr>
<tr>
<td>binary</td>
<td>HDF5 Format</td>
<td>read_hdf</td>
<td>to_hdf</td>
</tr>
<tr>
<td>binary</td>
<td>Feather Format</td>
<td>read_feather</td>
<td>to_feather</td>
</tr>
<tr>
<td>binary</td>
<td>Parquet Format</td>
<td>read_parquet</td>
<td>to_parquet</td>
</tr>
<tr>
<td>binary</td>
<td>Msgpack</td>
<td>read_msgpack</td>
<td>to_msgpack</td>
</tr>
<tr>
<td>binary</td>
<td>Stata</td>
<td>read_stata</td>
<td>to_stata</td>
</tr>
<tr>
<td>binary</td>
<td>SAS</td>
<td>read_sas</td>
<td></td>
</tr>
<tr>
<td>binary</td>
<td>Python Pickle Format</td>
<td>read_pickle</td>
<td>to_pickle</td>
</tr>
<tr>
<td>SQL</td>
<td>SQL</td>
<td>read_sql</td>
<td>to_sql</td>
</tr>
<tr>
<td>SQL</td>
<td>Google Big Query</td>
<td>read_gbq</td>
<td>to_gbq</td>
</tr>
</tbody>
</table>

Here is an informal performance comparison for some of these IO methods.

Note: For examples that use the `StringIO` class, make sure you import it according to your Python version, i.e. `from StringIO import StringIO` for Python 2 and `from io import StringIO` for Python 3.

24.1 CSV & Text files

The two workhorse functions for reading text files (a.k.a. flat files) are `read_csv()` and `read_table()`. They both use the same parsing code to intelligently convert tabular data into a `DataFrame` object. See the cookbook for some advanced strategies.

24.1.1 Parsing options

The functions `read_csv()` and `read_table()` accept the following common arguments:
24.1.1.1 Basic

filepath_or_buffer [various] Either a path to a file (a str, pathlib.Path, or py._path.local.LocalPath), URL (including http, ftp, and S3 locations), or any object with a read() method (such as an open file or StringIO).

sep [str, defaults to ', ' for read_csv(), \t for read_table()] Delimiter to use. If sep is None, the C engine cannot automatically detect the separator, but the Python parsing engine can, meaning the latter will be used and automatically detect the separator by Python's builtin sniffer tool, csv.Sniffer. In addition, separators longer than 1 character and different from '\s+' will be interpreted as regular expressions and will also force the use of the Python parsing engine. Note that regex delimiters are prone to ignoring quoted data. Regex example: '\r\t'.

delimiter [str, default None] Alternative argument name for sep.

delim_whitespace [boolean, default False] Specifies whether or not whitespace (e.g. ' ' or '\t') will be used as the delimiter. Equivalent to setting sep='\s+'. If this option is set to True, nothing should be passed in for the delimiter parameter.

New in version 0.18.1: support for the Python parser.

24.1.1.2 Column and Index Locations and Names

header [int or list of ints, default 'infer'] Row number(s) to use as the column names, and the start of the data. Default behavior is to infer the column names: if no names are passed the behavior is identical to header=0 and column names are inferred from the first line of the file, if column names are passed explicitly then the behavior is identical to header=None. Explicitly pass header=0 to be able to replace existing names.

The header can be a list of ints that specify row locations for a multi-index on the columns e.g. [0,1,3]. Intervening rows that are not specified will be skipped (e.g. 2 in this example is skipped). Note that this parameter ignores commented lines and empty lines if skip_blank_lines=True, so header=0 denotes the first line of data rather than the first line of the file.

names [array-like, default None] List of column names to use. If file contains no header row, then you should explicitly pass header=None. Duplicates in this list will cause a UserWarning to be issued.

index_col [int or sequence or False, default None] Column to use as the row labels of the DataFrame. If a sequence is given, a MultiIndex is used. If you have a malformed file with delimiters at the end of each line, you might consider index_col=False to force pandas to not use the first column as the index (row names).

usecols [list-like or callable, default None] Return a subset of the columns. If list-like, all elements must either be positional (i.e. integer indices into the document columns) or strings that correspond to column names provided either by the user in names or inferred from the document header row(s). For example, a valid list-like usecols parameter would be [0, 1, 2] or ['foo', 'bar', 'baz'].

Element order is ignored, so usecols=[0, 1] is the same as [1, 0]. To instantiate a DataFrame from data with element order preserved use pd.read_csv(data, usecols=['foo', 'bar'])[['foo', 'bar']] for columns in ['foo', 'bar'] order or pd.read_csv(data, usecols=['foo', 'bar'])[['bar', 'foo']] for ['bar', 'foo'] order.

If callable, the callable function will be evaluated against the column names, returning names where the callable function evaluates to True:

```
In [1]: data = 'col1, col2, col3\na, b, 1\nb, 2\nc, d, 3'

In [2]: pd.read_csv(StringIO(data))
Out[2]:
   col1  col2  col3
0   a     b     1
1   b     2     c
2   c     d     3
```

(continues on next page)
Using this parameter results in much faster parsing time and lower memory usage.

**squeeze** [boolean, default False] If the parsed data only contains one column then return a Series.

**prefix** [str, default None] Prefix to add to column numbers when no header, e.g. ‘X’ for X0, X1, ...

**mangle_dupe_cols** [boolean, default True] Duplicate columns will be specified as ‘X’, ‘X.1’…’X.N’, rather than ‘X’…’X’. Passing in False will cause data to be overwritten if there are duplicate names in the columns.

### 24.1.1.3 General Parsing Configuration

**dtype** [Type name or dict of column -> type, default None] Data type for data or columns. E.g. {'a': np.float64, 'b': np.int32} (unsupported with engine='python'). Use str or object together with suitable na_values settings to preserve and not interpret dtype.

New in version 0.20.0: support for the Python parser.

**engine** [['c', 'python']] Parser engine to use. The C engine is faster while the Python engine is currently more feature-complete.

**converters** [dict, default None] Dict of functions for converting values in certain columns. Keys can either be integers or column labels.

**true_values** [list, default None] Values to consider as True.

**false_values** [list, default None] Values to consider as False.

**skipinitialspace** [boolean, default False] Skip spaces after delimiter.

**skiprows** [list-like or integer, default None] Line numbers to skip (0-indexed) or number of lines to skip (int) at the start of the file.

If callable, the callable function will be evaluated against the row indices, returning True if the row should be skipped and False otherwise:
skipfooter [int, default 0] Number of lines at bottom of file to skip (unsupported with engine=’c’).
nrows [int, default None] Number of rows of file to read. Useful for reading pieces of large files.
low_memory [boolean, default True] Internally process the file in chunks, resulting in lower memory use while parsing, but possibly mixed type inference. To ensure no mixed types either set False, or specify the type with the dtype parameter. Note that the entire file is read into a single DataFrame regardless, use the chunksize or iterator parameter to return the data in chunks. (Only valid with C parser)
memory_map [boolean, default False] If a filepath is provided for filepath_or_buffer, map the file object directly onto memory and access the data directly from there. Using this option can improve performance because there is no longer any I/O overhead.

24.1.1.4 NA and Missing Data Handling

na_values [scalar, str, list-like, or dict, default None] Additional strings to recognize as NA/NaN. If dict passed, specific per-column NA values. See na values const below for a list of the values interpreted as NaN by default.
keep_default_na [boolean, default True] Whether or not to include the default NaN values when parsing the data. Depending on whether na_values is passed in, the behavior is as follows:
   • If keep_default_na is True, and na_values are specified, na_values is appended to the default NaN values used for parsing.
   • If keep_default_na is True, and na_values are not specified, only the default NaN values are used for parsing.
   • If keep_default_na is False, and na_values are specified, only the NaN values specified na_values are used for parsing.
   • If keep_default_na is False, and na_values are not specified, no strings will be parsed as NaN.

Note that if na_filter is passed in as False, the keep_default_na and na_values parameters will be ignored.
na_filter [boolean, default True] Detect missing value markers (empty strings and the value of na_values). In data without any NAs, passing na_filter=False can improve the performance of reading a large file.
verbose [boolean, default False] Indicate number of NA values placed in non-numeric columns.
skip_blank_lines [boolean, default True] If True, skip over blank lines rather than interpreting as NaN values.

24.1.1.5 Datetime Handling

parse_dates [boolean or list of ints or names or list of lists or dict, default False.] If True -> try parsing the index.
   • If [1, 2, 3] -> try parsing columns 1, 2, 3 each as a separate date column.
   • If [[1, 3]] -> combine columns 1 and 3 and parse as a single date column.
   • If {'foo': [1, 3]} -> parse columns 1, 3 as date and call result ‘foo’. A fast-path exists for iso8601-formatted dates.
infer_datetime_format [boolean, default False] If True and parse_dates is enabled for a column, attempt to infer the datetime format to speed up the processing.
keep_date_col [boolean, default False] If True and parse_dates specifies combining multiple columns then keep the original columns.

date_parser [function, default None] Function to use for converting a sequence of string columns to an array of datetime instances. The default uses datetime.parser.parser to do the conversion. Pandas will try to call date_parser in three different ways, advancing to the next if an exception occurs: 1) Pass one or more arrays (as defined by parse_dates) as arguments; 2) concatenate (row-wise) the string values from the columns defined by parse_dates into a single array and pass that; and 3) call date_parser once for each row using one or more strings (corresponding to the columns defined by parse_dates) as arguments.

dayfirst [boolean, default False] DD/MM format dates, international and European format.

24.1.1.6 Iteration

iterator [boolean, default False] Return TextFileReader object for iteration or getting chunks with get_chunk().

chunksize [int, default None] Return TextFileReader object for iteration. See iterating and chunking below.

24.1.1.7 Quoting, Compression, and File Format

compression [{'infer', 'gzip', 'bz2', 'zip', 'xz', None}, default 'infer'] For on-the-fly decompression of on-disk data. If 'infer', then use gzip, bz2, zip, or xz if filepath_or_buffer is a string ending in ‘.gz’, ‘.bz2’, ‘.zip’, or ‘.xz’, respectively, and no decompression otherwise. If using ‘zip’, the ZIP file must contain only one data file to be read in. Set to None for no decompression.

New in version 0.18.1: support for ‘zip’ and ‘xz’ compression.

thousands [str, default None] Thousands separator.

decimal [str, default ' '] Character to recognize as decimal point. E.g. use ', ' for European data.

float_precision [string, default None] Specifies which converter the C engine should use for floating-point values. The options are None for the ordinary converter, high for the high-precision converter, and round_trip for the round-trip converter.

lineterminator [str (length 1), default None] Character to break file into lines. Only valid with C parser.

quotechar [str (length 1)] The character used to denote the start and end of a quoted item. Quoted items can include the delimiter and it will be ignored.

quoting [int or csv.QUOTE_* instance, default 0] Control field quoting behavior per csv.QUOTE_* constants. Use one of QUOTE_MINIMAL (0), QUOTE_ALL (1), QUOTE_NONNUMERIC (2) or QUOTE_NONE (3).

doublequote [boolean, default True] When quotechar is specified and quoting is not QUOTE_NONE, indicate whether or not to interpret two consecutive quotechar elements inside a field as a single quotechar element.

escapechar [str (length 1), default None] One-character string used to escape delimiter when quoting is QUOTE_NONE.

comment [str, default None] Indicates remainder of line should not be parsed. If found at the beginning of a line, the line will be ignored altogether. This parameter must be a single character. Like empty lines (as long as skip_blank_lines=True), fully commented lines are ignored by the parameter header but not by skiprows. For example, if comment='
', parsing '#empty
da,b,c
1,2,3' with header=0 will result in 'a,b,c' being treated as the header.

encoding [str, default None] Encoding to use for UTF when reading/writing (e.g. 'utf-8'). List of Python standard encodings.
dialect [str or csv.Dialect instance, default None] If provided, this parameter will override values (default or not) for the following parameters: delimiter, doublequote, escapechar, skipinitialspace, quotechar, and quoting. If it is necessary to override values, a ParserWarning will be issued. See csv.Dialect documentation for more details.

tupleize_cols [boolean, default False]  
  Deprecated since version 0.21.0.  
  This argument will be removed and will always convert to MultiIndex  
  Leave a list of tuples on columns as is (default is to convert to a MultiIndex on the columns).

24.1.1.8 Error Handling

error_bad_lines [boolean, default True] Lines with too many fields (e.g. a csv line with too many commas) will by default cause an exception to be raised, and no DataFrame will be returned. If False, then these “bad lines” will dropped from the DataFrame that is returned. See bad lines below.

warn_bad_lines [boolean, default True] If error_bad_lines is False, and warn_bad_lines is True, a warning for each “bad line” will be output.

24.1.2 Specifying column data types

You can indicate the data type for the whole DataFrame or individual columns:

In [7]: data = 'a,b,c\n1,2,3\n4,5,6\n7,8,9'

In [8]: print(data)
a,b,c
1,2,3
4,5,6
7,8,9

In [9]: df = pd.read_csv(StringIO(data), dtype=object)

In [10]: df
Out[10]:
a   b   c
0   1   2   3
1   4   5   6
2   7   8   9

In [11]: df['a'][0]
Out[11]: '1'

In [12]: df = pd.read_csv(StringIO(data), dtype={'b': object, 'c': np.float64})

In [13]: df.dtypes
Out[13]:
a    int64
b    object
c   float64
dtype: object

Fortunately, pandas offers more than one way to ensure that your column(s) contain only one dtype. If you’re unfamiliar with these concepts, you can see here to learn more about dtypes, and here to learn more about object conversion in pandas.
For instance, you can use the converters argument of `read_csv()`:

```
In [14]: data = "col_1\n\n1\n\n2\n\n\n'A'\n\n4.22"

In [15]: df = pd.read_csv(StringIO(data), converters={'col_1': str})

In [16]: df
Out[16]:
   col_1
0   1
1   2
2   A
3  4.22

In [17]: df['col_1'].apply(type).value_counts()

Out[17]:
<class 'str'>    4
Name: col_1, dtype: int64
```

Or you can use the `to_numeric()` function to coerce the dtypes after reading in the data,

```
In [18]: df2 = pd.read_csv(StringIO(data))

In [19]: df2['col_1'] = pd.to_numeric(df2['col_1'], errors='coerce')

In [20]: df2
Out[20]:
   col_1
0   1.00
1   2.00
2   NaN
3   4.22

In [21]: df2['col_1'].apply(type).value_counts()

Out[21]:
<class 'float'>    4
Name: col_1, dtype: int64
```

which will convert all valid parsing to floats, leaving the invalid parsing as NaN.

Ultimately, how you deal with reading in columns containing mixed dtypes depends on your specific needs. In the case above, if you wanted to NaN out the data anomalies, then `to_numeric()` is probably your best option. However, if you wanted for all the data to be coerced, no matter the type, then using the converters argument of `read_csv()` would certainly be worth trying.

New in version 0.20.0: support for the Python parser.

The `dtype` option is supported by the ‘python’ engine.

**Note:** In some cases, reading in abnormal data with columns containing mixed dtypes will result in an inconsistent dataset. If you rely on pandas to infer the dtypes of your columns, the parsing engine will go and infer the dtypes for different chunks of the data, rather than the whole dataset at once. Consequently, you can end up with column(s) with mixed dtypes. For example,

```
In [22]: df = pd.DataFrame({'col_1': list(range(500000)) + ['a', 'b'] + list(range(500000)))})

In [23]: df.to_csv('foo.csv')
```

(continues on next page)
pandas: powerful Python data analysis toolkit, Release 0.23.2

In [24]: mixed_df = pd.read_csv('foo.csv')

In [25]: mixed_df['col_1'].apply(type).value_counts()
Out[25]:
<class 'int'>  737858
<class 'str'>  262144
Name: col_1, dtype: int64

In [26]: mixed_df['col_1'].dtype

will result with mixed_df containing an int dtype for certain chunks of the column, and str for others due to the mixed dtypes from the data that was read in. It is important to note that the overall column will be marked with a dtype of object, which is used for columns with mixed dtypes.

24.1.3 Specifying Categorical dtype

New in version 0.19.0.

Categorical columns can be parsed directly by specifying dtype='category' or dtype=CategoricalDtype(categories, ordered).

In [27]: data = 'col1,col2,col3
a,b,1
a,b,2
c,d,3'

In [28]: pd.read_csv(StringIO(data))
Out[28]:
col1  col2  col3
0   a     b     1
1   a     b     2
2   c     d     3

In [29]: pd.read_csv(StringIO(data)).dtypes

Individual columns can be parsed as a Categorical using a dict specification:

In [30]: pd.read_csv(StringIO(data), dtype={'col1': 'category'}).dtypes

(continues on next page)
New in version 0.21.0.

Specifying dtype='category' will result in an unordered Categorical whose categories are the unique values observed in the data. For more control on the categories and order, create a CategoricalDtype ahead of time, and pass that for that column’s dtype.

```python
In [32]: from pandas.api.types import CategoricalDtype
In [33]: dtype = CategoricalDtype(['d', 'c', 'b', 'a'], ordered=True)
In [34]: pd.read_csv(StringIO(data), dtype={'col1': dtype}).dtypes
Out[34]:
       col1    col2    col3
dtype: category    object    int64
```

When using dtype=CategoricalDtype, “unexpected” values outside of dtype.categories are treated as missing values.

```python
In [35]: dtype = CategoricalDtype(['a', 'b', 'd'])  # No 'c'
In [36]: pd.read_csv(StringIO(data), dtype={'col1': dtype}).col1
Out[36]:
0   a
1   a
2   Na\nName: col1, dtype: category
Categories (3, object): [a, b, d]
```

This matches the behavior of Categorical.set_categories().

**Note:** With dtype='category', the resulting categories will always be parsed as strings (object dtype). If the categories are numeric they can be converted using the to_numeric() function, or as appropriate, another converter such as to_datetime().

When dtype is a CategoricalDtype with homogenous categories (all numeric, all datetimes, etc.), the conversion is done automatically.

```python
In [37]: df = pd.read_csv(StringIO(data), dtype='category')
In [38]: df.dtypes
Out[38]:
       col1    col2    col3
dtype: category    category    int64
In [39]: df['col3']
```

(continues on next page)
2 3
Name: col3, dtype: category
Categories (3, object): [1, 2, 3]

In [40]: df['col3'].cat.categories = pd.to_numeric(df['col3'].cat.categories)

In [41]: df['col3']
Out[41]:
0 1
1 2
2 3
Name: col3, dtype: category
Categories (3, int64): [1, 2, 3]

24.1.4 Naming and Using Columns

24.1.4.1 Handling column names

A file may or may not have a header row. pandas assumes the first row should be used as the column names:

In [42]: data = 'a,b,c
1,2,3
4,5,6
7,8,9'

In [43]: print(data)
a,b,c
1,2,3
4,5,6
7,8,9

In [44]: pd.read_csv(StringIO(data))

Out[44]:
   a  b  c
0  1  2  3
1  4  5  6
2  7  8  9

By specifying the names argument in conjunction with header you can indicate other names to use and whether or not to throw away the header row (if any):

In [45]: print(data)
a,b,c
1,2,3
4,5,6
7,8,9

In [46]: pd.read_csv(StringIO(data), names=['foo', 'bar', 'baz'], header=0)

Out[46]:
     foo  bar  baz
0  1  2  3
1  4  5  6
2  7  8  9

In [47]: pd.read_csv(StringIO(data), names=['foo', 'bar', 'baz'], header=None)

(continues on next page)
foo bar baz
0 a b c
1 1 2 3
2 4 5 6
3 7 8 9

If the header is in a row other than the first, pass the row number to header. This will skip the preceding rows:

```
In [48]: data = 'skip this skip it

a,b,c

1,2,3

4,5,6

7,8,9'

In [49]: pd.read_csv(StringIO(data), header=1)
Out[49]:
   a  b  c
0  1  2  3
1  4  5  6
2  7  8  9
```

Note: Default behavior is to infer the column names: if no names are passed the behavior is identical to header=0 and column names are inferred from the first nonblank line of the file, if column names are passed explicitly then the behavior is identical to header=None.

### 24.1.5 Duplicate names parsing

If the file or header contains duplicate names, pandas will by default distinguish between them so as to prevent overwriting data:

```
In [50]: data = 'a,b,a

0,1,2

3,4,5'

In [51]: pd.read_csv(StringIO(data))
Out[51]:
   a  b  a.1
0  2  1  2
1  5  4  5
```

There is no more duplicate data because mangle_dupe_cols=True by default, which modifies a series of duplicate columns ‘X’, ‘X’, ‘X’ to become ‘X’, ‘X.1’, ‘X.2’. If mangle_dupe_cols=False, duplicate data can arise:

```
In [2]: data = 'a,b,a

0,1,2

3,4,5'

In [3]: pd.read_csv(StringIO(data), mangle_dupe_cols=False)
Out[3]:
   a  b  a
0  1  2
1  3  4
```

To prevent users from encountering this problem with duplicate data, a ValueError exception is raised if mangle_dupe_cols != True:

```
In [2]: data = 'a,b,a

0,1,2

3,4,5'

In [3]: pd.read_csv(StringIO(data), mangle_dupe_cols=False)
...  
ValueError: Setting mangle_dupe_cols=False is not supported yet
```
24.1.5.1 Filtering columns (usecols)

The `usecols` argument allows you to select any subset of the columns in a file, either using the column names, position numbers or a callable:

New in version 0.20.0: support for callable `usecols` arguments

```
In [52]: data = 'a,b,c,d\n1,2,3,foo\n4,5,6,bar\n7,8,9,baz'

In [53]: pd.read_csv(StringIO(data))
Out[53]:
   a  b  c  d
0  1  2  3  foo
1  4  5  6  bar
2  7  8  9  baz

In [54]: pd.read_csv(StringIO(data), usecols=['b', 'd'])
Out[54]:
   b  d
0  2  foo
1  5  bar
2  8  baz

In [55]: pd.read_csv(StringIO(data), usecols=[0, 2, 3])
   a  c  d
0  1  3  foo
1  4  6  bar
2  7  9  baz

In [56]: pd.read_csv(StringIO(data), usecols=lambda x: x.upper() in ['A', 'C'])
   a  c
0  1  3
1  4  6
2  7  9
```

The `usecols` argument can also be used to specify which columns not to use in the final result:

```
In [57]: pd.read_csv(StringIO(data), usecols=lambda x: x not in ['a', 'c'])
Out[57]:
   b  d
0  2  foo
1  5  bar
2  8  baz
```

In this case, the callable is specifying that we exclude the “a” and “c” columns from the output.

24.1.6 Comments and Empty Lines

24.1.6.1 Ignoring line comments and empty lines

If the `comment` parameter is specified, then completely commented lines will be ignored. By default, completely blank lines will be ignored as well.
In [58]: data = '\na,b,c
\n# commented line
1,2,3
4,5,6'

In [59]: print(data)
a,b,c
# commented line
1,2,3
4,5,6

In [60]: pd.read_csv(StringIO(data), comment='#')
Out[60]:
   a  b  c
0  1  2  3
1  4  5  6

If `skip_blank_lines=False`, then `read_csv` will not ignore blank lines:

In [61]: data = 'a,b,c

1,2,3

4,5,6'

In [62]: pd.read_csv(StringIO(data), skip_blank_lines=False)
Out[62]:
   a  b  c
0  NaN NaN NaN
1  1.0  2.0  3.0
2  NaN NaN NaN
3  NaN NaN NaN
4  4.0  5.0  6.0

**Warning:** The presence of ignored lines might create ambiguities involving line numbers; the parameter `header` uses row numbers (ignoring commented/empty lines), while `skiprows` uses line numbers (including commented/empty lines):

In [63]: data = '#comment
na,b,c
A,B,C
1,2,3'

In [64]: pd.read_csv(StringIO(data), comment='#', header=1)
Out[64]:
   A  B  C
0  1  2  3

In [65]: data = 'A,B,C
#comment
na,b,c
1,2,3'

In [66]: pd.read_csv(StringIO(data), comment='#', skiprows=2)
Out[66]:
   a  b  c
0  1  2  3

If both `header` and `skiprows` are specified, `header` will be relative to the end of `skiprows`. For example:
24.1.6.2 Comments

Sometimes comments or meta data may be included in a file:

```
In [70]: print(open('tmp.csv').read())
ID,level,category
Patient1,123000,x # really unpleasant
Patient2,23000,y # wouldn't take his medicine
Patient3,1234018,z # awesome
```

By default, the parser includes the comments in the output:

```
In [71]: df = pd.read_csv('tmp.csv')
In [72]: df
Out[72]:
   ID    level category
0 Patient1 123000   x # really unpleasant
1 Patient2 23000    y # wouldn't take his medicine
2 Patient3 1234018  z # awesome
```

We can suppress the comments using the `comment` keyword:

```
In [73]: df = pd.read_csv('tmp.csv', comment='#')
In [74]: df
Out[74]:
   ID    level category
0 Patient1 123000   x
1 Patient2 23000    y
2 Patient3 1234018  z
```
24.1.7 Dealing with Unicode Data

The encoding argument should be used for encoded unicode data, which will result in byte strings being decoded to unicode in the result:

```python
In [75]: data = b'word,length
Träumen,7
Grüße,5'.decode('utf8').encode('latin-1')

In [76]: df = pd.read_csv(BytesIO(data), encoding='latin-1')

In [77]: df
Out[77]:
     word  length
0  Träumen   7
1    Grüße   5

In [78]: df['word'][1]
Out[78]: 'Grüße'
```

Some formats which encode all characters as multiple bytes, like UTF-16, won’t parse correctly at all without specifying the encoding. Full list of Python standard encodings.

24.1.8 Index columns and trailing delimiters

If a file has one more column of data than the number of column names, the first column will be used as the DataFrame’s row names:

```python
In [79]: data = 'a,b,c
4,apple,bat,5.7
8,orange,cow,10'

In [80]: pd.read_csv(StringIO(data))
Out[80]:
     a    b    c
  4  apple  bat  5.7
  8  orange  cow  10.0

In [81]: data = 'index,a,b,c
4,apple,bat,5.7
8,orange,cow,10'

In [82]: pd.read_csv(StringIO(data), index_col=0)
Out[82]:
     a    b    c
index
  4  apple  bat  5.7
  8  orange  cow  10.0
```

Ordinarily, you can achieve this behavior using the index_col option.

There are some exception cases when a file has been prepared with delimiters at the end of each data line, confusing the parser. To explicitly disable the index column inference and discard the last column, pass index_col=False:

```python
In [83]: data = 'a,b,c
4,apple,bat,5.7
8,orange,cow,'

In [84]: print(data)
a,b,c
4,apple,bat,
8,orange,cow,
```
If a subset of data is being parsed using the `usecols` option, the `index_col` specification is based on that subset, not the original data.

```
In [87]: data = 'a,b,c
4,apple,bat,
8,orange,cow,'

In [88]: print(data)
a,b,c
4,apple,bat,
8,orange,cow,

In [89]: pd.read_csv(StringIO(data), usecols=['b', 'c'])

In [90]: pd.read_csv(StringIO(data), usecols=['b', 'c'], index_col=0)
```

### 24.1.9 Date Handling

#### 24.1.9.1 Specifying Date Columns

To better facilitate working with datetime data, `read_csv()` and `read_table()` use the keyword arguments `parse_dates` and `date_parser` to allow users to specify a variety of columns and date/time formats to turn the input text data into `datetime` objects.

The simplest case is to just pass in `parse_dates=True`:

```
# Use a column as an index, and parse it as dates.
In [91]: df = pd.read_csv('foo.csv', index_col=0, parse_dates=True)
```

```
Out[92]:
   A   B  C
date     
2009-01-01 a 1 2
2009-01-02 b 3 4
2009-01-03 c 4 5
```
# These are Python datetime objects

```python
In [93]: df.index

DatetimeIndex(['2009-01-01', '2009-01-02', '2009-01-03'], dtype='datetime64[ns]',
name='date', freq=None)
```

It is often the case that we may want to store date and time data separately, or store various date fields separately. The `parse_dates` keyword can be used to specify a combination of columns to parse the dates and/or times from.

You can specify a list of column lists to `parse_dates`, the resulting date columns will be prepended to the output (so as to not affect the existing column order) and the new column names will be the concatenation of the component column names:

```python
In [94]: print(open('tmp.csv').read())
KORD,19990127, 19:00:00, 18:56:00, 0.8100
KORD,19990127, 20:00:00, 19:56:00, 0.0100
KORD,19990127, 21:00:00, 20:56:00, -0.5900
KORD,19990127, 21:00:00, 21:18:00, -0.9900
KORD,19990127, 22:00:00, 21:56:00, -0.5900
KORD,19990127, 23:00:00, 22:56:00, -0.5900

In [95]: df = pd.read_csv('tmp.csv', header=None, parse_dates=[[1, 2], [1, 3]])

In [96]: df

```

```python
Out[96]:

<table>
<thead>
<tr>
<th></th>
<th>1_2</th>
<th>1_3</th>
<th>0</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1999-01-27 19:00:00</td>
<td>1999-01-27 18:56:00</td>
<td>KORD</td>
<td>0.81</td>
</tr>
<tr>
<td>1</td>
<td>1999-01-27 20:00:00</td>
<td>1999-01-27 19:56:00</td>
<td>KORD</td>
<td>0.01</td>
</tr>
<tr>
<td>2</td>
<td>1999-01-27 21:00:00</td>
<td>1999-01-27 20:56:00</td>
<td>KORD</td>
<td>-0.59</td>
</tr>
<tr>
<td>3</td>
<td>1999-01-27 21:00:00</td>
<td>1999-01-27 21:18:00</td>
<td>KORD</td>
<td>-0.99</td>
</tr>
<tr>
<td>4</td>
<td>1999-01-27 22:00:00</td>
<td>1999-01-27 21:56:00</td>
<td>KORD</td>
<td>-0.59</td>
</tr>
<tr>
<td>5</td>
<td>1999-01-27 23:00:00</td>
<td>1999-01-27 22:56:00</td>
<td>KORD</td>
<td>-0.59</td>
</tr>
</tbody>
</table>
```

By default the parser removes the component date columns, but you can choose to retain them via the `keep_date_col` keyword:

```python
In [97]: df = pd.read_csv('tmp.csv', header=None, parse_dates=[[1, 2], [1, 3]],
                      keep_date_col=True)

In [98]: df
```

```python
Out[98]:

<table>
<thead>
<tr>
<th></th>
<th>1_2</th>
<th>1_3</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1999-01-27 19:00:00</td>
<td>1999-01-27 18:56:00</td>
<td>KORD</td>
<td>19990127</td>
<td>19:00:00</td>
<td>18:56:00</td>
<td>0.81</td>
</tr>
<tr>
<td>1</td>
<td>1999-01-27 20:00:00</td>
<td>1999-01-27 19:56:00</td>
<td>KORD</td>
<td>19990127</td>
<td>20:00:00</td>
<td>19:56:00</td>
<td>0.01</td>
</tr>
<tr>
<td>2</td>
<td>1999-01-27 21:00:00</td>
<td>1999-01-27 20:56:00</td>
<td>KORD</td>
<td>19990127</td>
<td>21:00:00</td>
<td>20:56:00</td>
<td>-0.59</td>
</tr>
<tr>
<td>3</td>
<td>1999-01-27 21:00:00</td>
<td>1999-01-27 21:18:00</td>
<td>KORD</td>
<td>19990127</td>
<td>21:00:00</td>
<td>21:18:00</td>
<td>-0.99</td>
</tr>
<tr>
<td>4</td>
<td>1999-01-27 22:00:00</td>
<td>1999-01-27 21:56:00</td>
<td>KORD</td>
<td>19990127</td>
<td>22:00:00</td>
<td>21:56:00</td>
<td>-0.59</td>
</tr>
<tr>
<td>5</td>
<td>1999-01-27 23:00:00</td>
<td>1999-01-27 22:56:00</td>
<td>KORD</td>
<td>19990127</td>
<td>23:00:00</td>
<td>22:56:00</td>
<td>-0.59</td>
</tr>
</tbody>
</table>
```

Note that if you wish to combine multiple columns into a single date column, a nested list must be used. In other words, `parse_dates=[[1, 2]]` indicates that the second and third columns should each be parsed as separate date columns while `parse_dates=[[[1, 2]]]` means the two columns should be parsed into a single column.

You can also use a dict to specify custom name columns:
In [99]: date_spec = {'nominal': [1, 2], 'actual': [1, 3]}

In [100]: df = pd.read_csv('tmp.csv', header=None, parse_dates=date_spec)

In [101]: df
Out[101]:
   nominal actual 0 4
0 1999-01-27 19:00:00 1999-01-27 18:56:00 KORD 0.81
1 1999-01-27 20:00:00 1999-01-27 19:56:00 KORD 0.01
2 1999-01-27 21:00:00 1999-01-27 20:56:00 KORD -0.59
3 1999-01-27 21:00:00 1999-01-27 21:18:00 KORD -0.99
4 1999-01-27 22:00:00 1999-01-27 21:56:00 KORD -0.59
5 1999-01-27 23:00:00 1999-01-27 22:56:00 KORD -0.59

It is important to remember that if multiple text columns are to be parsed into a single date column, then a new column is prepended to the data. The index_col specification is based off of this new set of columns rather than the original data columns:

In [102]: date_spec = {'nominal': [1, 2], 'actual': [1, 3]}

In [103]: df = pd.read_csv('tmp.csv', header=None, parse_dates=date_spec,
   ....:   index_col=0) # index is the nominal column

In [104]: df
Out[104]:
   actual 0 4
nominal
0 1999-01-27 19:00:00 1999-01-27 18:56:00 KORD 0.81
1 1999-01-27 20:00:00 1999-01-27 19:56:00 KORD 0.01
2 1999-01-27 21:00:00 1999-01-27 20:56:00 KORD -0.59
3 1999-01-27 21:00:00 1999-01-27 21:18:00 KORD -0.99
4 1999-01-27 22:00:00 1999-01-27 21:56:00 KORD -0.59
5 1999-01-27 23:00:00 1999-01-27 22:56:00 KORD -0.59

Note: If a column or index contains an unparseable date, the entire column or index will be returned unaltered as an object data type. For non-standard datetime parsing, use to_datetime() after pd.read_csv.

Note: read_csv has a fast_path for parsing datetime strings in iso8601 format, e.g “2000-01-01T00:01:02+00:00” and similar variations. If you can arrange for your data to store datetimes in this format, load times will be significantly faster, ~20x has been observed.

Note: When passing a dict as the parse_dates argument, the order of the columns prepended is not guaranteed, because dict objects do not impose an ordering on their keys. On Python 2.7+ you may use collections.OrderedDict instead of a regular dict if this matters to you. Because of this, when using a dict for ‘parse_dates’ in conjunction with the index_col argument, it’s best to specify index_col as a column label rather then as an index on the resulting frame.
**24.1.9.2 Date Parsing Functions**

Finally, the parser allows you to specify a custom `date_parser` function to take full advantage of the flexibility of the date parsing API:

```python
In [105]: import pandas.io.date_converters as conv
In [106]: df = pd.read_csv('tmp.csv', header=None, parse_dates=date_spec,
             ......:    date_parser=conv.parse_date_time)
             ......:
In [107]: df
Out[107]:
  nominal actual  0  4
  0 1999-01-27 19:00:00 1999-01-27 18:56:00 KORD 0.81
  1 1999-01-27 20:00:00 1999-01-27 19:56:00 KORD 0.01
  2 1999-01-27 21:00:00 1999-01-27 20:56:00 KORD -0.59
  3 1999-01-27 21:00:00 1999-01-27 21:18:00 KORD -0.99
  4 1999-01-27 22:00:00 1999-01-27 21:56:00 KORD -0.59
  5 1999-01-27 23:00:00 1999-01-27 22:56:00 KORD -0.59
```

Pandas will try to call the `date_parser` function in three different ways. If an exception is raised, the next one is tried:

1. `date_parser` is first called with one or more arrays as arguments, as defined using `parse_dates` (e.g., `date_parser(['2013', '2013'], ['1', '2'])`).
2. If #1 fails, `date_parser` is called with all the columns concatenated row-wise into a single array (e.g., `date_parser(['2013 1', '2013 2'])`).
3. If #2 fails, `date_parser` is called once for every row with one or more string arguments from the columns indicated with `parse_dates` (e.g., `date_parser('2013', '1')` for the first row, `date_parser('2013', '2')` for the second, etc.).

Note that performance-wise, you should try these methods of parsing dates in order:

1. Try to infer the format using `infer_datetime_format=True` (see section below).
2. If you know the format, use `pd.to_datetime()`: `date_parser=lambda x: pd.to_datetime(x, format=...)`.
3. If you have a really non-standard format, use a custom `date_parser` function. For optimal performance, this should be vectorized, i.e., it should accept arrays as arguments.

You can explore the date parsing functionality in `date_converters.py` and add your own. We would love to turn this module into a community supported set of date/time parsers. To get you started, `date_converters.py` contains functions to parse dual date and time columns, year/month/day columns, and year/month/day/hour/minute/second columns. It also contains a `generic_parser` function so you can curry it with a function that deals with a single date rather than the entire array.

**24.1.9.3 Inferring Datetime Format**

If you have `parse_dates` enabled for some or all of your columns, and your datetime strings are all formatted the same way, you may get a large speed up by setting `infer_datetime_format=True`. If set, pandas will attempt to guess the format of your datetime strings, and then use a faster means of parsing the strings. 5-10x parsing speeds have been observed. pandas will fallback to the usual parsing if either the format cannot be guessed or the format that was guessed cannot properly parse the entire column of strings. So in general, `infer_datetime_format` should not have any negative consequences if enabled.
Here are some examples of datetime strings that can be guessed (All representing December 30th, 2011 at 00:00:00):

- “20111230”
- “2011/12/30”
- “20111230 00:00:00”
- “12/30/2011 00:00:00”
- “30/Dec/2011 00:00:00”
- “30/December/2011 00:00:00”

Note that `infer_datetime_format` is sensitive to `dayfirst`. With `dayfirst=True`, it will guess “01/12/2011” to be December 1st. With `dayfirst=False` (default) it will guess “01/12/2011” to be January 12th.

```python
# Try to infer the format for the index column
In [108]: df = pd.read_csv('foo.csv', index_col=0, parse_dates=True,
                    ....:               infer_datetime_format=True)
In [109]: df
Out[109]:
     A  B  C
date
2009-01-01 a 1 2
2009-01-02 b 3 4
2009-01-03 c 4 5
```

### 24.1.9.4 International Date Formats

While US date formats tend to be MM/DD/YYYY, many international formats use DD/MM/YYYY instead. For convenience, a `dayfirst` keyword is provided:

```python
In [110]: print(open('tmp.csv').read())
date,value,cat
1/6/2000,5,a
2/6/2000,10,b
3/6/2000,15,c
In [111]: pd.read_csv('tmp.csv', parse_dates=[0])
Out[111]:
      date  value  cat
0 2000-01-06   5  a
1 2000-02-06  10  b
2 2000-03-06  15  c
In [112]: pd.read_csv('tmp.csv', dayfirst=True, parse_dates=[0])
   date  value  cat
0 2000-06-01   5  a
1 2000-06-02  10  b
2 2000-06-03  15  c
```
24.1.10 Specifying method for floating-point conversion

The parameter `float_precision` can be specified in order to use a specific floating-point converter during parsing with the C engine. The options are the ordinary converter, the high-precision converter, and the round-trip converter (which is guaranteed to round-trip values after writing to a file). For example:

```python
In [113]: val = '0.3066101993807095471566981359501369297504425048828125'
In [114]: data = 'a,b,c\n1,2,\n'.format(val)
In [115]: abs(pd.read_csv(StringIO(data), engine='c', float_precision=None)['c'][0] - float(val))
Out[115]: 1.1102230246251565e-16
In [116]: abs(pd.read_csv(StringIO(data), engine='c', float_precision='high')['c'][0] - float(val))
Out[116]: 5.5511151231257827e-17
In [117]: abs(pd.read_csv(StringIO(data), engine='c', float_precision='round_trip')['c'][0] - float(val))
```

24.1.11 Thousand Separators

For large numbers that have been written with a thousands separator, you can set the `thousands` keyword to a string of length 1 so that integers will be parsed correctly:

By default, numbers with a thousands separator will be parsed as strings:

```python
In [118]: print(open('tmp.csv').read())
ID|level|category
Patient1|123,000|x
Patient2|23,000|y
Patient3|1,234,018|z
In [119]: df = pd.read_csv('tmp.csv', sep='|')
In [120]: df
Out[120]:
   ID    level  category
0 Patient1  123,000   x
1 Patient2   23,000   y
2 Patient3  1,234,018  z
In [121]: df.level.dtype
```

The `thousands` keyword allows integers to be parsed correctly:

```python
In [122]: print(open('tmp.csv').read())
ID|level|category
Patient1|123,000|x
Patient2|23,000|y
Patient3|1,234,018|z
```

(continues on next page)
24.1.12 NA Values

To control which values are parsed as missing values (which are signified by NaN), specify a string in `na_values`. If you specify a list of strings, then all values in it are considered to be missing values. If you specify a number (a float, like 5.0 or an integer like 5), the corresponding equivalent values will also imply a missing value (in this case effectively [5.0, 5] are recognized as NaN).

To completely override the default values that are recognized as missing, specify `keep_default_na=False`.

The default NaN recognized values are ['-1.#IND', '1.#QNAN', '1.#IND', '-1.#QNAN', '#N/A
N/A', '#N/A', 'N/A', 'n/a', 'NA', '#NA', 'NULL', 'null', 'NaN', '-NaN', 'nan', '-nan', ''].

Let us consider some examples:

```python
read_csv(path, na_values=[5])
```

In the example above 5 and 5.0 will be recognized as NaN, in addition to the defaults. A string will first be interpreted as a numerical 5, then as a NaN.

```python
read_csv(path, keep_default_na=False, na_values=["\"])
```

Above, only an empty field will be recognized as NaN.

```python
read_csv(path, keep_default_na=False, na_values=["NA", "0"])
```

Above, both NA and 0 as strings are NaN.

```python
read_csv(path, na_values=["Nope"])
```

The default values, in addition to the string "Nope" are recognized as NaN.

24.1.13 Infinity

Inf like values will be parsed as np.inf (positive infinity), and -inf as -np.inf (negative infinity). These will ignore the case of the value, meaning Inf, will also be parsed as np.inf.

24.1.14 Returning Series

Using the `squeeze` keyword, the parser will return output with a single column as a Series:
24.1.15 Boolean values

The common values `True`, `False`, `TRUE`, and `FALSE` are all recognized as boolean. Occasionally you might want to recognize other values as being boolean. To do this, use the `true_values` and `false_values` options as follows:

```
In [130]: data = 'a,b,c
1,Yes,2
3,No,4'

In [131]: print(data)
a,b,c
1,Yes,2
3,No,4

In [132]: pd.read_csv(StringIO(data))
Out[132]:
a b c
0 1 Yes 2
1 3 No 4

In [133]: pd.read_csv(StringIO(data), true_values=['Yes'], false_values=['No'])
Out[133]:
a b c
0 1 True 2
1 3 False 4
```

24.1.16 Handling “bad” lines

Some files may have malformed lines with too few fields or too many. Lines with too few fields will have NA values filled in the trailing fields. Lines with too many fields will raise an error by default:

```
In [27]: data = 'a,b,c
1,2,3
4,5,6,7
8,9,10'

In [28]: pd.read_csv(StringIO(data))
---------------------------------------------------------------------------
ParserError Traceback (most recent call last)
ParserError: Error tokenizing data. C error: Expected 3 fields in line 3, saw 4
```
You can elect to skip bad lines:

```python
In [29]: pd.read_csv(StringIO(data), error_bad_lines=False)
Skipping line 3: expected 3 fields, saw 4
```

```
Out[29]:
    a  b  c
0  1  2  3
1  8  9 10
```

You can also use the `usecols` parameter to eliminate extraneous column data that appear in some lines but not others:

```python
In [30]: pd.read_csv(StringIO(data), usecols=[0, 1, 2])
```

```
Out[30]:
    a  b  c
0  1  2  3
1  4  5  6
2  8  9 10
```

### 24.1.17 Dialect

The `dialect` keyword gives greater flexibility in specifying the file format. By default it uses the Excel dialect but you can specify either the dialect name or a `csv.Dialect` instance.

Suppose you had data with unenclosed quotes:

```python
In [134]: print(data)
label1,label2,label3
index1,"a,c,e
index2,b,d,f
```

By default, `read_csv` uses the Excel dialect and treats the double quote as the quote character, which causes it to fail when it finds a newline before it finds the closing double quote.

We can get around this using `dialect`:

```python
In [135]: dia = csv.excel()
In [136]: dia.quoting = csv.QUOTE_NONE
In [137]: pd.read_csv(StringIO(data), dialect=dia)
```

```
Out[137]:
label1  label2  label3
index1   "a  c  e
index2    b  d  f
```

All of the dialect options can be specified separately by keyword arguments:

```python
In [138]: data = 'a,b,c~1,2,3~4,5,6'
In [139]: pd.read_csv(StringIO(data), lineterminator='~')
```

```
Out[139]:
    a  b  c
0  1  2  3
1  4  5  6
```

Another common dialect option is `skipinitialspace`, to skip any whitespace after a delimiter:
The parsers make every attempt to “do the right thing” and not be fragile. Type inference is a pretty big deal. If a column can be coerced to integer dtype without altering the contents, the parser will do so. Any non-numeric columns will come through as object dtype as with the rest of pandas objects.

### 24.1.18 Quoting and Escape Characters

Quotes (and other escape characters) in embedded fields can be handled in any number of ways. One way is to use backslashes; to properly parse this data, you should pass the `escapechar` option:

```python
In [143]: data = 'a,b

"hello, "Bob", nice to see you",5'

In [144]: print(data)
print(a,b

"hello, "Bob", nice to see you",5

In [145]: pd.read_csv(StringIO(data), escapechar='\')
\\\\\\\\\\\\\\\\\\\\\Out[145]:
a b
0 hello, "Bob", nice to see you 5
```

### 24.1.19 Files with Fixed Width Columns

While `read_csv()` reads delimited data, the `read_fwf()` function works with data files that have known and fixed column widths. The function parameters to `read_fwf` are largely the same as `read_csv` with two extra parameters, and a different usage of the `delimiter` parameter:

- **colspecs**: A list of pairs (tuples) giving the extents of the fixed-width fields of each line as half-open intervals (i.e., [from, to]). String value ‘infer’ can be used to instruct the parser to try detecting the column specifications from the first 100 rows of the data. Default behavior, if not specified, is to infer.

- **widths**: A list of field widths which can be used instead of ‘colspecs’ if the intervals are contiguous.

- **delimiter**: Characters to consider as filler characters in the fixed-width file. Can be used to specify the filler character of the fields if it is not spaces (e.g., ‘~’).

Consider a typical fixed-width data file:

```python
In [146]: print(open('bar.csv').read())
id8141 360.242940 149.910199 11950.7
id1594 444.953632 166.985655 11788.4
id1849 364.136849 183.628767 11806.2
id1230 413.836124 184.375703 11916.8
id1948 502.953953 173.237159 12468.3
```
In order to parse this file into a DataFrame, we simply need to supply the column specifications to the `read_fwf` function along with the file name:

```python
# Column specifications are a list of half-intervals
In [147]: colspecs = [(0, 6), (8, 20), (21, 33), (34, 43)]

In [148]: df = pd.read_fwf('bar.csv', colspecs=colspecs, header=None, index_col=0)

In [149]: df
Out[149]:
   0     1     2     3
0 id8141 360.242940 149.910199 11950.7
1 id1594 444.953632 166.985655 11788.4
2 id1849 364.136849 183.628767 11806.2
3 id1230 413.836124 184.375703 11916.8
4 id1948 502.953953 173.237159 12468.3
```

Note how the parser automatically picks column names X.<column number> when `header=None` argument is specified. Alternatively, you can supply just the column widths for contiguous columns:

```python
# Widths are a list of integers
In [150]: widths = [6, 14, 13, 10]

In [151]: df = pd.read_fwf('bar.csv', widths=widths, header=None)

In [152]: df
Out[152]:
   0     1     2     3
0 id8141 360.242940 149.910199 11950.7
1 id1594 444.953632 166.985655 11788.4
2 id1849 364.136849 183.628767 11806.2
3 id1230 413.836124 184.375703 11916.8
4 id1948 502.953953 173.237159 12468.3
```

The parser will take care of extra white spaces around the columns so it’s ok to have extra separation between the columns in the file.

By default, `read_fwf` will try to infer the file’s `colspecs` by using the first 100 rows of the file. It can do it only in cases when the columns are aligned and correctly separated by the provided delimiter (default delimiter is whitespace).

```python
In [153]: df = pd.read_fwf('bar.csv', header=None, index_col=0)

In [154]: df
Out[154]:
   0     1     2     3
0 id8141 360.242940 149.910199 11950.7
1 id1594 444.953632 166.985655 11788.4
2 id1849 364.136849 183.628767 11806.2
3 id1230 413.836124 184.375703 11916.8
4 id1948 502.953953 173.237159 12468.3
```

New in version 0.20.0.

`read_fwf` supports the `dtype` parameter for specifying the types of parsed columns to be different from the inferred type.
In [155]: pd.read_fwf('bar.csv', header=None, index_col=0).dtypes
Out[155]:
1  float64
2  float64
3  float64
dtype: object

In [156]: pd.read_fwf('bar.csv', header=None, dtype={2: 'object'}).dtypes
Out[156]:
0  object
1  float64
2  object
3  float64
dtype: object

24.1.20 Indexes

24.1.20.1 Files with an “implicit” index column

Consider a file with one less entry in the header than the number of data column:

In [157]:
print(open('foo.csv').read())
A,B,C
20090101,a,1,2
20090102,b,3,4
20090103,c,4,5

In this special case, read_csv assumes that the first column is to be used as the index of the DataFrame:

In [158]: pd.read_csv('foo.csv')
Out[158]:
A  B  C
20090101 a 1 2
20090102 b 3 4
20090103 c 4 5

Note that the dates weren’t automatically parsed. In that case you would need to do as before:

In [159]: df = pd.read_csv('foo.csv', parse_dates=True)

In [160]: df.index
Out[160]: DatetimeIndex(['2009-01-01', '2009-01-02', '2009-01-03'], dtype=˓→'datetime64[ns]', freq=None)

24.1.20.2 Reading an index with a MultiIndex

Suppose you have data indexed by two columns:

In [161]:
print(open('data/mindex_ex.csv').read())
year,indiv,zit,xit
1977,"A",1.2,.6
1977,"B",1.5,.5
1977,"C",1.7,.8
1978,"A",.2,.06

(continues on next page)
The `index_col` argument to `read_csv` and `read_table` can take a list of column numbers to turn multiple columns into a MultiIndex for the index of the returned object:

```python
In [162]: df = pd.read_csv("data/mindex_ex.csv", index_col=[0,1])
```

```python
In [163]: df
Out[163]:
   zit  xit
year indiv
1977 A   1.20  0.60
         B   1.50  0.50
         C   1.70  0.80
1978 A   0.20  0.06
         B   0.70  0.20
         C   0.80  0.30
         D   0.90  0.50
         E   1.40  0.90
1979 C   0.20  0.15
         D   0.14  0.05
         E   0.50  0.15
         F   1.20  0.50
         G   3.40  1.90
         H   5.40  2.70
         I   6.40  1.20
```

24.1.20.3 Reading columns with a MultiIndex

By specifying list of row locations for the `header` argument, you can read in a MultiIndex for the columns. Specifying non-consecutive rows will skip the intervening rows.

```python
In [164]: df.loc[1978]
```

```python
In [165]: from pandas.util.testing import makeCustomDataframe as mkdf
```
In [166]: df = mkdf(5, 3, r_idx_nlevels=2, c_idx_nlevels=4)

In [167]: df.to_csv('mi.csv')

In [168]: print(open('mi.csv').read())

C0,,C_l0_g0,C_l0_g1,C_l0_g2
C1,,C_l1_g0,C_l1_g1,C_l1_g2
C2,,C_l2_g0,C_l2_g1,C_l2_g2
C3,,C_l3_g0,C_l3_g1,C_l3_g2
R0,R1,,
   R_l0_g0,R_l1_g0,R0C0,R0C1,R0C2
   R_l0_g1,R_l1_g1,R1C0,R1C1,R1C2
   R_l0_g2,R_l1_g2,R2C0,R2C1,R2C2
   R_l0_g3,R_l1_g3,R3C0,R3C1,R3C2
   R_l0_g4,R_l1_g4,R4C0,R4C1,R4C2

In [169]: pd.read_csv('mi.csv', header=[0, 1, 2, 3], index_col=[0, 1])

<table>
<thead>
<tr>
<th></th>
<th>C_l0_g0</th>
<th>C_l0_g1</th>
<th>C_l0_g2</th>
<th>C_l1_g0</th>
<th>C_l1_g1</th>
<th>C_l1_g2</th>
<th>C_l2_g0</th>
<th>C_l2_g1</th>
<th>C_l2_g2</th>
<th>C_l3_g0</th>
<th>C_l3_g1</th>
<th>C_l3_g2</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0</td>
<td></td>
<td></td>
<td></td>
<td>R0C0</td>
<td>R0C1</td>
<td>R0C2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td></td>
<td></td>
<td></td>
<td>R1C0</td>
<td>R1C1</td>
<td>R1C2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_l0_g0</td>
<td>R_l1_g0</td>
<td>R0C0</td>
<td>R0C1</td>
<td>R0C2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_l0_g1</td>
<td>R_l1_g1</td>
<td>R1C0</td>
<td>R1C1</td>
<td>R1C2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_l0_g2</td>
<td>R_l1_g2</td>
<td>R2C0</td>
<td>R2C1</td>
<td>R2C2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_l0_g3</td>
<td>R_l1_g3</td>
<td>R3C0</td>
<td>R3C1</td>
<td>R3C2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_l0_g4</td>
<td>R_l1_g4</td>
<td>R4C0</td>
<td>R4C1</td>
<td>R4C2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_l0_g5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

read_csv is also able to interpret a more common format of multi-columns indices.

In [170]: print(open('mi2.csv').read())

,a,a,a,b,c,c
,q,r,s,t,u,v
one,1,2,3,4,5,6
two,7,8,9,10,11,12

In [171]: pd.read_csv('mi2.csv', header=[0, 1], index_col=0)

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td>q</td>
<td>r</td>
<td>s</td>
<td>t</td>
</tr>
<tr>
<td>one</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>two</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

Note: If an index_col is not specified (e.g. you don’t have an index, or wrote it with df.to_csv(..., index=False)), then any names on the columns index will be lost.

### 24.1.21 Automatically “sniffing” the delimiter

read_csv is capable of inferring delimited (not necessarily comma-separated) files, as pandas uses the csv.Sniffer class of the csv module. For this, you have to specify `sep=None`.
24.1.22 Reading multiple files to create a single DataFrame

It’s best to use `concat()` to combine multiple files. See the cookbook for an example.

24.1.23 Iterating through files chunk by chunk

Suppose you wish to iterate through a (potentially very large) file lazily rather than reading the entire file into memory, such as the following:

```python
In [174]: print(open('tmp.sv').read())
|0|1|2|3
0|0.469112 -0.282863 -1.509058 -1.135632
1|1.212112 -0.173215 0.119209 -1.044236
2|-0.861849 -0.494929 1.071804
3|0.721555 -0.706771 0.524989
4|-0.424972 0.276232 -1.087401
5|0.673690 0.524988
6|0.404705 0.134432 0.844885
7|1.075770 1.649388
8|0.357021 -0.968914
```

```python
In [175]: table = pd.read_table('tmp.sv', sep='|')
```

(continues on next page)
By specifying a chunksize to read_csv or read_table, the return value will be an iterable object of type TextFileReader:

```
In [177]: reader = pd.read_table('tmp.sv', sep='|', chunksize=4)
In [178]: reader
Out[178]: <pandas.io.parsers.TextFileReader at 0x1c2bb8f8d0>
```

```
In [179]: for chunk in reader: print(chunk)
......: Unnamed: 0  0  1  2  3
......:
   0   0  0.469112 -0.282863 -1.509059 -1.135632
   1   1  1.212112 -0.173215  0.119209 -1.044236
   2  -2 -0.861849 -2.104569  0.494929  1.071804
   3   3  0.721555 -0.706771 -1.039575  0.271860
   4  -4  0.424972  0.567020  0.276232 -1.087401
   5   5  0.673690  0.113648 -1.478427  0.524988
   6   6  0.404705  0.577046 -1.715002 -1.039268
   7  -7 -0.370647 -1.157892 -1.344312  0.844885
   8   8  1.075770 -0.109050  1.643563 -1.469388
   9   9  0.357021 -0.674600 -1.776904 -0.968914
```

Specifying iterator=True will also return the TextFileReader object:

```
In [180]: reader = pd.read_table('tmp.sv', sep='|', iterator=True)
In [181]: reader.get_chunk(5)
Out[181]: Unnamed: 0  0  1  2  3
   0   0  0.469112 -0.282863 -1.509059 -1.135632
   1   1  1.212112 -0.173215  0.119209 -1.044236
   2  -2 -0.861849 -2.104569  0.494929  1.071804
   3   3  0.721555 -0.706771 -1.039575  0.271860
   4  -4  0.424972  0.567020  0.276232 -1.087401
```

24.1. CSV & Text files 1155
24.1.24 Specifying the parser engine

Under the hood pandas uses a fast and efficient parser implemented in C as well as a Python implementation which is currently more feature-complete. Where possible pandas uses the C parser (specified as engine='c'), but may fall back to Python if C-unsupported options are specified. Currently, C-unsupported options include:

- `sep` other than a single character (e.g. regex separators)
- `skipfooter`
- `sep=None` with `delim_whitespace=False`

Specifying any of the above options will produce a `ParserWarning` unless the python engine is selected explicitly using `engine='python'`.

24.1.25 Reading remote files

You can pass in a URL to a CSV file:

```python
df = pd.read_csv('https://download.bls.gov/pub/time.series/cu/cu.item',
                 sep='\t')
```

S3 URLs are handled as well:

```python
df = pd.read_csv('s3://pandas-test/tips.csv')
```

24.1.26 Writing out Data

24.1.26.1 Writing to CSV format

The `Series` and `DataFrame` objects have an instance method `to_csv` which allows storing the contents of the object as a comma-separated-values file. The function takes a number of arguments. Only the first is required.

- `path_or_buf`: A string path to the file to write or a StringIO
- `sep`: Field delimiter for the output file (default ",")
- `na_rep`: A string representation of a missing value (default '')
- `float_format`: Format string for floating point numbers
- `cols`: Columns to write (default None)
- `header`: Whether to write out the column names (default True)
- `index`: whether to write row (index) names (default True)
- `index_label`: Column label(s) for index column(s) if desired. If None (default), and `header` and `index` are True, then the index names are used. (A sequence should be given if the `DataFrame` uses MultiIndex).
- `mode`: Python write mode, default 'w'
- `encoding`: a string representing the encoding to use if the contents are non-ASCII, for Python versions prior to 3
- `line_terminator`: Character sequence denoting line end (default 'n')
- `quoting`: Set quoting rules as in csv module (default csv.QUOTE_MINIMAL). Note that if you have set a `float_format` then floats are converted to strings and csv.QUOTE_NONNUMERIC will treat them as non-numeric
• `quotechar`: Character used to quote fields (default `""`)
• `doublequote`: Control quoting of `quotechar` in fields (default True)
• `escapechar`: Character used to escape `sep` and `quotechar` when appropriate (default None)
• `chunksize`: Number of rows to write at a time
• `tupleize_cols`: If False (default), write as a list of tuples, otherwise write in an expanded line format suitable for `read_csv`
• `date_format`: Format string for datetime objects

24.1.26.2 Writing a formatted string

The `DataFrame` object has an instance method `to_string` which allows control over the string representation of the object. All arguments are optional:

• `buf` default None, for example a `StringIO` object
• `columns` default None, which columns to write
• `col_space` default None, minimum width of each column.
• `na_rep` default `NaN`, representation of NA value
• `formatters` default None, a dictionary (by column) of functions each of which takes a single argument and returns a formatted string
• `float_format` default None, a function which takes a single (float) argument and returns a formatted string; to be applied to floats in the `DataFrame`
• `sparsify` default True, set to False for a `DataFrame` with a hierarchical index to print every multiindex key at each row.
• `index_names` default True, will print the names of the indices
• `header` default True, will print the index (ie, row labels)
• `justify` default left, will print column headers left- or right-justified

The `Series` object also has a `to_string` method, but with only the `buf, na_rep, float_format` arguments. There is also a `length` argument which, if set to True, will additionally output the length of the `Series`.

24.2 JSON

Read and write JSON format files and strings.

24.2.1 Writing JSON

A `Series` or `DataFrame` can be converted to a valid JSON string. Use `to_json` with optional parameters:

• `path_or_buf`: the pathname or buffer to write the output This can be `None` in which case a JSON string is returned
• `orient`:
  
  **Series:**
pandas: powerful Python data analysis toolkit, Release 0.23.2

- default is `index`
- allowed values are `{split, records, index}`

**DataFrame:**

- default is `columns`
- allowed values are `{split, records, index, columns, values, table}`

The format of the JSON string

<table>
<thead>
<tr>
<th>keyword</th>
<th>format</th>
</tr>
</thead>
<tbody>
<tr>
<td>split</td>
<td>dict like <code>{index -&gt; [index], columns -&gt; [columns], data -&gt; [values]}</code></td>
</tr>
<tr>
<td>records</td>
<td>list like <code>[{column -&gt; value}, ..., {column -&gt; value}]</code></td>
</tr>
<tr>
<td>index</td>
<td>dict like <code>{index -&gt; {column -&gt; value}}</code></td>
</tr>
<tr>
<td>columns</td>
<td>dict like <code>{column -&gt; {index -&gt; value}}</code></td>
</tr>
<tr>
<td>values</td>
<td>just the values array</td>
</tr>
</tbody>
</table>

- **date_format**: string, type of date conversion, ‘epoch’ for timestamp, ‘iso’ for ISO8601.
- **double_precision**: The number of decimal places to use when encoding floating point values, default 10.
- **force_ascii**: force encoded string to be ASCII, default True.
- **date_unit**: The time unit to encode to, governs timestamp and ISO8601 precision. One of ‘s’, ‘ms’, ‘us’ or ‘ns’ for seconds, milliseconds, microseconds and nanoseconds respectively. Default ‘ms’.
- **default_handler**: The handler to call if an object cannot otherwise be converted to a suitable format for JSON. Takes a single argument, which is the object to convert, and returns a serializable object.
- **lines**: If `records` orient, then will write each record per line as json.

Note `NaN`'s, `NaT`'s and `None` will be converted to `null` and `datetime` objects will be converted based on the `date_format` and `date_unit` parameters.

```
In [182]: dfj = pd.DataFrame(randn(5, 2), columns=list('AB'))
In [183]: json = dfj.to_json()
In [184]: json
Out[184]: 'A
    0 -1.2945235903
    1  0.2766617129
    2 -0.0139597524
    3  0.8957173022
    4  0.8052440254
   --
   B
    0  0.4137381054
    1 -0.472034511
    2 -0.3625429925
    3 -0.923060654
    4  0.8052440254

24.2.1 Orient Options

There are a number of different options for the format of the resulting JSON file / string. Consider the following DataFrame and Series:

```
In [185]: dfjo = pd.DataFrame(dict(A=range(1, 4), B=range(4, 7), C=range(7, 10)),
                       columns=list('ABC'), index=list('xyz'))

In [186]: dfjo
Out[186]:
   A  B  C
x 1 4 7
y 2 5 8
z 3 6 9

```
In [187]: sjo = pd.Series(dict(x=15, y=16, z=17), name='D')

In [188]: sjo
Out[188]:
   x  15
   y  16
   z  17
Name: D, dtype: int64

Column oriented (the default for DataFrame) serializes the data as nested JSON objects with column labels acting as the primary index:

In [189]: dfjo.to_json(orient="columns")
Out[189]: '{"A":{"x":1,"y":2,"z":3},"B":{"x":4,"y":5,"z":6},"C":{"x":7,"y":8,"z":9}}'

Index oriented (the default for Series) similar to column oriented but the index labels are now primary:

In [190]: dfjo.to_json(orient="index")

In [191]: sjo.to_json(orient="index")
   {'x':15,'y':16,'z':17}'

Record oriented serializes the data to a JSON array of column -> value records, index labels are not included. This is useful for passing DataFrame data to plotting libraries, for example the JavaScript library d3.js:

In [192]: dfjo.to_json(orient="records")
Out[192]: '[["A",1,"B",4,"C",7],
   ["A",2,"B",5,"C",8],

In [193]: sjo.to_json(orient="records")
   '[[15,16,17]]'

Value oriented is a bare-bones option which serializes to nested JSON arrays of values only, column and index labels are not included:

In [194]: dfjo.to_json(orient="values")
Out[194]: '[[1,4,7],[2,5,8],[3,6,9]]'

# Not available for Series

Split oriented serializes to a JSON object containing separate entries for values, index and columns. Name is also included for Series:

In [195]: dfjo.to_json(orient="split")
Out[195]: '{"columns": ["A","B","C"],
   "index": ["x","y","z"],
   "data": [[1,4,7],[2,5,8],[3,6,9]]}'

In [196]: sjo.to_json(orient="split")
   '{"name":"D","index": ["x","y","z"],
   "data": [15,16,17]}'
pandas: powerful Python data analysis toolkit, Release 0.23.2

Table oriented serializes to the JSON Table Schema, allowing for the preservation of metadata including but not
limited to dtypes and index names.
Note: Any orient option that encodes to a JSON object will not preserve the ordering of index and column labels
during round-trip serialization. If you wish to preserve label ordering use the split option as it uses ordered containers.

24.2.1.2 Date Handling
Writing in ISO date format:
In [197]: dfd = pd.DataFrame(randn(5, 2), columns=list('AB'))
In [198]: dfd['date'] = pd.Timestamp('20130101')
In [199]: dfd = dfd.sort_index(1, ascending=False)
In [200]: json = dfd.to_json(date_format='iso')
In [201]: json
Out[201]: '{"date":{"0":"2013-01-01T00:00:00.000Z","1":"2013-01-01T00:00:00.000Z","2":
˓→"2013-01-01T00:00:00.000Z","3":"2013-01-01T00:00:00.000Z","4":"2013-01-01T00:00:00.
˓→000Z"},"B":{"0":2.5656459463,"1":1.3403088498,"2":-0.2261692849,"3":0.8138502857,"4
˓→":-0.8273169356},"A":{"0":-1.2064117817,"1":1.4312559863,"2":-1.1702987971,"3":0.
˓→4108345112,"4":0.1320031703}}'

Writing in ISO date format, with microseconds:
In [202]: json = dfd.to_json(date_format='iso', date_unit='us')
In [203]: json
Out[203]: '{"date":{"0":"2013-01-01T00:00:00.000000Z","1":"2013-01-01T00:00:00.000000Z
˓→","2":"2013-01-01T00:00:00.000000Z","3":"2013-01-01T00:00:00.000000Z","4":"2013-01˓→01T00:00:00.000000Z"},"B":{"0":2.5656459463,"1":1.3403088498,"2":-0.2261692849,"3
˓→":0.8138502857,"4":-0.8273169356},"A":{"0":-1.2064117817,"1":1.4312559863,"2":-1.
˓→1702987971,"3":0.4108345112,"4":0.1320031703}}'

Epoch timestamps, in seconds:
In [204]: json = dfd.to_json(date_format='epoch', date_unit='s')
In [205]: json
Out[205]: '{"date":{"0":1356998400,"1":1356998400,"2":1356998400,"3":1356998400,"4
˓→":1356998400},"B":{"0":2.5656459463,"1":1.3403088498,"2":-0.2261692849,"3":0.
˓→8138502857,"4":-0.8273169356},"A":{"0":-1.2064117817,"1":1.4312559863,"2":-1.
˓→1702987971,"3":0.4108345112,"4":0.1320031703}}'

Writing to a file, with a date index and a date column:
In [206]: dfj2 = dfj.copy()
In [207]: dfj2['date'] = pd.Timestamp('20130101')
In [208]: dfj2['ints'] = list(range(5))
In [209]: dfj2['bools'] = True
(continues on next page)

1160

Chapter 24. IO Tools (Text, CSV, HDF5, . . . )


In [210]: dfj2.index = pd.date_range('20130101', periods=5)
In [211]: dfj2.to_json('test.json')
In [212]: open('test.json').read()
Out[212]: '{"A":{"1356998400000":-1.2945235903,"1357084800000":0.2766617129,
  "1357171200000":-0.0139597524,"1357257600000":-0.0061535699,"1357344000000":0.
  
  → 8957130222},"B":{"1356998400000":0.4137381054,"1357084800000":-0.472034511,
  "1357171200000":-0.3625429925,"1357257600000":-0.92360654,"1357344000000":0.
  → 8052440254},"date":{"1356998400000":1356998400000,"1357084800000":1356998400000,
  "1357171200000":1356998400000,"1357257600000":1356998400000,"1357344000000":1356998400000,
  "ints":{"1356998400000":0,"1357084800000":1,"1357171200000":2,
  "1357257600000":3,"1357344000000":4},"bools":{"1356998400000":true,"1357084800000":false,"1357171200000":true,"1357257600000":true,"1357344000000":true})

24.2.1.3 Fallback Behavior
If the JSON serializer cannot handle the container contents directly it will fall back in the following manner:

- if the dtype is unsupported (e.g. np.complex) then the default_handler, if provided, will be called for each value, otherwise an exception is raised.
- if an object is unsupported it will attempt the following:
  - check if the object has defined a to_dict method and call it. A to_dict method should return a dict which will then be JSON serialized.
  - invoke the default_handler if one was provided.
  - convert the object to a dict by traversing its contents. However this will often fail with an OverflowError or give unexpected results.

In general the best approach for unsupported objects or dtypes is to provide a default_handler. For example:

```python
DataFrame([1.0, 2.0, complex(1.0, 2.0)]).to_json()  # raises
```
RuntimeError: Unhandled numpy dtype 15
can be dealt with by specifying a simple default_handler:

```python
In [213]: pd.DataFrame([1.0, 2.0, complex(1.0, 2.0)]).to_json(default_handler=str)
Out[213]: '{"0":"(1+0j)","1":"(2+0j)","2":"(1+2j)"}'
```

24.2.2 Reading JSON
Reading a JSON string to pandas object can take a number of parameters. The parser will try to parse a DataFrame if typ is not supplied or is None. To explicitly force Series parsing, pass typ=series

- filepath_or_buffer: a VALID JSON string or file handle / StringIO. The string could be a URL. Valid URL schemes include http, ftp, S3, and file. For file URLs, a host is expected. For instance, a local file could be file:///localhost/path/to/table.json
- typ: type of object to recover (series or frame), default ‘frame’
- orient: 1161
Series:
- default is `index`
- allowed values are `split, records, index`

DataFrame:
- default is `columns`
- allowed values are `split, records, index, columns, values, table`

The format of the JSON string:

<table>
<thead>
<tr>
<th>key</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>split</code></td>
<td>dict like <code>{index -&gt; [index], columns -&gt; [columns], data -&gt; [values]}</code></td>
</tr>
<tr>
<td><code>records</code></td>
<td>list like <code>[{column -&gt; value}, ..., {column -&gt; value}]</code></td>
</tr>
<tr>
<td><code>index</code></td>
<td>dict like <code>{index -&gt; {column -&gt; value}}</code></td>
</tr>
<tr>
<td><code>columns</code></td>
<td>dict like <code>{column -&gt; {index -&gt; value}}</code></td>
</tr>
<tr>
<td><code>values</code></td>
<td>just the values array</td>
</tr>
<tr>
<td><code>table</code></td>
<td>adhering to the JSON Table Schema</td>
</tr>
</tbody>
</table>

- **dtype**: if True, infer dtypes, if a dict of column to dtype, then use those, if False, then don’t infer dtypes at all, default is True, apply only to the data.
- **convert_axes**: boolean, try to convert the axes to the proper dtypes, default is True
- **convert_dates**: a list of columns to parse for dates; If True, then try to parse date-like columns, default is True.
- **keep_default_dates**: boolean, default True. If parsing dates, then parse the default date-like columns.
- **numpy**: direct decoding to NumPy arrays. default is False; Supports numeric data only, although labels may be non-numeric. Also note that the JSON ordering MUST be the same for each term if `numpy=True`.
- **precise_float**: boolean, default False. Set to enable usage of higher precision (strtod) function when decoding string to double values. Default (False) is to use fast but less precise built-in functionality.
- **date_unit**: string, the timestamp unit to detect if converting dates. Default None. By default the timestamp precision will be detected, if this is not desired then pass one of ‘s’, ‘ms’, ‘us’ or ‘ns’ to force timestamp precision to seconds, milliseconds, microseconds or nanoseconds respectively.
- **lines**: reads file as one json object per line.
- **encoding**: The encoding to use to decode py3 bytes.
- **chunksize**: when used in combination with `lines=True`, return a JsonReader which reads in `chunksize` lines per iteration.

The parser will raise one of `ValueError/TypeError/AssertionError` if the JSON is not parseable.

If a non-default `orient` was used when encoding to JSON be sure to pass the same option here so that decoding produces sensible results, see `Orient Options` for an overview.

### 24.2.2.1 Data Conversion

The default of `convert_axes=True, dtype=True, and convert_dates=True` will try to parse the axes, and all of the data into appropriate types, including dates. If you need to override specific dtypes, pass a dict to `dtype`. `convert_axes` should only be set to False if you need to preserve string-like numbers (e.g. ‘1’, ‘2’) in an axes.
Note: Large integer values may be converted to dates if convert_dates=True and the data and/or column labels appear ‘date-like’. The exact threshold depends on the date_unit specified. ‘date-like’ means that the column label meets one of the following criteria:

- it ends with '_at'
- it ends with '_time'
- it begins with 'timestamp'
- it is 'modified'
- it is 'date'

Warning: When reading JSON data, automatic coercing into dtypes has some quirks:

- an index can be reconstructed in a different order from serialization, that is, the returned order is not guaranteed to be the same as before serialization
- a column that was float data will be converted to integer if it can be done safely, e.g. a column of 1.
- bool columns will be converted to integer on reconstruction

Thus there are times where you may want to specify specific dtypes via the dtype keyword argument.

Reading from a JSON string:

```
In [214]: pd.read_json(json)
Out[214]:
   date    B    A
0 2013-01-01  2.565646 -1.206412
1 2013-01-01  1.340309  1.431256
2 2013-01-01 -0.226169 -1.170299
3 2013-01-01  0.813850  0.410835
4 2013-01-01 -0.827317  0.132003
```

Reading from a file:

```
In [215]: pd.read_json('test.json')
Out[215]:
   date    A    B    date    ints    bools
2013-01-01 -1.294524  0.413738  2013-01-01   0   True
2013-01-02  0.276662 -0.472035  2013-01-01   1   True
2013-01-03 -0.013960 -0.362543  2013-01-01   2   True
2013-01-04 -0.006154 -0.923061  2013-01-01   3   True
2013-01-05  0.895717  0.805244  2013-01-01   4   True
```

Don’t convert any data (but still convert axes and dates):

```
In [216]: pd.read_json('test.json', dtype=object).dtypes
Out[216]:
       A    object
       B    object
date  object
ints  object
bools object
dtype: object
```
Specify dtypes for conversion:

```python
In [217]: pd.read_json('test.json', dtype={'A': 'float32', 'bools': 'int8'}).dtypes
Out[217]:
A    float32
B    float64
date  datetime64[ns]
ints  int64
bools int8
dtype: object
```

Preserve string indices:

```python
In [218]: si = pd.DataFrame(np.zeros((4, 4)),
                      columns=list(range(4)),
                      index=[str(i) for i in range(4)])
In [219]: si
Out[219]:
      0  1  2  3
0   0.0  0.0  0.0  0.0
1   0.0  0.0  0.0  0.0
2   0.0  0.0  0.0  0.0
3   0.0  0.0  0.0  0.0
In [220]: si.index
Out[220]:
Index(['0', '1', '2', '3'], dtype='object')
In [221]: si.columns
Out[221]:
Int64Index([0, 1, 2, 3], dtype='int64')
In [222]: json = si.to_json()
In [223]: sij = pd.read_json(json, convert_axes=False)
In [224]: sij
Out[224]:
      0  1  2  3
0   0  0  0  0
1   0  0  0  0
2   0  0  0  0
3   0  0  0  0
In [225]: sij.index
Out[225]:
Index(['0', '1', '2', '3'], dtype='object')
In [226]: sij.columns
Out[226]:
Index(['0', '1', '2', '3'], dtype='object')
```

Dates written in nanoseconds need to be read back in nanoseconds:

```python
In [227]: json = dfj2.to_json(date_unit='ns')
```

(continues on next page)
# Try to parse timestamps as milliseconds -> Won't Work
In [228]: dfju = pd.read_json(json, date_unit='ms')

In [229]: dfju
Out[229]:
     A    B      date    ints    bools
1356998400000000000 -1.294524  0.413738 1356998400000000000 True
1357084800000000000  0.276662 -0.472035 1356998400000000000 True
1357171200000000000 -0.013960 -0.362543 1356998400000000000 True
1357257600000000000 -0.006154 -0.923061 1356998400000000000 True
1357344000000000000  0.895717  0.805244 1356998400000000000 True

# Let pandas detect the correct precision
In [230]: dfju = pd.read_json(json)

In [231]: dfju
Out[231]:
     A    B     date    ints    bools
2013-01-01 -1.294524  0.413738 2013-01-01 0 True
2013-01-02  0.276662 -0.472035 2013-01-01 1 True
2013-01-03 -0.013960 -0.362543 2013-01-01 2 True
2013-01-04 -0.006154 -0.923061 2013-01-01 3 True
2013-01-05  0.895717  0.805244 2013-01-01 4 True

# Or specify that all timestamps are in nanoseconds
In [232]: dfju = pd.read_json(json, date_unit='ns')

In [233]: dfju
Out[233]:
     A    B     date    ints    bools
2013-01-01 -1.294524  0.413738 2013-01-01 0 True
2013-01-02  0.276662 -0.472035 2013-01-01 1 True
2013-01-03 -0.013960 -0.362543 2013-01-01 2 True
2013-01-04 -0.006154 -0.923061 2013-01-01 3 True
2013-01-05  0.895717  0.805244 2013-01-01 4 True

### 24.2.2.2 The Numpy Parameter

**Note:** This supports numeric data only. Index and columns labels may be non-numeric, e.g. strings, dates etc.

If `numpy=True` is passed to `read_json` an attempt will be made to sniff an appropriate dtype during deserialization and to subsequently decode directly to NumPy arrays, bypassing the need for intermediate Python objects. This can provide speedups if you are deserialising a large amount of numeric data:

In [234]: randfloats = np.random.uniform(-100, 1000, 10000)

In [235]: randfloats.shape = (1000, 10)

In [236]: dffloats = pd.DataFrame(randfloats, columns=list('ABCDEFGHIJ'))

In [237]: jsonfloats = dffloats.to_json()
Warning: Direct NumPy decoding makes a number of assumptions and may fail or produce unexpected output if these assumptions are not satisfied:

- data is numeric.
- data is uniform. The dtype is sniffed from the first value decoded. A `ValueError` may be raised, or incorrect output may be produced if this condition is not satisfied.
- labels are ordered. Labels are only read from the first container, it is assumed that each subsequent row / column has been encoded in the same order. This should be satisfied if the data was encoded using `to_json` but may not be the case if the JSON is from another source.

### 24.2.3 Normalization

pandas provides a utility function to take a dict or list of dicts and `normalize` this semi-structured data into a flat table.
24.2.4 Line delimited json

New in version 0.19.0.

pandas is able to read and write line-delimited json files that are common in data processing pipelines using Hadoop or Spark.

New in version 0.21.0.

For line-delimited json files, pandas can also return an iterator which reads in chunksize lines at a time. This can be useful for large files or to read from a stream.
24.2.5 Table Schema

New in version 0.20.0.

Table Schema is a spec for describing tabular datasets as a JSON object. The JSON includes information on the field names, types, and other attributes. You can use the orient table to build a JSON string with two fields, schema and data.

In [255]: df = pd.DataFrame(
    .....:     {'A': [1, 2, 3],
    .....:     'B': ['a', 'b', 'c'],
    .....:     'C': pd.date_range('2016-01-01', freq='d', periods=3),
    .....:     }, index=pd.Index(range(3), name='idx'))

In [256]: df
Out[256]:
   A  B          C
   idx
0  1  a 2016-01-01
1  2  b 2016-01-02
2  3  c 2016-01-03

In [257]: df.to_json(orient='table', date_format="iso")

The schema field contains the fields key, which itself contains a list of column name to type pairs, including the Index or MultiIndex (see below for a list of types). The schema field also contains a primaryKey field if the (Multi)index is unique.

The second field, data, contains the serialized data with the records orient. The index is included, and any datetimes are ISO 8601 formatted, as required by the Table Schema spec.

The full list of types supported are described in the Table Schema spec. This table shows the mapping from pandas types:
Pandas type | Table Schema type  
---|---  
int64 | integer  
float64 | number  
bool | boolean  
datetime64[ns] | datetime  
timedelta64[ns] | duration  
categorical | any  
object | str

A few notes on the generated table schema:

- The schema object contains a pandas_version field. This contains the version of pandas’ dialect of the schema, and will be incremented with each revision.

- All dates are converted to UTC when serializing. Even timezone naïve values, which are treated as UTC with an offset of 0.

```python
In [258]: from pandas.io.json import build_table_schema

In [259]: s = pd.Series(pd.date_range('2016', periods=4))

In [260]: build_table_schema(s)
Out[260]:

{'fields': [{'name': 'index', 'type': 'integer'},
            {'name': 'values', 'type': 'datetime'}],
'primaryKey': ['index'],
'pandas_version': '0.20.0'}
```

- Datetimes with a timezone (before serializing), include an additional field tz with the time zone name (e.g. 'US/Central').

```python
In [261]: s_tz = pd.Series(pd.date_range('2016', periods=12,
                                        ....:       tz='US/Central'))

In [262]: build_table_schema(s_tz)
Out[262]:

{'fields': [{'name': 'index', 'type': 'integer'},
            {'name': 'values', 'type': 'datetime', 'tz': 'US/Central'}],
'primaryKey': ['index'],
'pandas_version': '0.20.0'}
```

- Periods are converted to timestamps before serialization, and so have the same behavior of being converted to UTC. In addition, periods will contain and additional field freq with the period’s frequency, e.g. 'A-DEC'.

```python
In [263]: s_per = pd.Series(1, index=pd.period_range('2016', freq='A-DEC',
                                              ....:       periods=4))

In [264]: build_table_schema(s_per)
Out[264]:

{'fields': [{'name': 'index', 'type': 'datetime', 'freq': 'A-DEC'},
            {'name': 'values', 'type': 'integer'}],
'primaryKey': ['index'],
'pandas_version': '0.20.0'}
```
• Categoricals use the `any` type and an `enum` constraint listing the set of possible values. Additionally, an `ordered` field is included:

```
In [265]: s_cat = pd.Series(pd.Categorical(['a', 'b', 'a']))
In [266]: build_table_schema(s_cat)
Out[266]:
{'fields': [{'name': 'index', 'type': 'integer'},
            {'name': 'values', 'type': 'any',
             'constraints': {'enum': ['a', 'b']},
             'ordered': False},
            'primaryKey': ['index'],
            'pandas_version': '0.20.0'}
```

• A `primaryKey` field, containing an array of labels, is included if the index is unique:

```
In [267]: s_dupe = pd.Series([1, 2], index=[1, 1])
In [268]: build_table_schema(s_dupe)
Out[268]:
{'fields': [{'name': 'index', 'type': 'integer'},
            {'name': 'values', 'type': 'integer'}],
 'pandas_version': '0.20.0'}
```

• The `primaryKey` behavior is the same with MultiIndexes, but in this case the `primaryKey` is an array:

```
In [269]: s_multi = pd.Series(1, index=pd.MultiIndex.from_product([('a', 'b'),
                                                            (0, 1)]))
In [270]: build_table_schema(s_multi)
Out[270]:
{'fields': [{'name': 'level_0', 'type': 'string'},
            {'name': 'level_1', 'type': 'integer'},
            {'name': 'values', 'type': 'integer'}],
 'primaryKey': FrozenList(['level_0', 'level_1']),
 'pandas_version': '0.20.0'}
```

• The default naming roughly follows these rules:

  – For series, the `object.name` is used. If that’s none, then the name is `values`
  
  – For DataFrames, the stringified version of the column name is used
  
  – For Index (not MultiIndex), `index.name` is used, with a fallback to `index` if that is None.
  
  – For MultiIndex, `mi.names` is used. If any level has no name, then `level_<i>` is used.

New in version 0.23.0.

`read_json` also accepts `orient='table'` as an argument. This allows for the preservation of metadata such as dtypes and index names in a round-trippable manner.

```
In [271]: df = pd.DataFrame({'foo': [1, 2, 3, 4],
                      'bar': ['a', 'b', 'c', 'd'],
                      'baz': pd.date_range('2018-01-01', freq='d', periods=4),
                      'qux': pd.Categorical(['a', 'b', 'c', 'c'])}, index=pd.Index(range(4), name='idx'))
```

(continues on next page)
In [272]: df
Out[272]:
   foo bar  baz  qux
idx
0    1   a  2018-01-01  a
1    2   b  2018-01-02  b
2    3   c  2018-01-03  c
3    4   d  2018-01-04  c

In [273]: df.dtypes

Out[273]:
     foo    bar      baz     qux
dtype: object

In [274]: df.to_json('test.json', orient='table')

In [275]: new_df = pd.read_json('test.json', orient='table')

In [276]: new_df
Out[276]:
   foo bar  baz  qux
idx
0    1   a  2018-01-01  a
1    2   b  2018-01-02  b
2    3   c  2018-01-03  c
3    4   d  2018-01-04  c

In [277]: new_df.dtypes

Out[277]:
     foo    bar      baz     qux
dtype: object

Please note that the literal string ‘index’ as the name of an Index is not round-trippable, nor are any names beginning with ‘level_’ within a MultiIndex. These are used by default in DataFrame.to_json() to indicate missing values and the subsequent read cannot distinguish the intent.

In [278]: df.index.name = 'index'

In [279]: df.to_json('test.json', orient='table')

In [280]: new_df = pd.read_json('test.json', orient='table')

In [281]: print(new_df.index.name)
None
24.3 HTML

24.3.1 Reading HTML Content

Warning: We highly encourage you to read the HTML Table Parsing gotchas below regarding the issues surrounding the BeautifulSoup4/html5lib/lxml parsers.

The top-level read_html() function can accept an HTML string/file/URL and will parse HTML tables into list of pandas DataFrames. Let’s look at a few examples.

Note: read_html returns a list of DataFrame objects, even if there is only a single table contained in the HTML content.

Read a URL with no options:

```
In [282]: url = 'http://www.fdic.gov/bank/individual/failed/banklist.html'

In [283]: dfs = pd.read_html(url)

In [284]: dfs
Out[284]:

<table>
<thead>
<tr>
<th></th>
<th>Bank Name</th>
<th>Updated Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Washington Federal Bank for Savings</td>
<td>February 21, 2018</td>
</tr>
<tr>
<td>1</td>
<td>The Farmers and Merchants State Bank of Argonia</td>
<td>February 21, 2018</td>
</tr>
<tr>
<td>2</td>
<td>Fayette County Bank</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Guaranty Bank, (d/b/a BestBank in Georgia &amp; MI...</td>
<td>March 22, 2018</td>
</tr>
<tr>
<td>4</td>
<td>First NBC Bank</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Proficio Bank</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Seaway Bank and Trust Company</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>548</td>
<td>Hamilton Bank, NA En Espanol</td>
<td></td>
</tr>
<tr>
<td>549</td>
<td>Sinclair National Bank</td>
<td></td>
</tr>
<tr>
<td>550</td>
<td>Superior Bank, FSB</td>
<td></td>
</tr>
<tr>
<td>551</td>
<td>Malta National Bank</td>
<td></td>
</tr>
<tr>
<td>552</td>
<td>First Alliance Bank &amp; Trust Co.</td>
<td></td>
</tr>
<tr>
<td>553</td>
<td>National State Bank of Metropolis</td>
<td></td>
</tr>
<tr>
<td>554</td>
<td>Bank of Honolulu</td>
<td></td>
</tr>
<tr>
<td>555</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

(continues on next page)
[555 rows x 7 columns]

Note: The data from the above URL changes every Monday so the resulting data above and the data below may be slightly different.

Read in the content of the file from the above URL and pass it to `read_html` as a string:

```python
In [285]: with open(file_path, 'r') as f:
    .....:
    dfs = pd.read_html(f.read())
    .....:

In [286]: dfs
Out[286]:
[  Bank Name               City ...       ...       ...       
   Closing Date     Updated Date          
0    Banks of Wisconsin d/b/a Bank of Kenosha  Kenosha       ...       
   May 31, 2013     May 31, 2013          
1                        Central Arizona Bank  Scottsdale ...       
   May 14, 2013     May 20, 2013          
2                        Sunrise Bank        Valdosta ...       
   May 10, 2013     May 21, 2013          
3                        Pisgah Community Bank  Asheville ...       
   May 10, 2013     May 14, 2013          
4                        Douglas County Bank  Douglasville ...       
   April 26, 2013    May 16, 2013         
5                        Parkway Bank        Lenoir ...       
   April 26, 2013    May 17, 2013         
6                        Chipola Community Bank  Marianna ...       
   April 19, 2013    May 16, 2013         
..  ...  ...  ...  
498    Hamilton Bank, NAEn Espanol  Miami       ...       
   January 11, 2002  June 5, 2012         
499    Sinclair National Bank          Gravette ...       
   September 7, 2001  February 10, 2004   
500    Superior Bank, FSB              Hinsdale ...       
501    Malta National Bank             Malta ...       
   May 3, 2001      November 18, 2002     
502    First Alliance Bank & Trust Co.  Manchester ...       
   February 2, 2001  February 18, 2003    
503    National State Bank of Metropolis  Metropolis ...       
   December 14, 2000  March 17, 2005      
504    Bank of Honolulu                Honolulu ...       
   October 13, 2000  March 17, 2005      }

[505 rows x 7 columns]
```

You can even pass in an instance of `StringIO` if you so desire:

```python
In [287]: with open(file_path, 'r') as f:
    .....:
    sio = StringIO(f.read())
    .....:
```
In [288]: dfs = pd.read_html(sio)

In [289]: dfs
Out[289]:

<table>
<thead>
<tr>
<th>Bank Name</th>
<th>City</th>
<th>Closing Date</th>
<th>Updated Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Arizona Bank</td>
<td>Scottsdale</td>
<td>May 20, 2013</td>
<td></td>
</tr>
<tr>
<td>Sunrise Bank</td>
<td>Valdosta</td>
<td>May 21, 2013</td>
<td></td>
</tr>
<tr>
<td>Pisgah Community Bank</td>
<td>Asheville</td>
<td>May 14, 2013</td>
<td></td>
</tr>
<tr>
<td>Douglas County Bank</td>
<td>Douglasville</td>
<td>May 14, 2013</td>
<td></td>
</tr>
<tr>
<td>Parkway Bank</td>
<td>Lenoir</td>
<td>May 16, 2013</td>
<td></td>
</tr>
<tr>
<td>Chipola Community Bank</td>
<td>Marianna</td>
<td>May 16, 2013</td>
<td></td>
</tr>
<tr>
<td>Hamilton Bank, NAEn Espanol</td>
<td>Miami</td>
<td>January 11, 2002</td>
<td>June 5, 2012</td>
</tr>
<tr>
<td>Sinclair National Bank</td>
<td>Gravette</td>
<td>September 7, 2001</td>
<td>February 10, 2004</td>
</tr>
<tr>
<td>Malta National Bank</td>
<td>Malta</td>
<td>May 3, 2001</td>
<td>November 18, 2002</td>
</tr>
<tr>
<td>First Alliance Bank &amp; Trust Co.</td>
<td>Manchester</td>
<td>February 2, 2001</td>
<td>February 18, 2003</td>
</tr>
<tr>
<td>National State Bank of Metropolis</td>
<td>Metropolis</td>
<td>December 14, 2000</td>
<td>March 17, 2005</td>
</tr>
<tr>
<td>Bank of Honolulu</td>
<td>Honolulu</td>
<td>October 13, 2000</td>
<td>March 17, 2005</td>
</tr>
</tbody>
</table>

[505 rows x 7 columns]

Note: The following examples are not run by the IPython evaluator due to the fact that having so many network-accessing functions slows down the documentation build. If you spot an error or an example that doesn’t run, please do not hesitate to report it over on pandas GitHub issues page.

Read a URL and match a table that contains specific text:

```python
match = 'Metcalf Bank'
df_list = pd.read_html(url, match=match)
```

Specify a header row (by default `<th>` or `<td>` elements located within a `<thead>` are used to form the column index, if multiple rows are contained within `<thead>` then a multiindex is created); if specified, the header row is taken from the data minus the parsed header elements (`<th>` elements).

```python
dfs = pd.read_html(url, header=0)
```

Specify an index column:
dfs = pd.read_html(url, index_col=0)

Specify a number of rows to skip:

dfs = pd.read_html(url, skiprows=0)

Specify a number of rows to skip using a list (xrange (Python 2 only) works as well):

dfs = pd.read_html(url, skiprows=range(2))

Specify an HTML attribute:

dxsl = pd.read_html(url, attrs={'id': 'table'})
dfs2 = pd.read_html(url, attrs={'class': 'sortable'})

print(np.array_equal(dfs1[0], dfs2[0]))  # Should be True

Specify values that should be converted to NaN:

dfs = pd.read_html(url, na_values=['No Acquirer'])

New in version 0.19.

Specify whether to keep the default set of NaN values:

dfs = pd.read_html(url, keep_default_na=False)

New in version 0.19.

Specify converters for columns. This is useful for numerical text data that has leading zeros. By default columns that are numerical are cast to numeric types and the leading zeros are lost. To avoid this, we can convert these columns to strings.

url_mcc = 'https://en.wikipedia.org/wiki/Mobile_country_code'
dfs = pd.read_html(url_mcc, match='Telekom Albania', header=0, converters={'MNC': str})

New in version 0.19.

Use some combination of the above:

dfs = pd.read_html(url, match='Metcalf Bank', index_col=0)

Read in pandas to_html output (with some loss of floating point precision):

df = pd.DataFrame(randn(2, 2))
s = df.to_html(float_format='{{0:.40g}}'.format)
dfin = pd.read_html(s, index_col=0)

The lxml backend will raise an error on a failed parse if that is the only parser you provide. If you only have a single parser you can provide just a string, but it is considered good practice to pass a list with one string if, for example, the function expects a sequence of strings. You may use:

dfs = pd.read_html(url, 'Metcalf Bank', index_col=0, flavor=['lxml'])

Or you could pass flavor='lxml' without a list:

dfs = pd.read_html(url, 'Metcalf Bank', index_col=0, flavor='lxml')
However, if you have bs4 and html5lib installed and pass None or ['lxml', 'bs4'] then the parse will most likely succeed. Note that as soon as a parse succeeds, the function will return.

```python
dfs = pd.read_html(url, 'Metcalf Bank', index_col=0, flavor=['lxml', 'bs4'])
```

### 24.3.2 Writing to HTML files

DataFrames have an instance method `to_html` which renders the contents of the DataFrame as an HTML table. The function arguments are as in the method `to_string` described above.

**Note:** Not all of the possible options for DataFrame.to_html are shown here for brevity's sake. See `to_html()` for the full set of options.

```python
In [290]: df = pd.DataFrame(randn(2, 2))

In [291]: df
Out[291]:
   0     1
0 -0.184744  0.496971
1 -0.856240  1.857977

In [292]: print(df.to_html())  # raw html
    \[table border="1" class="dataframe"
    \thead
    \th 0 \th 1
    \t0 -0.184744  0.496971
    \t1 -0.856240  1.857977

In [293]: print(df.to_html(columns=[0]))
    \[table border="1" class="dataframe"
    \thead
    \th 0
    \t0 -0.184744
    \t1 -0.856240
    \t0 1.857977

(continues on next page)
**HTML:**

`float_format` takes a Python callable to control the precision of floating point values:

```python
In [294]: print(df.to_html(float_format='{0:.10f}'.format))
```

```html
<table border="1" class="dataframe">
<thead>
<tr style="text-align: right;">
<th></th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<th>0</th>
<td>-0.1847438576</td>
<td>0.4969711327</td>
</tr>
<tr>
<th>1</th>
<td>-0.8562396763</td>
<td>1.8579766508</td>
</tr>
</tbody>
</table>
```

**HTML:**

`bold_rows` will make the row labels bold by default, but you can turn that off:

```python
In [295]: print(df.to_html(bold_rows=False))
```

```html
<table border="1" class="dataframe">
<thead>
<tr style="text-align: right;">
<th></th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-0.1847438576</td>
<td>0.4969711327</td>
</tr>
<tr>
<td>1</td>
<td>-0.8562396763</td>
<td>1.8579766508</td>
</tr>
</tbody>
</table>
```
The `classes` argument provides the ability to give the resulting HTML table CSS classes. Note that these classes are appended to the existing 'dataframe' class.

```python
In [296]: print(df.to_html(classes=['awesome_table_class', 'even_more_awesome_class']))
```

```html
<table border="1" class="dataframe awesome_table_class even_more_awesome_class">
<thead>
<tr style="text-align: right;">  
<th></th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<th>0</th>
<td>-0.184744</td>
<td>0.496971</td>
</tr>
<tr>
<th>1</th>
<td>-0.856240</td>
<td>1.857977</td>
</tr>
</tbody>
</table>
```

Finally, the `escape` argument allows you to control whether the "<", ">" and "&" characters escaped in the resulting HTML (by default it is True). So to get the HTML without escaped characters pass `escape=False`

```python
In [297]: df = pd.DataFrame({'a': list('&<>'), 'b': randn(3)})
Escaped:
In [298]: print(df.to_html())
```

```html
<table border="1" class="dataframe">
<thead>
<tr style="text-align: right;">  
<th></th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<th>0</th>
<td>-0.184744</td>
<td>0.496971</td>
</tr>
<tr>
<th>1</th>
<td>-0.856240</td>
<td>1.857977</td>
</tr>
</tbody>
</table>
```

(continues on next page)
Not escaped:

```
In [299]: print(df.to_html(escape=False))
<table border="1" class="dataframe">
<thead>
<tr style="text-align: right;"> 
<th></th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<th>0</th>
<td>&amp;</td>
<td>-0.474063</td>
</tr>
<tr>
<th>1</th>
<td>&lt;</td>
<td>-0.230305</td>
</tr>
<tr>
<th>2</th>
<td>&gt;</td>
<td>-0.400654</td>
</tr>
</tbody>
</table>
```

**Note:** Some browsers may not show a difference in the rendering of the previous two HTML tables.

### 24.3.3 HTML Table Parsing Gotchas

There are some versioning issues surrounding the libraries that are used to parse HTML tables in the top-level pandas io function `read_html`.
Issues with lxml

- Benefits
  - lxml is very fast.
  - lxml requires Cython to install correctly.
- Drawbacks
  - lxml does not make any guarantees about the results of its parse unless it is given strictly valid markup.
  - In light of the above, we have chosen to allow you, the user, to use the lxml backend, but this backend will use html5lib if lxml fails to parse.
  - It is therefore highly recommended that you install both BeautifulSoup4 and html5lib, so that you will still get a valid result (provided everything else is valid) even if lxml fails.

Issues with BeautifulSoup4 using lxml as a backend

- The above issues hold here as well since BeautifulSoup4 is essentially just a wrapper around a parser backend.

Issues with Beautiful Soup 4 using html5lib as a backend

- Benefits
  - html5lib is far more lenient than lxml and consequently deals with real-life markup in a much saner way rather than just, e.g., dropping an element without notifying you.
  - html5lib generates valid HTML5 markup from invalid markup automatically. This is extremely important for parsing HTML tables, since it guarantees a valid document. However, that does NOT mean that it is “correct”, since the process of fixing markup does not have a single definition.
  - html5lib is pure Python and requires no additional build steps beyond its own installation.
- Drawbacks
  - The biggest drawback to using html5lib is that it is slow as molasses. However consider the fact that many tables on the web are not big enough for the parsing algorithm runtime to matter. It is more likely that the bottleneck will be in the process of reading the raw text from the URL over the web, i.e., IO (input-output). For very large tables, this might not be true.

24.4 Excel files

The read_excel() method can read Excel 2003 (.xls) and Excel 2007+ (.xlsx) files using the x1rd Python module. The to_excel() instance method is used for saving a DataFrame to Excel. Generally the semantics are similar to working with csv data. See the cookbook for some advanced strategies.

24.4.1 Reading Excel Files

In the most basic use-case, read_excel takes a path to an Excel file, and the sheet_name indicating which sheet to parse.

```python
# Returns a DataFrame
read_excel('path_to_file.xls', sheet_name='Sheet1')
```
24.4.1.1 ExcelFile class

To facilitate working with multiple sheets from the same file, the ExcelFile class can be used to wrap the file and can be passed into read_excel. There will be a performance benefit for reading multiple sheets as the file is read into memory only once.

```python
xlsx = pd.ExcelFile('path_to_file.xls')
df = pd.read_excel(xlsx, 'Sheet1')
```

The ExcelFile class can also be used as a context manager.

```python
with pd.ExcelFile('path_to_file.xls') as xls:
    df1 = pd.read_excel(xls, 'Sheet1')
    df2 = pd.read_excel(xls, 'Sheet2')
```

The sheet_names property will generate a list of the sheet names in the file.

The primary use-case for an ExcelFile is parsing multiple sheets with different parameters:

```python
data = {}
# For when Sheet1's format differs from Sheet2
with pd.ExcelFile('path_to_file.xls') as xls:
    data['Sheet1'] = pd.read_excel(xls, 'Sheet1', index_col=None, na_values=['NA'])
    data['Sheet2'] = pd.read_excel(xls, 'Sheet2', index_col=1)
```

Note that if the same parsing parameters are used for all sheets, a list of sheet names can simply be passed to read_excel with no loss in performance.

```python
# using the ExcelFile class
data = {}
with pd.ExcelFile('path_to_file.xls') as xls:
    data['Sheet1'] = read_excel(xls, 'Sheet1', index_col=None, na_values=['NA'])
    data['Sheet2'] = read_excel(xls, 'Sheet2', index_col=1)

# equivalent using the read_excel function
data = read_excel('path_to_file.xls', ['Sheet1', 'Sheet2'], index_col=None, na_values=['NA'])
```

24.4.1.2 Specifying Sheets

**Note:** The second argument is sheet_name, not to be confused with ExcelFile.sheet_names.

**Note:** An ExcelFile’s attribute sheet_names provides access to a list of sheets.

- The arguments sheet_name allows specifying the sheet or sheets to read.
- The default value for sheet_name is 0, indicating to read the first sheet.
- Pass a string to refer to the name of a particular sheet in the workbook.
- Pass an integer to refer to the index of a sheet. Indices follow Python convention, beginning at 0.
- Pass a list of either strings or integers, to return a dictionary of specified sheets.
- Pass a None to return a dictionary of all available sheets.
# Returns a DataFrame
read_excel('path_to_file.xls', 'Sheet1', index_col=None, na_values=['NA'])

Using the sheet index:

# Returns a DataFrame
read_excel('path_to_file.xls', 0, index_col=None, na_values=['NA'])

Using all default values:

# Returns a DataFrame
read_excel('path_to_file.xls')

Using None to get all sheets:

# Returns a dictionary of DataFrames
read_excel('path_to_file.xls', sheet_name=None)

Using a list to get multiple sheets:

# Returns the 1st and 4th sheet, as a dictionary of DataFrames.
read_excel('path_to_file.xls', sheet_name=['Sheet1', 3])

read_excel can read more than one sheet, by setting sheet_name to either a list of sheet names, a list of sheet positions, or None to read all sheets. Sheets can be specified by sheet index or sheet name, using an integer or string, respectively.

## 24.4.1.3 Reading a MultiIndex

read_excel can read a MultiIndex index, by passing a list of columns to index_col and a MultiIndex column by passing a list of rows to header. If either the index or columns have serialized level names those will be read in as well by specifying the rows/columns that make up the levels.

For example, to read in a MultiIndex index without names:

In [300]: df = pd.DataFrame({'a':[1, 2, 3, 4], 'b':[5, 6, 7, 8]},
.....:     index=pd.MultiIndex.from_product([['a', 'b'], ['c', 'd']])
.....:
In [301]: df.to_excel('path_to_file.xlsx')
In [302]: df = pd.read_excel('path_to_file.xlsx', index_col=[0, 1])
In [303]: df
Out[303]:
   a  b
a c 1 5
d 2 6
b c 3 7
d 4 8

If the index has level names, they will parsed as well, using the same parameters.

In [304]: df.index = df.index.set_names(['lv11', 'lv12'])
In [305]: df.to_excel('path_to_file.xlsx')

(continues on next page)
In [306]: df = pd.read_excel('path_to_file.xlsx', index_col=[0, 1])

In [307]: df
Out[307]:
a b
lvl1 lvl2
a c 1 5
d 2 6
b c 3 7
d 4 8

If the source file has both MultiIndex index and columns, lists specifying each should be passed to `index_col` and `header`:

In [308]: df.columns = pd.MultiIndex.from_product([['a'], ['b', 'd']], names=['c1', 'c2'])

In [309]: df.to_excel('path_to_file.xlsx')

In [310]: df = pd.read_excel('path_to_file.xlsx', index_col=[0, 1], header=[0, 1])

In [311]: df
Out[311]:
c1 a
c2 b d
lvl1 lvl2
a c 1 5
d 2 6
b c 3 7
d 4 8

### 24.4.1.4 Parsing Specific Columns

It is often the case that users will insert columns to do temporary computations in Excel and you may not want to read in those columns. `read_excel` takes a `usecols` keyword to allow you to specify a subset of columns to parse.

If `usecols` is an integer, then it is assumed to indicate the last column to be parsed.

```
read_excel('path_to_file.xls', 'Sheet1', usecols=2)
```

If `usecols` is a list of integers, then it is assumed to be the file column indices to be parsed.

```
read_excel('path_to_file.xls', 'Sheet1', usecols=[0, 2, 3])
```

Element order is ignored, so `usecols=[0, 1]` is the same as `[1, 0]`.

### 24.4.1.5 Parsing Dates

Datetime-like values are normally automatically converted to the appropriate dtype when reading the excel file. But if you have a column of strings that *look* like dates (but are not actually formatted as dates in excel), you can use the `parse_dates` keyword to parse those strings to datetimes:
24.4.1.6 Cell Converters

It is possible to transform the contents of Excel cells via the converters option. For instance, to convert a column to boolean:

```python
read_excel('path_to_file.xls', 'Sheet1', converters={'MyBools': bool})
```

This options handles missing values and treats exceptions in the converters as missing data. Transformations are applied cell by cell rather than to the column as a whole, so the array dtype is not guaranteed. For instance, a column of integers with missing values cannot be transformed to an array with integer dtype, because NaN is strictly a float. You can manually mask missing data to recover integer dtype:

```python
cfun = lambda x: int(x) if x else -1
read_excel('path_to_file.xls', 'Sheet1', converters={'MyInts': cfun})
```

24.4.1.7 dtype Specifications

New in version 0.20.

As an alternative to converters, the type for an entire column can be specified using the dtype keyword, which takes a dictionary mapping column names to types. To interpret data with no type inference, use the type str or object.

```python
read_excel('path_to_file.xls', dtype={'MyInts': 'int64', 'MyText': str})
```

24.4.2 Writing Excel Files

24.4.2.1 Writing Excel Files to Disk

To write a DataFrame object to a sheet of an Excel file, you can use the to_excel instance method. The arguments are largely the same as to_csv described above, the first argument being the name of the excel file, and the optional second argument the name of the sheet to which the DataFrame should be written. For example:

```python
df.to_excel('path_to_file.xlsx', sheet_name='Sheet1')
```

Files with a .xls extension will be written using xlwt and those with a .xlsx extension will be written using xlsxwriter (if available) or openpyxl.

The DataFrame will be written in a way that tries to mimic the REPL output. The index_label will be placed in the second row instead of the first. You can place it in the first row by setting the merge_cells option in to_excel() to False:

```python
df.to_excel('path_to_file.xlsx', index_label='label', merge_cells=False)
```

In order to write separate DataFrames to separate sheets in a single Excel file, one can pass an ExcelWriter.

```python
with ExcelWriter('path_to_file.xlsx') as writer:
df1.to_excel(writer, sheet_name='Sheet1')
df2.to_excel(writer, sheet_name='Sheet2')
```
24.4.2.2 Writing Excel Files to Memory

Pandas supports writing Excel files to buffer-like objects such as StringIO or BytesIO using ExcelWriter.

```python
# Safe import for either Python 2.x or 3.x
try:
    from io import BytesIO
except ImportError:
    from cStringIO import StringIO as BytesIO

bio = BytesIO()

# By setting the 'engine' in the ExcelWriter constructor.
writer = ExcelWriter(bio, engine='xlsxwriter')
df.to_excel(writer, sheet_name='Sheet1')

# Save the workbook
writer.save()

# Seek to the beginning and read to copy the workbook to a variable in memory
bio.seek(0)
workbook = bio.read()
```

**Note:** engine is optional but recommended. Setting the engine determines the version of workbook produced. Setting engine='xlrd' will produce an Excel 2003-format workbook (xls). Using either 'openpyxl' or 'xlsxwriter' will produce an Excel 2007-format workbook (xlsx). If omitted, an Excel 2007-formatted workbook is produced.

24.4.3 Excel writer engines

Pandas chooses an Excel writer via two methods:

1. the engine keyword argument
2. the filename extension (via the default specified in config options)

By default, pandas uses the XlsxWriter for .xlsx, openpyxl for .xlsm, and xlwt for .xls files. If you have multiple engines installed, you can set the default engine through setting the config options io.excel.xlsx.writer and io.excel.xls.writer. pandas will fall back on openpyxl for .xlsx files if Xlsxwriter is not available.

To specify which writer you want to use, you can pass an engine keyword argument to to_excel and to ExcelWriter. The built-in engines are:

- openpyxl: version 2.4 or higher is required
- xlsxwriter
- xlwt
# By setting the 'engine' in the DataFrame and Panel `to_excel()` methods.
df.to_excel('path_to_file.xlsx', sheet_name='Sheet1', engine='xlsxwriter')

# By setting the 'engine' in the ExcelWriter constructor.
writer = ExcelWriter('path_to_file.xlsx', engine='xlsxwriter')

# Or via pandas configuration.
from pandas import options
options.io.excel.xlsx.writer = 'xlsxwriter'
df.to_excel('path_to_file.xlsx', sheet_name='Sheet1')

## 24.4.4 Style and Formatting

The look and feel of Excel worksheets created from pandas can be modified using the following parameters on the DataFrame's `to_excel` method.

- **float_format**: Format string for floating point numbers (default `None`).
- **freeze_panes**: A tuple of two integers representing the bottommost row and rightmost column to freeze. Each of these parameters is one-based, so `(1, 1)` will freeze the first row and first column (default `None`).

### 24.5 Clipboard

A handy way to grab data is to use the `read_clipboard()` method, which takes the contents of the clipboard buffer and passes them to the `read_table` method. For instance, you can copy the following text to the clipboard (CTRL-C on many operating systems):

```
A B C
x  1  4 p
y  2  5 q
z  3  6 r
```

And then import the data directly to a DataFrame by calling:

```python
clipdf = pd.read_clipboard()
```

```
In [312]: clipdf
Out[312]:
   A  B  C
0  x  1  4 p
1  y  2  5 q
2  z  3  6 r
```

The `to_clipboard` method can be used to write the contents of a DataFrame to the clipboard. Following which you can paste the clipboard contents into other applications (CTRL-V on many operating systems). Here we illustrate writing a DataFrame into clipboard and reading it back.

```python
In [313]: df = pd.DataFrame(randn(5, 3))
In [314]: df
Out[314]:
   0  1  2
0  1  2  3
1  4  5  6
2  7  8  9
3 10 11 12
4 13 14 15
```

(continues on next page)
0 -0.288267 -0.084905 0.004772
1 1.382989 0.343635 -1.253994
2 -0.124925 0.212244 0.496654
3 0.525417 1.238640 -1.210543
4 -1.175743 -0.172372 -0.734129

In [315]: df.to_clipboard()
In [316]: pd.read_clipboard()
Out[316]:
   0   1   2
0 -0.288267 -0.084905 0.004772
1 1.382989 0.343635 -1.253994
2 -0.124925 0.212244 0.496654
3 0.525417 1.238640 -1.210543
4 -1.175743 -0.172372 -0.734129

We can see that we got the same content back, which we had earlier written to the clipboard.

Note: You may need to install xclip or xsel (with gtk, PyQt5, PyQt4 or qtpy) on Linux to use these methods.

24.6 Pickling

All pandas objects are equipped with to_pickle methods which use Python’s cPickle module to save data structures to disk using the pickle format.

In [317]: df
Out[317]:
   0   1   2
0 -0.288267 -0.084905 0.004772
1 1.382989 0.343635 -1.253994
2 -0.124925 0.212244 0.496654
3 0.525417 1.238640 -1.210543
4 -1.175743 -0.172372 -0.734129

In [318]: df.to_pickle('foo.pkl')

The read_pickle function in the pandas namespace can be used to load any pickled pandas object (or any other pickled object) from file:

In [319]: pd.read_pickle('foo.pkl')
Out[319]:
   0   1   2
0 -0.288267 -0.084905 0.004772
1 1.382989 0.343635 -1.253994
2 -0.124925 0.212244 0.496654
3 0.525417 1.238640 -1.210543
4 -1.175743 -0.172372 -0.734129

Warning: Loading pickled data received from untrusted sources can be unsafe.
Warning: Several internal refactorings have been done while still preserving compatibility with pickles created with older versions of pandas. However, for such cases, pickled DataFrames, Series etc, must be read with `pd.read_pickle`, rather than `pickle.load`.

See here and here for some examples of compatibility-breaking changes. See this question for a detailed explanation.

### 24.6.1 Compressed pickle files

New in version 0.20.0.

`read_pickle()`, `DataFrame.to_pickle()` and `Series.to_pickle()` can read and write compressed pickle files. The compression types of gzip, bz2, xz are supported for reading and writing. The zip file format only supports reading and must contain only one data file to be read.

The compression type can be an explicit parameter or be inferred from the file extension. If ‘infer’, then use gzip, bz2, zip, or xz if filename ends in ‘.gz’, ‘.bz2’, ‘.zip’, or ‘.xz’, respectively.

```python
In [320]: df = pd.DataFrame({
            'A': np.random.randn(1000),
            'B': 'foo',
            'C': pd.date_range('20130101', periods=1000, freq='s')})

In [321]: df
Out[321]:
   A    B     C
0  0.478412 foo 2013-01-01 00:00:00
1 -0.783748 foo 2013-01-01 00:00:01
2  1.403558 foo 2013-01-01 00:00:02
3 -0.539282 foo 2013-01-01 00:00:03
4 -1.651012 foo 2013-01-01 00:00:04
5  0.692072 foo 2013-01-01 00:00:05
6  1.022171 foo 2013-01-01 00:00:06
..    ...    ......
993 -1.613932 foo 2013-01-01 00:16:33
994  1.088104 foo 2013-01-01 00:16:34
995 -0.632963 foo 2013-01-01 00:16:35
996 -0.585314 foo 2013-01-01 00:16:36
997 -0.275038 foo 2013-01-01 00:16:37
998 -0.937512 foo 2013-01-01 00:16:38
999  0.632369 foo 2013-01-01 00:16:39
[1000 rows x 3 columns]
```

Using an explicit compression type:

```python
In [322]: df.to_pickle("data.pkl.compress", compression="gzip")
In [323]: rt = pd.read_pickle("data.pkl.compress", compression="gzip")
In [324]: rt
```

(continues on next page)
Inferring compression type from the extension:

In [325]: df.to_pickle("data.pkl.xz", compression="infer")

In [326]: rt = pd.read_pickle("data.pkl.xz", compression="infer")

In [327]: rt

Out[327]:

A   B     C
0 0.478412 foo 2013-01-01 00:00:00
1 -0.783748 foo 2013-01-01 00:00:01
2 1.403558 foo 2013-01-01 00:00:02
3 -0.539282 foo 2013-01-01 00:00:03
4 -1.651012 foo 2013-01-01 00:00:04
5 0.692072 foo 2013-01-01 00:00:05
6 1.022171 foo 2013-01-01 00:00:06
... ... ... ...
993 -1.613932 foo 2013-01-01 00:16:33
994 1.088104 foo 2013-01-01 00:16:34
995 -0.632963 foo 2013-01-01 00:16:35
996 -0.585314 foo 2013-01-01 00:16:36
997 -0.275038 foo 2013-01-01 00:16:37
998 -0.937512 foo 2013-01-01 00:16:38
999 0.632369 foo 2013-01-01 00:16:39

[1000 rows x 3 columns]

The default is to ‘infer’:

In [328]: df.to_pickle("data.pkl.gz")

In [329]: rt = pd.read_pickle("data.pkl.gz")

In [330]: rt

Out[330]:

A   B     C
0 0.478412 foo 2013-01-01 00:00:00

(continues on next page)
1   -0.783748  foo  2013-01-01 00:00:01
2    1.403558  foo  2013-01-01 00:00:02
3   -0.539282  foo  2013-01-01 00:00:03
4   -1.651012  foo  2013-01-01 00:00:04
5    0.692072  foo  2013-01-01 00:00:05
6    1.022171  foo  2013-01-01 00:00:06
...   ...  ...  ...  ...  
993  -1.613932  foo  2013-01-01 00:16:33
994   1.088104  foo  2013-01-01 00:16:34
995  -0.632963  foo  2013-01-01 00:16:35
996  -0.585314  foo  2013-01-01 00:16:36
997  -0.275038  foo  2013-01-01 00:16:37
998  -0.937512  foo  2013-01-01 00:16:38
999   0.632369  foo  2013-01-01 00:16:39

[1000 rows x 3 columns]

In [331]: df["A"].to_pickle("s1.pkl.bz2")

In [332]: rt = pd.read_pickle("s1.pkl.bz2")

In [333]: rt

Out[333]:
   0  0.478412
  1  -0.783748
  2   1.403558
  3  -0.539282
  4  -1.651012
  5   0.692072
  6   1.022171
...      ...
993  -1.613932
994   1.088104
995  -0.632963
996  -0.585314
997  -0.275038
998  -0.937512
999   0.632369
Name: A, Length: 1000, dtype: float64

24.7 msgpack

pandas supports the msgpack format for object serialization. This is a lightweight portable binary format, similar to binary JSON, that is highly space efficient, and provides good performance both on the writing (serialization), and reading (deserialization).

**Warning:** This is a very new feature of pandas. We intend to provide certain optimizations in the io of the msgpack data. Since this is marked as an EXPERIMENTAL LIBRARY, the storage format may not be stable until a future release.

In [334]: df = pd.DataFrame(np.random.rand(5, 2), columns=list('AB'))
In [335]: df.to_msgpack('foo.msg')

In [336]: pd.read_msgpack('foo.msg')
Out[336]:
      A     B
0  0.1708  0.895366
1  0.8382  0.052592
2  0.6641  0.289750
3  0.4495  0.872087
4  0.9836  0.744359

In [337]: s = pd.Series(np.random.rand(5), index=pd.date_range('20130101', periods=5))

You can pass a list of objects and you will receive them back on deserialization.

In [338]: pd.to_msgpack('foo.msg', df, 'foo', np.array([1, 2, 3]), s)

In [339]: pd.read_msgpack('foo.msg')
Out[339]:
[ A   B
0  0.1708  0.895366
1  0.8382  0.052592
2  0.6641  0.289750
3  0.4495  0.872087
4  0.9836  0.744359, 'foo', array([1, 2, 3]), 2013-01-01 0.548134
2013-01-02 0.503447
2013-01-03 0.348438
2013-01-04 0.707267
2013-01-05 0.261656
Freq: D, dtype: float64]

You can pass `iterator=True` to iterate over the unpacked results:

In [340]: for o in pd.read_msgpack('foo.msg', iterator=True):
   ....:     print(o)
   ....:
      A     B
0  0.1708  0.895366
1  0.8382  0.052592
2  0.6641  0.289750
3  0.4495  0.872087
4  0.9836  0.744359
foo
[1 2 3]
2013-01-01 0.548134
2013-01-02 0.503447
2013-01-03 0.348438
2013-01-04 0.707267
2013-01-05 0.261656
Freq: D, dtype: float64

You can pass `append=True` to the writer to append to an existing pack:

In [341]: df.to_msgpack('foo.msg', append=True)

In [342]: pd.read_msgpack('foo.msg')
Out[342]:
(continues on next page)
pandas: powerful Python data analysis toolkit, Release 0.23.2

(continued from previous page)

[

A
B
0 0.170801 0.895366
1 0.838238 0.052592
2 0.664140 0.289750
3 0.449593 0.872087
4 0.983618 0.744359, 'foo', array([1, 2, 3]), 2013-01-01
2013-01-02
0.503447
2013-01-03
0.348438
2013-01-04
0.707267
2013-01-05
0.261656
Freq: D, dtype: float64,
A
B
0 0.170801 0.895366
1 0.838238 0.052592
2 0.664140 0.289750
3 0.449593 0.872087
4 0.983618 0.744359]

0.548134

Unlike other io methods, to_msgpack is available on both a per-object basis, df.to_msgpack() and using the
top-level pd.to_msgpack(...) where you can pack arbitrary collections of Python lists, dicts, scalars, while
intermixing pandas objects.
In [343]: pd.to_msgpack('foo2.msg', {'dict': [{ 'df': df }, {'string': 'foo'},
.....:
{'scalar': 1.}, {'s': s}]})
.....:
In [344]: pd.read_msgpack('foo2.msg')
Out[344]:
{'dict': ({'df':
A
B
0 0.170801 0.895366
1 0.838238 0.052592
2 0.664140 0.289750
3 0.449593 0.872087
4 0.983618 0.744359},
{'string': 'foo'},
{'scalar': 1.0},
{'s': 2013-01-01
0.548134
2013-01-02
0.503447
2013-01-03
0.348438
2013-01-04
0.707267
2013-01-05
0.261656
Freq: D, dtype: float64})}

24.7.1 Read/Write API
Msgpacks can also be read from and written to strings.

In [345]: df.to_msgpack()
Out[345]: b'\x84\xa3typ\xadblock_
˓→manager\xa5klass\xa9DataFrame\xa4axes\x92\x86\xa3typ\xa5index\xa5klass\xa5Index\xa4name\xc0\xa5dtyp
˓→index\xa5klass\xaaRangeIndex\xa4name\xc0\xa5start\x00\xa4stop\x05\xa4step\x01\xa6blocks\x91\x86\xa4
˓→<\xfd\xd2f\xcf\xdc\xc5?0\x15\xebN\xd9\xd2\xea?,\x9c\x16A\xa2@\xe5?\xd8/\xdd\xf4
˓→"\xc6\xdc?\x11\x1e\x97\x1b\xcdy\xef?&\x1e<\xee\xd6\xa6\xec?p\xd3;\xb2N\xed\xaa?
˓→h\xcb\xb1\xbdB\x8b\xd2?\xaf4\x01r"\xe8\xeb?)G6\xd9\xc9\xd1\xe7?
˓→\xa5shape\x92\x02\x05\xa5dtype\xa7float64\xa5klass\xaaFloatBlock\xa8compress\xc0'

Furthermore you can concatenate the strings to produce a list of the original objects.
1192

Chapter 24. IO Tools (Text, CSV, HDF5, . . . )


24.8 HDF5 (PyTables)

HDFStore is a dict-like object which reads and writes pandas using the high performance HDF5 format using the excellent PyTables library. See the cookbook for some advanced strategies

**Warning:** pandas requires PyTables >= 3.0.0. There is a indexing bug in PyTables < 3.2 which may appear when querying stores using an index. If you see a subset of results being returned, upgrade to PyTables >= 3.2. Stores created previously will need to be rewritten using the updated version.
# the type of stored data
In [357]: store.root.wp._v_attrs.pandas_type
Out[357]: 'wide'

In [358]: store

Out[358]: <class 'pandas.io.pytables.HDFStore'>
File path: store.h5

In a current or later Python session, you can retrieve stored objects:

# store.get('df') is an equivalent method
In [359]: store['df']

Out[359]:
   A     B     C
2000-01-01  0.887163  0.859588 -0.636524
2000-01-02  0.015696 -2.242685  1.150036
2000-01-03  0.991946  0.953324 -2.021255
2000-01-04 -0.334077  0.002118  0.405453
2000-01-05  0.289092  1.321158 -1.546906
2000-01-06 -0.202646 -0.655969  0.193421
2000-01-07  0.553439  1.318152 -0.469305
2000-01-08  0.675554 -1.817027 -0.183109

# dotted (attribute) access provides get as well
In [360]: store.df

Out[360]:
   A     B     C
2000-01-01  0.887163  0.859588 -0.636524
2000-01-02  0.015696 -2.242685  1.150036
2000-01-03  0.991946  0.953324 -2.021255
2000-01-04 -0.334077  0.002118  0.405453
2000-01-05  0.289092  1.321158 -1.546906
2000-01-06 -0.202646 -0.655969  0.193421
2000-01-07  0.553439  1.318152 -0.469305
2000-01-08  0.675554 -1.817027 -0.183109

Deletion of the object specified by the key:

# store.remove('wp') is an equivalent method
In [361]: del store['wp']

In [362]: store

Out[362]: <class 'pandas.io.pytables.HDFStore'>
File path: store.h5

Closing a Store and using a context manager:

In [363]: store.close()

In [364]: store

Out[364]: <class 'pandas.io.pytables.HDFStore'>
File path: store.h5

(continues on next page)
In [365]: store.is_open
Out[365]: False

# Working with, and automatically closing the store using a context manager
In [366]: with pd.HDFStore('store.h5') as store:
    store.keys()

24.8.1 Read/Write API

HDFStore supports an top-level API using read_hdf for reading and to_hdf for writing, similar to how read_csv and to_csv work.

In [367]: df_tl = pd.DataFrame(dict(A=list(range(5)), B=list(range(5))))
In [368]: df_tl.to_hdf('store_tl.h5','table', append=True)
In [369]: pd.read_hdf('store_tl.h5', 'table', where=['index>2'])
Out[369]:
   A  B
0 3  3
1 4  4

HDFStore will by default not drop rows that are all missing. This behavior can be changed by setting dropna=True.

In [370]: df_with_missing = pd.DataFrame({'col1': [0, np.nan, 2],
       'col2': [1, np.nan, np.nan]})
In [371]: df_with_missing.to_hdf('file.h5', 'df_with_missing',
       format='table', mode='w')
In [372]: pd.read_hdf('file.h5', 'df_with_missing')
Out[372]:
   col1  col2
0  0.0  1.0
1  NaN  NaN
2  2.0  NaN

In [373]: df_with_missing.to_hdf('file.h5', 'df_with_missing',
       format='table', mode='w', dropna=True)
In [374]: pd.read_hdf('file.h5', 'df_with_missing')
Out[374]:
   col1  col2
0  0.0  1.0
1  NaN  NaN
2  2.0  NaN

(continues on next page)
This is also true for the major axis of a Panel:

```python
In [376]: matrix = [[np.nan, np.nan, np.nan], [1, np.nan, np.nan], [np.nan, 5, 6], [np.nan, 3, np.nan]]

In [377]: panel_with_major_axis_all_missing=pd.Panel(matrix,
          items=['Item1', 'Item2', 'Item3'],
          major_axis=[1, 2],
          minor_axis=['A', 'B', 'C'])

In [378]: panel_with_major_axis_all_missing
Out[378]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 2 (major_axis) x 3 (minor_axis)
Items axis: Item1 to Item3
Major_axis axis: 1 to 2
Minor_axis axis: A to C

In [379]: panel_with_major_axis_all_missing.to_hdf('file.h5', 'panel',
          dropna=True,
          format='table',
          mode='w')

In [380]: reloaded = pd.read_hdf('file.h5', 'panel')

In [381]: reloaded
Out[381]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 1 (major_axis) x 3 (minor_axis)
Items axis: Item1 to Item3
Major_axis axis: 2 to 2
Minor_axis axis: A to C
```

24.8.2 Fixed Format

The examples above show storing using `put`, which write the HDF5 to PyTables in a fixed array format, called the fixed format. These types of stores are not appendable once written (though you can simply remove them and rewrite). Nor are they queryable; they must be retrieved in their entirety. They also do not support dataframes with non-unique column names. The fixed format stores offer very fast writing and slightly faster reading than table stores. This format is specified by default when using `put` or `to_hdf` or by `format='fixed'` or `format='f'`.

**Warning:** A fixed format will raise a `TypeError` if you try to retrieve using a `where`:

```python
pd.DataFrame(randn(10, 2)).to_hdf('test_fixed.h5', 'df')
pd.read_hdf('test_fixed.h5', 'df', where='index>5')
```

**TypeError:** cannot pass a where specification when reading a fixed format. This store must be selected in its entirety.
24.8.3 Table Format

HDFStore supports another PyTables format on disk, the table format. Conceptually a table is shaped very much like a DataFrame, with rows and columns. A table may be appended to in the same or other sessions. In addition, delete and query type operations are supported. This format is specified by format='table' or format='t' to append or put or to_hdf.

This format can be set as an option as well pd.set_option('io.hdf.default_format','table') to enable put/append/to_hdf to by default store in the table format.

In [382]: store = pd.HDFStore('store.h5')

In [383]: df1 = df[0:4]

In [384]: df2 = df[4:]

# append data (creates a table automatically)
In [385]: store.append('df', df1)

In [386]: store.append('df', df2)

In [387]: store

Out[387]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5

# select the entire object
In [388]: store.select('df')

A   B     C
2000-01-01 0.887163 0.859588 -0.636524
2000-01-02 0.015696 -2.242685 1.150036
2000-01-03 0.991946 0.953324 -2.021255
2000-01-04 -0.334077 0.002118 0.405453
2000-01-05 0.289092 1.321158 -1.546906
2000-01-06 -0.202646 -0.655969 0.193421
2000-01-07 0.553439 1.318152 -0.469305
2000-01-08 0.675554 -1.817027 -0.183109

# the type of stored data
In [389]: store.root.df._v_attrs.pandas_type

˓→'frame_table'

Note: You can also create a table by passing format='table' or format='t' to a put operation.

24.8.4 Hierarchical Keys

Keys to a store can be specified as a string. These can be in a hierarchical path-name like format (e.g. foo/bar/bah), which will generate a hierarchy of sub-stores (or Groups in PyTables parlance). Keys can be specified with
out the leading ‘/’ and are always absolute (e.g. ‘foo’ refers to ‘/foo’). Removal operations can remove everything in the sub-store and below, so be careful.

```
In [390]: store.put('foo/bar/bah', df)
In [391]: store.append('food/orange', df)
In [392]: store.append('food/apple', df)
In [393]: store
Out[393]: <class 'pandas.io.pytables.HDFStore'>
File path: store.h5
# a list of keys are returned
In [394]: store.keys()
Out[394]: ['/df', '/food/apple', '/food/orange', '/foo/bar/bah']
# remove all nodes under this level
In [395]: store.remove('food')
In [396]: store
Out[396]: <class 'pandas.io.pytables.HDFStore'>
File path: store.h5
```

**Warning:** Hierarchical keys cannot be retrieved as dotted (attribute) access as described above for items stored under the root node.

```
In [8]: store.foo.bar.bah
AttributeError: 'HDFStore' object has no attribute 'foo'
# you can directly access the actual PyTables node but using the root node
In [9]: store.root.foo.bar.bah
Out[9]:
/foo/bar/bah (Group) ''
  children := ['block0_items' (Array), 'block0_values' (Array), 'axis0' (Array), 'axis1' (Array)]
```

Instead, use explicit string based keys:

```
In [397]: store['foo/bar/bah']
Out[397]:
     A       B       C
2000-01-01  0.887163  0.859588 -0.636524
2000-01-02  0.015696 -2.242685  1.150036
2000-01-03  0.991946  0.953324 -2.021255
2000-01-04 -0.334077  0.002118  0.405453
2000-01-05  0.289092  1.321158 -1.546906
2000-01-06 -0.202646 -0.655969  0.193421
2000-01-07  0.553439  1.318152 -0.183109
2000-01-08  0.675554 -1.817027 -0.183109
```

1198 Chapter 24. IO Tools (Text, CSV, HDF5, …)
24.8.5 Storing Types

24.8.5.1 Storing Mixed Types in a Table

Storing mixed-dtype data is supported. Strings are stored as a fixed-width using the maximum size of the appended column. Subsequent attempts at appending longer strings will raise a `ValueError`.

Passing `min_itemsize={'values': size}` as a parameter to append will set a larger minimum for the string columns. Storing `floats, strings, ints, bools, datetime64` are currently supported. For string columns, passing `nan_rep = 'nan'` to append will change the default nan representation on disk (which converts to/from `np.nan`), this default to `nan`.

```python
In [398]: df_mixed = pd.DataFrame({'A': randn(8),
                               'B': randn(8),
                               'C': np.array(randn(8), dtype='float32'),
                               'string': 'string',
                               'int': 1,
                               'bool': True,
                               'datetime64': pd.Timestamp('20010102')},
                               index=list(range(8)))

In [399]: df_mixed.loc[df_mixed.index[3:5], ['A', 'B', 'string', 'datetime64']] = np.nan

In [400]: store.append('df_mixed', df_mixed, min_itemsize = {'values': 50})

In [401]: df_mixed1 = store.select('df_mixed')

In [402]: df_mixed1
Out[402]:
     A        B        C      string  int  bool      datetime64
0  0.704721  -1.152659  -0.430096        string    1   True 2001-01-02
1  0.246796   0.609329   0.308267        string    1   True 2001-01-02
2 -0.785435    0.502610    0.841324        string    1   True 2001-01-02
3  0.280445  -0.456176   0.694395        string    1   True 2001-01-02
4   NaN        NaN   0.270836          NaN    1   True     NaT
5 -0.926254    1.321106   0.079842        string    1   True 2001-01-02
6  0.207843  -0.152631  -0.399965        string    1   True 2001-01-02
7  0.226963   0.164530  -1.027851        string    1   True 2001-01-02

In [403]: df_mixed1.get_dtype_counts()
Out[403]:
      float64  2
      float32  1
           object  1
            int64  1
             bool  1
   datetime64[ns]  1
dtype: int64

# we have provided a minimum string column size
In [404]: store.root.df_mixed.table
```

(continues on next page)
24.8.5.2 Storing Multi-Index DataFrames

Storing multi-index DataFrames as tables is very similar to storing/selecting from homogeneous index DataFrames.

```
In [405]: index = pd.MultiIndex(levels=[[['foo', 'bar', 'baz', 'qux'],
                                  ['one', 'two', 'three']],
                                 labels=[[0, 0, 0, 1, 1, 2, 2, 3, 3, 3],
                                  [0, 1, 2, 0, 1, 1, 2, 0, 1, 2]],
                                 names=['foo', 'bar'])

In [406]: df_mi = pd.DataFrame(np.random.randn(10, 3), index=index,
                                 columns=['A', 'B', 'C'])

In [407]: df_mi
Out[407]:
   A    B    C
foo  bar
  foo one   -0.584718  0.816594 -0.081947
  two    -0.344766  0.528288 -1.068989
  three   -0.511881  0.291205  0.566534
  bar one   0.503592  0.285296  0.484288
  two     1.363482 -0.781105  0.468018
  baz two  1.224574 -1.281108  0.875476
  three   -1.710715  0.4050765  0.749164
  qux one  -0.203933 -0.182175  0.680656
  two    -1.818499  0.047072  0.394844
  three   -0.248432 -0.617707 -0.682884

In [408]: store.append('df_mi', df_mi)

In [409]: store.select('df_mi')
Out[409]:
   A    B    C
foo  bar
  foo one   -0.584718  0.816594 -0.081947
  two    -0.344766  0.528288 -1.068989
  three   -0.511881  0.291205  0.566534
  bar one   0.503592  0.285296  0.484288
```

(continues on next page)
two 1.363482 -0.781105 -0.468018
baz two 1.224574 -1.281108 0.875476
three -1.710715 -0.450765 0.749164
qux one -0.203933 -0.182175 0.680656
two -1.818499 0.047072 0.394844
three -0.248432 -0.617707 -0.682884

# the levels are automatically included as data columns
In [410]: store.select('df_mi', 'foo=bar')

    foo  bar
bar one 0.503592 0.285296 0.484288
two   1.363482 -0.781105 -0.468018

24.8.6 Querying

24.8.6.1 Querying a Table

select and delete operations have an optional criterion that can be specified to select/delete only a subset of the data. This allows one to have a very large on-disk table and retrieve only a portion of the data.

A query is specified using the Term class under the hood, as a boolean expression.

- index and columns are supported indexers of a DataFrame.
- major_axis, minor_axis, and items are supported indexers of the Panel.
- if data_columns are specified, these can be used as additional indexers.

Valid comparison operators are:

- =, ==, !=, >, >=, <, <=

Valid boolean expressions are combined with:

- |: or
- &: and
- (and): for grouping

These rules are similar to how boolean expressions are used in pandas for indexing.

Note:

- = will be automatically expanded to the comparison operator ==
- ~ is the not operator, but can only be used in very limited circumstances
- If a list/tuple of expressions is passed they will be combined via &

The following are valid expressions:

- "index >= date"
- "columns = ['A', 'D']"
- "columns in ['A', 'D']"
• 'columns = A'
• 'columns == A'
• 'index > df.index[3] & string = "bar"
• '(index > df.index[3] & index <= df.index[6]) | string = "bar"
• 'ts >= Timestamp('2012-02-01')'
• 'major_axis>=20130101'

The indexers are on the left-hand side of the sub-expression:
columns, major_axis, ts

The right-hand side of the sub-expression (after a comparison operator) can be:
• functions that will be evaluated, e.g. Timestamp('2012-02-01')
• strings, e.g. "bar"
• date-like, e.g. 20130101, or "20130101"
• lists, e.g. "['A', 'B']"
• variables that are defined in the local names space, e.g. date

Note: Passing a string to a query by interpolating it into the query expression is not recommended. Simply assign the string of interest to a variable and use that variable in an expression. For example, do this

```python
string = "HolyMoly"
store.select('df', 'index == string')
```

instead of this

```python
string = "HolyMoly"
store.select('df', 'index == %s' % string)
```

The latter will not work and will raise a SyntaxError. Note that there’s a single quote followed by a double quote in the string variable.

If you must interpolate, use the '%r' format specifier

```python
store.select('df', 'index == %r' % string)
```

which will quote string.

Here are some examples:

```python
In [411]: dfq = pd.DataFrame(randn(10, 4), columns=list('ABCD'),
    index=pd.date_range('20130101', periods=10))
    .....:
In [412]: store.append('dfq', dfq, format='table', data_columns=True)
```

Use boolean expressions, with in-line function evaluation.
In [413]: store.select('dfq', "index>pd.Timestamp('20130104') & columns=['A', 'B']")

Out[413]:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>2013-01-05</td>
<td>1.210384 0.797435</td>
</tr>
<tr>
<td>2013-01-06</td>
<td>-0.850346 1.176812</td>
</tr>
<tr>
<td>2013-01-07</td>
<td>0.984188 -0.121728</td>
</tr>
<tr>
<td>2013-01-08</td>
<td>0.796595 -0.474021</td>
</tr>
<tr>
<td>2013-01-09</td>
<td>-0.804834 -2.123620</td>
</tr>
<tr>
<td>2013-01-10</td>
<td>0.334198 0.536784</td>
</tr>
</tbody>
</table>

Use and inline column reference

In [414]: store.select('dfq', where="A>0 or C>0")

Out[414]:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>2013-01-01</td>
<td>0.436258 -1.703013 0.393711 -0.479324</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-01-02</td>
<td>-0.299016 0.694103 0.678630 0.239556</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-01-03</td>
<td>0.151227 0.816127 1.893534 0.639633</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-01-04</td>
<td>-0.962029 -2.085266 1.930247 -1.735349</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-01-05</td>
<td>1.210384 0.797435 -0.379811 0.702562</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-01-07</td>
<td>0.984188 -0.121728 2.365769 0.496143</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-01-08</td>
<td>0.796595 -0.474021 -0.056696 1.357797</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013-01-10</td>
<td>0.334198 0.536784 -0.743830 -0.320204</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Works with a Panel as well.

In [415]: store.append('wp', wp)

In [416]: store

Out[416]:
<class 'pandas.io.pytables.HDFStore'>
File path: store.h5

In [417]: store.select('wp', "major_axis>pd.Timestamp('20000102') & minor_axis=['A', 'B']")

Out[417]:
<class 'pandas.core.panel.Panel'>
Dimensions: 2 (items) x 3 (major_axis) x 2 (minor_axis)
Items axis: Item1 to Item2
Major_axis axis: 2000-01-03 00:00:00 to 2000-01-05 00:00:00
Minor_axis axis: A to B

The columns keyword can be supplied to select a list of columns to be returned, this is equivalent to passing a 'columns=list_of_columns_to_filter':

In [418]: store.select('df', "columns=['A', 'B']")

Out[418]:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>2000-01-01</td>
<td>0.887163 0.859588</td>
</tr>
<tr>
<td>2000-01-02</td>
<td>0.015696 -2.242685</td>
</tr>
<tr>
<td>2000-01-03</td>
<td>0.991946 0.953324</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>-0.334077 0.002118</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>0.289092 1.321158</td>
</tr>
<tr>
<td>2000-01-06</td>
<td>-0.202646 -0.655969</td>
</tr>
<tr>
<td>2000-01-07</td>
<td>0.553439 1.318152</td>
</tr>
<tr>
<td>2000-01-08</td>
<td>0.675554 -1.817027</td>
</tr>
</tbody>
</table>

start and stop parameters can be specified to limit the total search space. These are in terms of the total number
of rows in a table.

```
# this is effectively what the storage of a Panel looks like
In [419]: wp.to_frame()
Out[419]:
          Item1     Item2
major minor          
2000-01-01 A  1.058969  0.215269
    B   -0.397840  0.841009
    C    0.337438 -1.445810
    D   1.047579 -1.401973
2000-01-02 A  1.045938 -0.100918
    B   0.863717 -0.548242
    C  -0.122092 -0.144620
...      ...      ...
2000-01-04 B  0.036142  0.307969
    C  -2.074978 -0.208499
    D   0.247792  1.033801
2000-01-05 A -0.897157 -2.400454
    B  -0.136795  2.030604
    C   0.018289 -1.142631
    D   0.755414  0.211883
[20 rows x 2 columns]
```

# limiting the search
```
In [420]: store.select('wp', "major_axis>20000102 & minor_axis=['A', 'B']",
      start=0, stop=10)
```

Note: select will raise a ValueError if the query expression has an unknown variable reference. Usually this means that you are trying to select on a column that is not a data_column.

select will raise a SyntaxError if the query expression is not valid.

### 24.8.6.2 Using timedelta64[ns]

You can store and query using the `timedelta64[ns]` type. Terms can be specified in the format: `<float>(<unit>)`, where float may be signed (and fractional), and unit can be `D,s,ms,us,ns` for the timedelta. Here’s an example:

```
In [421]: from datetime import timedelta
In [422]: dftd = pd.DataFrame(dict(A = pd.Timestamp('20130101'), B = [ pd.Timestamp('20130101') + timedelta(days=i, seconds=10) for i in range(10) ]))
In [423]: dftd['C'] = dftd['A'] - dftd['B']
```
In [424]: dftd
Out[424]:
          A          B          C
0  2013-01-01  2013-01-01  00:00:10 -1 days +23:59:50
1  2013-01-01  2013-01-02  00:00:10 -2 days +23:59:50
2  2013-01-01  2013-01-03  00:00:10 -3 days +23:59:50
3  2013-01-01  2013-01-04  00:00:10 -4 days +23:59:50
4  2013-01-01  2013-01-05  00:00:10 -5 days +23:59:50
5  2013-01-01  2013-01-06  00:00:10 -6 days +23:59:50
6  2013-01-01  2013-01-07  00:00:10 -7 days +23:59:50
7  2013-01-01  2013-01-08  00:00:10 -8 days +23:59:50
8  2013-01-01  2013-01-09  00:00:10 -9 days +23:59:50
9  2013-01-01  2013-01-10  00:00:10 -10 days +23:59:50

In [425]: store.append('dftd', dftd, data_columns=True)

In [426]: store.select('dftd', "C<'-3.5D'")
Out[426]:
          A          B          C
4  2013-01-01  2013-01-05  00:00:10 -5 days +23:59:50
5  2013-01-01  2013-01-06  00:00:10 -6 days +23:59:50
6  2013-01-01  2013-01-07  00:00:10 -7 days +23:59:50
7  2013-01-01  2013-01-08  00:00:10 -8 days +23:59:50
8  2013-01-01  2013-01-09  00:00:10 -9 days +23:59:50
9  2013-01-01  2013-01-10  00:00:10 -10 days +23:59:50

24.8.6.3 Indexing

You can create/modify an index for a table with `create_table_index` after data is already in the table (after and append/put operation). Creating a table index is **highly** encouraged. This will speed your queries a great deal when you use a `select` with the indexed dimension as the `where`.

**Note:** Indexes are automagically created on the indexables and any data columns you specify. This behavior can be turned off by passing `index=False` to `append`.

# we have automagically already created an index (in the first section)
In [427]: i = store.root.df.table.cols.index.index

In [428]: i.optlevel, i.kind
Out[428]: (6, 'medium')

# change an index by passing new parameters
In [429]: store.create_table_index('df', optlevel=9, kind='full')

In [430]: i = store.root.df.table.cols.index.index

In [431]: i.optlevel, i.kind
Out[431]: (9, 'full')

Oftentimes when appending large amounts of data to a store, it is useful to turn off index creation for each append, then recreate at the end.
In [432]: df_1 = pd.DataFrame(randn(10, 2), columns=list('AB'))
In [433]: df_2 = pd.DataFrame(randn(10, 2), columns=list('AB'))
In [434]: st = pd.HDFStore('appends.h5', mode='w')
In [435]: st.append('df', df_1, data_columns=['B'], index=False)
In [436]: st.append('df', df_2, data_columns=['B'], index=False)
In [437]: st.get_storer('df').table
Out[437]:
/df/table (Table(20,)) ''
   description := {
      "index": Int64Col(shape=(), dflt=0, pos=0),
      "values_block_0": Float64Col(shape=(1,), dflt=0.0, pos=1),
      "B": Float64Col(shape=(), dflt=0.0, pos=2)}
   byteorder := 'little'
   chunkshape := (2730,)

Then create the index when finished appending.

In [438]: st.create_table_index('df', columns=['B'], optlevel=9, kind='full')
In [439]: st.get_storer('df').table
Out[439]:
/df/table (Table(20,)) ''
   description := {
      "index": Int64Col(shape=(), dflt=0, pos=0),
      "values_block_0": Float64Col(shape=(1,), dflt=0.0, pos=1),
      "B": Float64Col(shape=(), dflt=0.0, pos=2)}
   byteorder := 'little'
   chunkshape := (2730,)
   autoindex := True
   colindexes := {
      "B": Index(9, full, shuffle, zlib(1)).is_csi=True}
In [440]: st.close()

See [here](#) for how to create a completely-sorted-index (CSI) on an existing store.

### 24.8.6.4 Query via Data Columns

You can designate (and index) certain columns that you want to be able to perform queries (other than the indexable columns, which you can always query). For instance say you want to perform this common operation, on-disk, and return just the frame that matches this query. You can specify data_columns = True to force all columns to be data_columns.

In [441]: df_dc = df.copy()
In [442]: df_dc['string'] = 'foo'
In [443]: df_dc.loc[df_dc.index[4:6], 'string'] = np.nan
In [444]: df_dc.loc[df_dc.index[7:9], 'string'] = 'bar'

(continues on next page)
In [445]: df_dc['string2'] = 'cool'

In [446]: df_dc.loc[df_dc.index[1:3], ['B', 'C']] = 1.0

In [447]: df_dc

<table>
<thead>
<tr>
<th>Date</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>string</th>
<th>string2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-01</td>
<td>0.887</td>
<td>0.859</td>
<td>-0.636</td>
<td>foo</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-02</td>
<td>0.015</td>
<td>1.000</td>
<td>1.000</td>
<td>foo</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-03</td>
<td>0.991</td>
<td>1.000</td>
<td>1.000</td>
<td>foo</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>-0.334</td>
<td>0.002</td>
<td>0.405</td>
<td>foo</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>0.289</td>
<td>1.321</td>
<td>-1.546</td>
<td>NaN</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-06</td>
<td>-0.202</td>
<td>-0.656</td>
<td>0.193</td>
<td>NaN</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-07</td>
<td>0.553</td>
<td>1.318</td>
<td>1.000</td>
<td>foo</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-08</td>
<td>0.675</td>
<td>-1.817</td>
<td>-0.183</td>
<td>bar</td>
<td>cool</td>
</tr>
</tbody>
</table>

# on-disk operations
In [448]: store.append('df_dc', df_dc, data_columns=['B', 'C', 'string', 'string2'])

In [449]: store.select('df_dc', where='B > 0')

<table>
<thead>
<tr>
<th>Date</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>string</th>
<th>string2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-01</td>
<td>0.887</td>
<td>0.859</td>
<td>-0.636</td>
<td>foo</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-02</td>
<td>0.015</td>
<td>1.000</td>
<td>1.000</td>
<td>foo</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-03</td>
<td>0.991</td>
<td>1.000</td>
<td>1.000</td>
<td>foo</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>-0.334</td>
<td>0.002</td>
<td>0.405</td>
<td>foo</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>0.289</td>
<td>1.321</td>
<td>-1.546</td>
<td>NaN</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-07</td>
<td>0.553</td>
<td>1.318</td>
<td>1.000</td>
<td>foo</td>
<td>cool</td>
</tr>
</tbody>
</table>

# getting creative
In [450]: store.select('df_dc', 'B > 0 & C > 0 & string == foo')

<table>
<thead>
<tr>
<th>Date</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>string</th>
<th>string2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-02</td>
<td>0.015</td>
<td>1.000</td>
<td>1.000</td>
<td>foo</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-03</td>
<td>0.991</td>
<td>1.000</td>
<td>1.000</td>
<td>foo</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>-0.334</td>
<td>0.002</td>
<td>0.405</td>
<td>foo</td>
<td>cool</td>
</tr>
</tbody>
</table>

# this is in-memory version of this type of selection
In [451]: df_dc[(df_dc.B > 0) & (df_dc.C > 0) & (df_dc.string == 'foo')]

<table>
<thead>
<tr>
<th>Date</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>string</th>
<th>string2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-02</td>
<td>0.015</td>
<td>1.000</td>
<td>1.000</td>
<td>foo</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-03</td>
<td>0.991</td>
<td>1.000</td>
<td>1.000</td>
<td>foo</td>
<td>cool</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>-0.334</td>
<td>0.002</td>
<td>0.405</td>
<td>foo</td>
<td>cool</td>
</tr>
</tbody>
</table>

# we have automagically created this index and the B/C/string/string2
# columns are stored separately as ``PyTables`` columns
In [452]: store.root.df_dc.table

```
description := {
  "index": Int64Col(shape=(), dflt=0, pos=0),
  "values_block_0": Float64Col(shape=(1,), dflt=0.0, pos=1),
  "B": Float64Col(shape=(), dflt=0.0, pos=2),
  "C": Float64Col(shape=(), dflt=0.0, pos=3),
  "string": CategoricalCol(shape=(), dflt='foo', pos=4),
  "string2": CategoricalCol(shape=(), dflt='cool', pos=5)
}
```
There is some performance degradation by making lots of columns into data columns, so it is up to the user to designate these. In addition, you cannot change data columns (nor indexables) after the first append/put operation (Of course you can simply read in the data and create a new table!).

24.8.6.5 Iterator

You can pass iterator=True or chunksize=number_in_a_chunk to select and select_as_multiple to return an iterator on the results. The default is 50,000 rows returned in a chunk.

```python
In [453]: for df in store.select('df', chunksize=3):
    ....:     print(df)
```

```
A   B   C
2000-01-01 0.887163 0.859588 -0.636524
2000-01-02 0.015696 -2.242685 1.150036
2000-01-03 0.991946 0.953324 -2.021255
    A   B   C
2000-01-04 -0.334077 0.002118 0.405453
2000-01-05 0.289092 1.321158 -1.546906
2000-01-06 -0.202646 -0.655969 0.193421
    A   B   C
2000-01-07 0.553439 1.318152 -0.469305
2000-01-08 0.675554 -1.817027 -0.183109
```

Note: You can also use the iterator with read_hdf which will open, then automatically close the store when finished iterating.

```python
for df in pd.read_hdf('store.h5','df', chunksize=3):
    print(df)
```

Note, that the chunksize keyword applies to the source rows. So if you are doing a query, then the chunksize will subdivide the total rows in the table and the query applied, returning an iterator on potentially unequal sized chunks.

Here is a recipe for generating a query and using it to create equal sized return chunks.

```python
In [454]: dfeq = pd.DataFrame({'number': np.arange(1, 11)})

In [455]: dfeq
```

```
Out[455]:
   number
0      1
1      2
2      3
3      4
4      5
5      6
6      7
7      8
8      9
9     10
```
24.8.6.6 Advanced Queries

Select a Single Column

To retrieve a single indexable or data column, use the method `select_column`. This will, for example, enable you to get the index very quickly. These return a `Series` of the result, indexed by the row number. These do not currently accept the `where` selector.

```
in [461]: store.select_column('df_dc', 'index')
out[461]:
0 2000-01-01
1 2000-01-02
2 2000-01-03
3 2000-01-04
4 2000-01-05
5 2000-01-06
6 2000-01-07
7 2000-01-08
Name: index, dtype: datetime64[ns]
in [462]: store.select_column('df_dc', 'string')
```
\[\text{Out}[462]\]:

\[
\begin{array}{l}
0 \text{ foo} \\
1 \text{ foo} \\
2 \text{ foo} \\
3 \text{ foo} \\
4 \text{ NaN} \\
5 \text{ NaN} \\
6 \text{ foo} \\
7 \text{ bar}
\end{array}
\]

Name: string, dtype: object

**Selecting coordinates**

Sometimes you want to get the coordinates (a.k.a the index locations) of your query. This returns an `Int64Index` of the resulting locations. These coordinates can also be passed to subsequent `where` operations.

```python
In [463]: df_coord = pd.DataFrame(np.random.randn(1000, 2),
                            index=pd.date_range('20000101', periods=1000))

In [464]: store.append('df_coord', df_coord)

In [465]: c = store.select_as_coordinates('df_coord', 'index > 20020101')

In [466]: c

Out[466]:
Int64Index([732, 733, 734, 735, 736, 737, 738, 739, 740, 741, ...
            990, 991, 992, 993, 994, 995, 996, 997, 998, 999],
           dtype='int64', length=268)
```

```python
In [467]: store.select('df_coord', where=c)

\[\text{Out}[467]\]:

\[
\begin{array}{l}
0 \quad 1 \\
2002-01-02 \quad -0.178266 \quad -0.064638 \\
2002-01-03 \quad 1.204956 \quad -3.880898 \\
2002-01-04 \quad 0.974470 \quad 0.415160 \\
2002-01-05 \quad 1.751967 \quad 0.485011 \\
2002-01-06 \quad -0.170894 \quad 0.748870 \\
2002-01-07 \quad 0.629793 \quad 0.811053 \\
2002-01-08 \quad 2.133776 \quad 0.238459 \\
\end{array}
\]

[268 rows x 2 columns]
```
Selecting using a where mask

Sometime your query can involve creating a list of rows to select. Usually this mask would be a resulting index from an indexing operation. This example selects the months of a datetimeindex which are 5.

```
In [468]: df_mask = pd.DataFrame(np.random.randn(1000, 2),
                   index=pd.date_range('20000101', periods=1000))

In [469]: store.append('df_mask', df_mask)

In [470]: c = store.select_column('df_mask', 'index')

In [471]: where = c[pd.DatetimeIndex(c).month == 5].index

In [472]: store.select('df_mask', where=where)
```

```
Out[472]:
     0      1
2000-05-01 -1.006245 -0.616759
2000-05-02  0.218940  0.717838
2000-05-03  0.013333  1.348060
2000-05-04  0.662176 -1.050645
2000-05-05 -1.034870 -0.243242
2000-05-06 -0.753366 -1.454329
2000-05-07 -1.022920 -0.476989
...     ...     ...
2002-05-25 -0.509090 -0.389376
2002-05-26  0.150674  1.164337
2002-05-27 -0.332944  0.115181
2002-05-28 -1.048127 -0.605733
2002-05-29  1.418754 -0.442835
2002-05-30 -0.433200  0.835001
2002-05-31 -1.041278  1.401811
[93 rows x 2 columns]
```

Storer Object

If you want to inspect the stored object, retrieve via `get_storer`. You could use this programmatically to say get the number of rows in an object.

```
In [473]: store.get_storer('df_dc').nrows
Out[473]: 8
```

24.8.6.7 Multiple Table Queries

The methods `append_to_multiple` and `select_as_multiple` can perform appending/selecting from multiple tables at once. The idea is to have one table (call it the selector table) that you index most/all of the columns, and perform your queries. The other table(s) are data tables with an index matching the selector table’s index. You can then perform a very fast query on the selector table, yet get lots of data back. This method is similar to having a very wide table, but enables more efficient queries.

The `append_to_multiple` method splits a given single DataFrame into multiple tables according to `d`, a dictionary that maps the table names to a list of ‘columns’ you want in that table. If `None` is used in place of a list, that table will have the remaining unspecified columns of the given DataFrame. The argument `selector` defines which
table is the selector table (which you can make queries from). The argument dropna will drop rows from the input DataFrame to ensure tables are synchronized. This means that if a row for one of the tables being written to is entirely np.NaN, that row will be dropped from all tables.

If dropna is False, THE USER IS RESPONSIBLE FOR SYNCHRONIZING THE TABLES. Remember that entirely np.nan rows are not written to the HDFStore, so if you choose to call dropna=False, some tables may have more rows than others, and therefore select_as_multiple may not work or it may return unexpected results.

In [474]: df_mt = pd.DataFrame(randn(8, 6), index=pd.date_range('1/1/2000', periods=8), columns=['A', 'B', 'C', 'D', 'E', 'F'])

In [475]: df_mt['foo'] = 'bar'

In [476]: df_mt.loc[df_mt.index[1], ('A', 'B')] = np.nan

# you can also create the tables individually
In [477]: store.append_to_multiple({'df1_mt': ['A', 'B'], 'df2_mt': None },
                                   df_mt, selector='df1_mt')

In [478]: store
Out[478]: <class 'pandas.io.pytables.HDFStore'>
File path: store.h5

# individual tables were created
In [479]: store.select('df1_mt')

Out[479]:
     A    B
2000-01-01  0.714697  0.318215
2000-01-02   NaN       NaN
2000-01-03  0.489131  0.253340
2000-01-04 -0.382952 -0.397373
2000-01-05  0.538116  0.226388
2000-01-06 -2.073479 -0.115926
2000-01-07  0.489131  0.253340
2000-01-08 -0.695400  0.402493

In [480]: store.select('df2_mt')

Out[480]:
     C    D    E    F    foo
2000-01-01  0.607460  0.790907  0.852225  0.096696    bar
2000-01-02  0.811031 -0.356817  1.047085  0.664705    bar
2000-01-03 -0.764381 -0.287229 -0.089351 -1.035115    bar
2000-01-04 -1.948100 -0.116556  0.800597 -0.796154    bar
2000-01-05 -0.717627  0.156995 -0.344718 -0.171208    bar
2000-01-06  1.541729  0.205256  1.998065  0.953591    bar
2000-01-07  1.391070  0.303013  1.093347 -0.101000    bar
2000-01-08 -1.507639  0.089575  0.658822 -1.037627    bar

# as a multiple
In [481]: store.select_as_multiple(['df1_mt', 'df2_mt'], where=['A>0', 'B>0'],
                                     selector='df1_mt')

(continues on next page)
24.8.7 Delete from a Table

You can delete from a table selectively by specifying a `where`. In deleting rows, it is important to understand that `PyTables` deletes rows by erasing the rows, then moving the following data. Thus deleting can potentially be a very expensive operation depending on the orientation of your data. This is especially true in higher dimensional objects (`Panel` and `Panel4D`). To get optimal performance, it’s worthwhile to have the dimension you are deleting be the first of the indexables.

Data is ordered (on the disk) in terms of the indexables. Here’s a simple use case. You store panel-type data, with dates in the `major_axis` and ids in the `minor_axis`. The data is then interleaved like this:

- `date_1 - id_1 - id_2 - .. - id_n`
- `date_2 - id_1 - .. - id_n`

It should be clear that a delete operation on the `major_axis` will be fairly quick, as one chunk is removed, then the following data moved. On the other hand a delete operation on the `minor_axis` will be very expensive. In this case it would almost certainly be faster to rewrite the table using a `where` that selects all but the missing data.

```python
# returns the number of rows deleted
In [482]: store.remove('wp', 'major_axis > 20000102')
Out[482]: 12

In [483]: store.select('wp')
```

Warning: Please note that HDF5 **DOES NOT RECLAIM SPACE** in the h5 files automatically. Thus, repeatedly deleting (or removing nodes) and adding again, **WILL TEND TO INCREASE THE FILE SIZE**.

To repack and clean the file, use `ptrepack`.

24.8.8 Notes & Caveats

24.8.8.1 Compression

`PyTables` allows the stored data to be compressed. This applies to all kinds of stores, not just tables. Two parameters are used to control compression: `complevel` and `complib`.

- `complevel` specifies if and how hard data is to be compressed. `complevel=0` and `complevel=None` disables compression and `0<complevel<10` enables compression.
**complib specifies which compression library to use.** If nothing is specified the default library `zlib` is used. A compression library usually optimizes for either good compression rates or speed and the results will depend on the type of data. Which type of compression to choose depends on your specific needs and data. The list of supported compression libraries:

- **zlib**: The default compression library. A classic in terms of compression, achieves good compression rates but is somewhat slow.
- **lzo**: Fast compression and decompression.
- **bzip2**: Good compression rates.
- **blosc**: Fast compression and decompression.

New in version 0.20.2: Support for alternative blosc compressors:

- **blosc:blosclz**: This is the default compressor for blosc
- **blosc:lz4**: A compact, very popular and fast compressor.
- **blosc:lz4hc**: A tweaked version of LZ4, produces better compression ratios at the expense of speed.
- **blosc:snappy**: A popular compressor used in many places.
- **blosc:zlib**: A classic; somewhat slower than the previous ones, but achieving better compression ratios.
- **blosc:zstd**: An extremely well balanced codec; it provides the best compression ratios among the others above, and at reasonably fast speed.

If `complib` is defined as something other than the listed libraries a `ValueError` exception is issued.

Note: If the library specified with the `complib` option is missing on your platform, compression defaults to `zlib` without further ado.

Enable compression for all objects within the file:

```python
store_compressed = pd.HDFStore('store_compressed.h5', complevel=9,
                               complevel='blosc:blosclz')
```

Or on-the-fly compression (this only applies to tables) in stores where compression is not enabled:

```python
store.append('df', df, complevel='zlib', complevel=5)
```

### 24.8.8.2 ptrepack

PyTables offers better write performance when tables are compressed after they are written, as opposed to turning on compression at the very beginning. You can use the supplied PyTables utility `ptrepack`. In addition, `ptrepack` can change compression levels after the fact.

```bash
ptrepack --chunkshape=auto --propindexes --complevel=9 --complib=blosc in.h5 out.h5
```

Furthermore `ptrepack in.h5 out.h5` will `repack` the file to allow you to reuse previously deleted space. Alternatively, one can simply remove the file and write again, or use the `copy` method.
24.8.3 Caveats

**Warning:** HDFStore is not-threadsafe for writing. The underlying PyTables only supports concurrent reads (via threading or processes). If you need reading and writing at the same time, you need to serialize these operations in a single thread in a single process. You will corrupt your data otherwise. See the (GH2397) for more information.

- If you use locks to manage write access between multiple processes, you may want to use `fsync()` before releasing write locks. For convenience you can use `store.flush(fsync=True)` to do this for you.
- Once a table is created its items (Panel) / columns (DataFrame) are fixed; only exactly the same columns can be appended
- Be aware that timezones (e.g., `pytz.timezone('US/Eastern')`) are not necessarily equal across timezone versions. So if data is localized to a specific timezone in the HDFStore using one version of a timezone library and that data is updated with another version, the data will be converted to UTC since these timezones are not considered equal. Either use the same version of timezone library or use `tz_convert` with the updated timezone definition.

**Warning:** PyTables will show a NaturalNameWarning if a column name cannot be used as an attribute selector. Natural identifiers contain only letters, numbers, and underscores, and may not begin with a number. Other identifiers cannot be used in a where clause and are generally a bad idea.

24.8.9 DataTypes

HDFStore will map an object dtype to the PyTables underlying dtype. This means the following types are known to work:

<table>
<thead>
<tr>
<th>Type</th>
<th>Represents missing values</th>
</tr>
</thead>
<tbody>
<tr>
<td>floating: float64, float32, float16</td>
<td>np.nan</td>
</tr>
<tr>
<td>integer: int64, int32, int8, uint64, uint32, uint8</td>
<td></td>
</tr>
<tr>
<td>boolean</td>
<td>NaT</td>
</tr>
<tr>
<td>datetime64[ns]</td>
<td>NaT</td>
</tr>
<tr>
<td>timedelta64[ns]</td>
<td>NaT</td>
</tr>
<tr>
<td>categorical: see the section below</td>
<td></td>
</tr>
<tr>
<td>object: strings</td>
<td>np.nan</td>
</tr>
</tbody>
</table>

*unicode columns are not supported, and WILL FAIL.*

24.8.9.1 Categorical Data

You can write data that contains category dtypes to a HDFStore. Queries work the same as if it was an object array. However, the category dtyped data is stored in a more efficient manner.

```
In [484]: dfcat = pd.DataFrame({'A': pd.Series(list('aabbcdba')).astype('category'),
                           'B': np.random.randn(8) })
```

```
In [485]: dfcat
```

(continues on next page)
### 24.8.9.2 String Columns

**min_itemsize**

The underlying implementation of `HDFStore` uses a fixed column width (itemsize) for string columns. A string column itemsize is calculated as the maximum of the length of data (for that column) that is passed to the `HDFStore`, in the first append. Subsequent appends, may introduce a string for a column larger than the column can hold, an Exception will be raised (otherwise you could have a silent truncation of these columns, leading to loss of information). In the future we may relax this and allow a user-specified truncation to occur.

Pass `min_itemsize` on the first table creation to a-priori specify the minimum length of a particular string column. `min_itemsize` can be an integer, or a dict mapping a column name to an integer. You can pass `values` as a key to allow all `indexables` or `data_columns` to have this `min_itemsize`.

Passing a `min_itemsize` dict will cause all passed columns to be created as `data_columns` automatically.

---

**Note:** If you are not passing any `data_columns`, then the `min_itemsize` will be the maximum of the length of...
any string passed

```
In [492]: dfs = pd.DataFrame(dict(A='foo', B='bar'), index=list(range(5)))

In [493]: dfs
Out[493]:
   A   B
0  foo bar
1  foo bar
2  foo bar
3  foo bar
4  foo bar

# A and B have a size of 30
In [494]: store.append('dfs', dfs, min_itemsize=30)

In [495]: store.get_storer('dfs').table
Out[495]:
/dfs/table (Table(5,)) ''
    description := {
       "index": Int64Col(shape=(), dflt=0, pos=0),
       "values_block_0": StringCol(itemsize=30, shape=(2,), dflt=b'', pos=1)}
    byteorder := 'little'
    chunkshape := (963,)
    autoindex := True
    colindexes := {
       "index": Index(6, medium, shuffle, zlib(1)).is_csi=False}

# A is created as a data_column with a size of 30
# B is size is calculated
In [496]: store.append('dfs2', dfs, min_itemsize={'A': 30})

In [497]: store.get_storer('dfs2').table
Out[497]:
/dfs2/table (Table(5,)) ''
    description := {
       "index": Int64Col(shape=(), dflt=0, pos=0),
       "values_block_0": StringCol(itemsize=3, shape=(1,), dflt=b'', pos=1),
       "A": StringCol(itemsize=30, shape=(), dflt=b'', pos=2)}
    byteorder := 'little'
    chunkshape := (1598,)
    autoindex := True
    colindexes := {
       "index": Index(6, medium, shuffle, zlib(1)).is_csi=False,
       "A": Index(6, medium, shuffle, zlib(1)).is_csi=False}
```

**nan_rep**

String columns will serialize a np.nan (a missing value) with the nan_rep string representation. This defaults to the string value nan. You could inadvertently turn an actual nan value into a missing value.

```
In [498]: dfss = pd.DataFrame(dict(A=['foo', 'bar', 'nan']))

In [499]: dfss
Out[499]:
   A
0  foo
(continues on next page)
```
1 bar
2 nan

In [500]: store.append('dfss', dfss)

In [501]: store.select('dfss')
Out[501]:
A
0 foo
1 bar
2 NaN

# here you need to specify a different nan rep
In [502]: store.append('dfss2', dfss, nan_rep='\_nan\_')

In [503]: store.select('dfss2')
Out[503]:
A
0 foo
1 bar
2 nan

### 24.8.10 External Compatibility

HDFStore writes table format objects in specific formats suitable for producing loss-less round trips to pandas objects. For external compatibility, HDFStore can read native PyTables format tables.

It is possible to write an HDFStore object that can easily be imported into R using the rhdf5 library (Package website). Create a table format store like this:

In [504]: np.random.seed(1)

In [505]: df_for_r = pd.DataFrame({'first': np.random.rand(100),
                             'second': np.random.rand(100),
                             'class': np.random.randint(0, 2, (100, ))},
                             index=range(100))

In [506]: df_for_r.head()
Out[506]:
   first   second  class
0  0.417022  0.326645   0
1  0.720324  0.527058   0
2  0.000114  0.885942   1
3  0.302333  0.357270   1
4  0.146756  0.908535   1

In [507]: store_export = pd.HDFStore('export.h5')

In [508]: store_export.append('df_for_r', df_for_r, data_columns=df_dc.columns)

In [509]: store_export
Out[509]:
<class 'pandas.io.pytables.HDFStore'>
File path: export.h5
In R this file can be read into a `data.frame` object using the `rhdf5` library. The following example function reads the corresponding column names and data values from the values and assembles them into a `data.frame`:

```r
# Load values and column names for all datasets from corresponding nodes and
# insert them into one data.frame object.
library(rhdf5)
loadhdf5data <- function(h5File) {

  listing <- h5ls(h5File)
  # Find all data nodes, values are stored in *_values and corresponding column
  # titles in *_items
  data_nodes <- grep("_values", listing$name)
  name_nodes <- grep("_items", listing$name)
  data_paths = paste(listing$group[data_nodes], listing$name[data_nodes], sep = "/")
  name_paths = paste(listing$group[name_nodes], listing$name[name_nodes], sep = "/")

  columns = list()
  for (idx in seq(data_paths)) {
    # NOTE: matrices returned by h5read have to be transposed to obtain
    # required Fortran order!
    data <- data.frame(t(h5read(h5File, data_paths[idx])))
    names <- t(h5read(h5File, name_paths[idx]))
    entry <- data.frame(data)
    colnames(entry) <- names
    columns <- append(columns, entry)
  }

  data <- data.frame(columns)

  return(data)
}
```

Now you can import the `DataFrame` into R:

```r
> data = loadhdf5data("transfer.hdf5")
> head(data)
    first  second class
1 0.4170220047 0.3266449  0
2 0.7203244934 0.5270581  0
3 0.0001143748 0.8859421  1
4 0.3023325726 0.3572698  1
5 0.1467558908 0.9085352  1
6 0.0923385948 0.6233601  1
```

**Note:** The R function lists the entire HDF5 file’s contents and assembles the `data.frame` object from all matching nodes, so use this only as a starting point if you have stored multiple `DataFrame` objects to a single HDF5 file.

### 24.8.11 Performance

- `tables` format come with a writing performance penalty as compared to `fixed` stores. The benefit is the ability to append/delete and query (potentially very large amounts of data). Write times are generally longer as compared with regular stores. Query times can be quite fast, especially on an indexed axis.
- You can pass `chunksize=<int>` to `append`, specifying the write chunksize (default is 50000). This will
significantly lower your memory usage on writing.

- You can pass `expectedrows=<int>` to the first `append`, to set the TOTAL number of expected rows that PyTables will expected. This will optimize read/write performance.
- Duplicate rows can be written to tables, but are filtered out in selection (with the last items being selected; thus a table is unique on major, minor pairs)
- A `PerformanceWarning` will be raised if you are attempting to store types that will be pickled by PyTables (rather than stored as endemic types). See Here for more information and some solutions.

### 24.9 Feather

New in version 0.20.0.

Feather provides binary columnar serialization for data frames. It is designed to make reading and writing data frames efficient, and to make sharing data across data analysis languages easy.

Feather is designed to faithfully serialize and de-serialize DataFrames, supporting all of the pandas dtypes, including extension dtypes such as categorical and datetime with tz.

Several caveats.

- This is a newer library, and the format, though stable, is not guaranteed to be backward compatible to the earlier versions.
- The format will NOT write an Index, or MultiIndex for the DataFrame and will raise an error if a non-default one is provided. You can `.reset_index()` to store the index or `.reset_index(drop=True)` to ignore it.
- Duplicate column names and non-string columns names are not supported
- Non supported types include `Period` and actual Python object types. These will raise a helpful error message on an attempt at serialization.

See the Full Documentation.

```python
In [510]: df = pd.DataFrame({'a': list('abc'),
       ...
'b': list(range(1, 4)),
       ...
'c': np.arange(3, 6).astype('u1'),
       ...
'd': np.arange(4.0, 7.0, dtype='float64'),
       ...
'e': [True, False, True],
       ...
'f': pd.Categorical(list('abc')),
       ...
'g': pd.date_range('20130101', periods=3),
       ...
'h': pd.date_range('20130101', periods=3, tz='US/Eastern'),
       ...
'i': pd.date_range('20130101', periods=3, freq='ns'))
```

```python
In [511]: df
Out[511]:
   a  b  c  d  e  f  g  h
0  a  1  3  4.0 True  a 2013-01-01 2013-01-01 00:00:00-05:00
1  b  2  4  5.0 False b 2013-01-02 2013-01-02 00:00:00-05:00
2  c  3  5  6.0 True  c 2013-01-03 2013-01-03 00:00:00-05:00
... ...
```

(continues on next page)
Write to a feather file.

```python
In [513]: df.to_feather('example.feather')
```

Read from a feather file.

```python
In [514]: result = pd.read_feather('example.feather')

In [515]: result
```

```
   a  b  c  d  ...  f  g  h
   --- --- --- ---  ...  --- --- ---
 0  a  1  3  4.0  ...  a  2013-01-01 2013-01-01 00:00:00-05:00
 1  b  2  4  5.0  ...  b  2013-01-02 2013-01-02 00:00:00-05:00
 2  c  3  5  6.0  ...  c  2013-01-03 2013-01-03 00:00:00-05:00

[3 rows x 9 columns]
```

# we preserve dtypes

```python
In [516]: result.dtypes
```

```
   a       object
   b        int64
   c       uint8
   d      float64
   e         bool
   f     category
g    datetime64[ns]
h  datetime64[ns, US/Eastern]
i    datetime64[ns]
```

```
24.10 Parquet

New in version 0.21.0.

Apache Parquet provides a partitioned binary columnar serialization for data frames. It is designed to make reading and writing data frames efficient, and to make sharing data across data analysis languages easy. Parquet can use a variety of compression techniques to shrink the file size as much as possible while still maintaining good read performance.

Parquet is designed to faithfully serialize and de-serialize DataFrame, supporting all of the pandas dtypes, including extension dtypes such as datetime with tz.

Several caveats.

- Duplicate column names and non-string columns names are not supported.
- Index level names, if specified, must be strings.
- Categorical dtypes can be serialized to parquet, but will de-serialize as object dtype.
- Non supported types include Period and actual Python object types. These will raise a helpful error message on an attempt at serialization.

You can specify an engine to direct the serialization. This can be one of pyarrow, or fastparquet, or auto. If the engine is NOT specified, then the pd.options.io.parquet.engine option is checked; if this is also auto, then pyarrow is tried, and falling back to fastparquet.

See the documentation for pyarrow and fastparquet.

Note: These engines are very similar and should read/write nearly identical parquet format files. Currently pyarrow does not support timedelta data, fastparquet>=0.1.4 supports timezone aware datetimes. These libraries differ by having different underlying dependencies (fastparquet by using numba, while pyarrow uses a c-library).

```
In [517]: df = pd.DataFrame({'a': list('abc'),
       .....: 'b': list(range(1, 4)),
       .....: 'c': np.arange(3, 6).astype('u1'),
       .....: 'd': np.arange(4.0, 7.0, dtype='float64'),
       .....: 'e': [True, False, True],
       .....: 'f': pd.date_range('20130101', periods=3),
       .....: 'g': pd.date_range('20130101', periods=3, tz='US/Eastern
       →')})
       .....:

In [518]: df
Out[518]:
   a  b  c  d   e   f                   g
0  a  1  3  4.0  True 2013-01-01 2013-01-01 00:00:00-05:00
1  b  2  4  5.0  False 2013-01-02 2013-01-02 00:00:00-05:00
2  c  3  5  6.0  True 2013-01-03 2013-01-03 00:00:00-05:00

In [519]: df.dtypes
   a  object
   b  int64
   c  uint8
   d  float64
   e  bool
   f  datetime64[ns]
```

(continues on next page)
Write to a parquet file.

```python
In [520]: df.to_parquet('example_pa.parquet', engine='pyarrow')
In [521]: df.to_parquet('example_fp.parquet', engine='fastparquet')
```

Read from a parquet file.

```python
In [522]: result = pd.read_parquet('example_fp.parquet', engine='fastparquet')
In [523]: result = pd.read_parquet('example_pa.parquet', engine='pyarrow')
In [524]: result.dtypes
Out[524]:
    a    object
    b    int64
    c    uint8
    d   float64
    e    bool
    f  datetime64[ns]
    g  datetime64[ns, US/Eastern]
    dtype: object
```

Read only certain columns of a parquet file.

```python
In [525]: result = pd.read_parquet('example_fp.parquet',
                           engine='fastparquet', columns=['a', 'b'])
In [526]: result.dtypes
Out[526]:
    a    object
    b    int64
    dtype: object
```

## 24.11 SQL Queries

The `pandas.io.sql` module provides a collection of query wrappers to both facilitate data retrieval and to reduce dependency on DB-specific API. Database abstraction is provided by SQLAlchemy if installed. In addition you will need a driver library for your database. Examples of such drivers are `psycopg2` for PostgreSQL or `pymysql` for MySQL. For SQLite this is included in Python’s standard library by default. You can find an overview of supported drivers for each SQL dialect in the SQLAlchemy docs.

If SQLAlchemy is not installed, a fallback is only provided for sqlite (and for mysql for backwards compatibility, but this is deprecated and will be removed in a future version). This mode requires a Python database adapter which respect the Python DB-API.

See also some `cookbook examples` for some advanced strategies.

The key functions are:
24.11.1 pandas.read_sql_table

pandas.read_sql_table(table_name, con[, schema, ...])

Read SQL database table into a DataFrame.

Parameters:
- **table_name**: string
  - Name of SQL table in database.
- **con**: SQLAlchemy connectable (or database string URI)
  - SQLite DBAPI connection mode not supported.
- **schema**: string, default None
  - Name of SQL schema in database to query (if database flavor supports this). Uses default schema if None (default).
- **index_col**: string or list of strings, optional, default: None
  - Column(s) to set as index(MultiIndex).
- **coerce_float**: boolean, default True
  - Attempts to convert values of non-string, non-numeric objects (like decimal.Decimal) to floating point. Can result in loss of Precision.
- **parse_dates**: list or dict, default: None
  - List of column names to parse as dates.
  - Dict of {column_name: format string} where format string is strftime compatible in case of parsing string times or is one of (D, s, ns, ms, us) in case of parsing integer timestamps.
  - Dict of {column_name: arg dict}, where the arg dict corresponds to the keyword arguments of pandas.to_datetime() Especially useful with databases without native Datetime support, such as SQLite.
- **columns**: list, default: None
  - List of column names to select from SQL table
- **chunksize**: int, default None
  - If specified, returns an iterator where chunksize is the number of rows to include in each chunk.

Returns:
- **DataFrame**: DataFrame

See also:
**read_sql_query**  Read SQL query into a DataFrame.

**read_sql**

**Notes**

Any datetime values with time zone information will be converted to UTC.

### 24.11.2 pandas.read_sql_query

**pandas.read_sql_query**(sql, con, index_col=None, coerce_float=True, params=None, parse_dates=None, chunksize=None)

Read SQL query into a DataFrame.

Returns a DataFrame corresponding to the result set of the query string. Optionally provide an `index_col` parameter to use one of the columns as the index, otherwise default integer index will be used.

**Parameters**

- **sql**: string SQL query or SQLAlchemy Selectable (select or text object)
  SQL query to be executed.
- **con**: SQLAlchemy connectable(engine/connection), database string URI, or sqlite3 DBAPI2 connection Using SQLAlchemy makes it possible to use any DB supported by that library. If a DBAPI2 object, only sqlite3 is supported.
- **index_col**: string or list of strings, optional, default: None
  Column(s) to set as index(MultiIndex).
- **coerce_float**: boolean, default True
  Attempts to convert values of non-string, non-numeric objects (like decimal.Decimal) to floating point. Useful for SQL result sets.
- **params**: list, tuple or dict, optional, default: None
  List of parameters to pass to execute method. The syntax used to pass parameters is database driver dependent. Check your database driver documentation for which of the five syntax styles, described in PEP 249’s paramstyle, is supported. Eg. for psycopg2, uses %(name)s so use params={'name' : 'value'}
- **parse_dates**: list or dict, default: None
  - List of column names to parse as dates.
  - Dict of {column_name: format string} where format string is strftime compatible in case of parsing string times, or is one of (D, s, ns, ms, us) in case of parsing integer timestamps.
  - Dict of {column_name: arg dict}, where the arg dict corresponds to the keyword arguments of `pandas.to_datetime()` Especially useful with databases without native Datetime support, such as SQLite.
- **chunksize**: int, default None
  If specified, return an iterator where chunksize is the number of rows to include in each chunk.

**Returns**

DataFrame
See also:

- **read_sql_table** Read SQL database table into a DataFrame.
- **read_sql**

**Notes**

Any datetime values with time zone information parsed via the *parse_dates* parameter will be converted to UTC.

### 24.11.3 pandas.read_sql

```python
pandas.read_sql(sql, con, index_col=None, coerce_float=True, params=None, parse_dates=None, columns=None, chunksize=None)
```

Read SQL query or database table into a DataFrame.

This function is a convenience wrapper around `read_sql_table` and `read_sql_query` (for backward compatibility). It will delegate to the specific function depending on the provided input. A SQL query will be routed to `read_sql_query`, while a database table name will be routed to `read_sql_table`. Note that the delegated function might have more specific notes about their functionality not listed here.

**Parameters**

- `sql` : string or SQLAlchemy Selectable (select or text object)
  
  SQL query to be executed or a table name.

- `con` : SQLAlchemy connectable (engine/connection) or database string URI
  
  or DBAPI2 connection (fallback mode)

  Using SQLAlchemy makes it possible to use any DB supported by that library. If a DBAPI2 object, only sqlite3 is supported.

- `index_col` : string or list of strings, optional, default: None
  
  Column(s) to set as index(MultiIndex).

- `coerce_float` : boolean, default True
  
  Attempts to convert values of non-string, non-numeric objects (like decimal.Decimal) to floating point, useful for SQL result sets.

- `params` : list, tuple or dict, optional, default: None
  
  List of parameters to pass to execute method. The syntax used to pass parameters is database driver dependent. Check your database driver documentation for which of the five syntax styles, described in PEP 249’s paramstyle, is supported. Eg. for psycopg2, uses %(name)s so use params={'name' : 'value'}

- `parse_dates` : list or dict, optional, default: None
  
  - List of column names to parse as dates.
  
  - Dic of `{column_name: format string}` where format string is strftime compatible in case of parsing string times, or is one of (D, s, ns, ms, us) in case of parsing integer timestamps.

  - Dic of `{column_name: arg dict}`, where the arg dict corresponds to the keyword arguments of `pandas.to_datetime()` Especially useful with databases without native Datetime support, such as SQLite.

- `columns` : list, default: None
  
  - List of column names to parse as dates.
  
  - Dic of `{column_name: format string}` where format string is strftime compatible in case of parsing string times, or is one of (D, s, ns, ms, us) in case of parsing integer timestamps.
List of column names to select from SQL table (only used when reading a table).

chunksize : int, default None

If specified, return an iterator where chunksize is the number of rows to include in each chunk.

Returns
DataFrame

See also:

read_sql_table Read SQL database table into a DataFrame.
read_sql_query Read SQL query into a DataFrame.

24.11.4 pandas.DataFrame.to_sql

DataFrame.to_sql(name, con, schema=None, if_exists='fail', index=True, index_label=None, chunksize=None, dtype=None)

Write records stored in a DataFrame to a SQL database.

Databases supported by SQLAlchemy [R16] are supported. Tables can be newly created, appended to, or overwritten.

Parameters name : string
Name of SQL table.

con : sqlalchemy.engine.Engine or sqlite3.Connection
Using SQLAlchemy makes it possible to use any DB supported by that library. Legacy support is provided for sqlite3.Connection objects.

schema : string, optional
Specify the schema (if database flavor supports this). If None, use default schema.

if_exists : {'fail', 'replace', 'append'}, default 'fail'
How to behave if the table already exists.
- fail: Raise a ValueError.
- replace: Drop the table before inserting new values.
- append: Insert new values to the existing table.

index : boolean, default True
Write DataFrame index as a column. Uses index_label as the column name in the table.

index_label : string or sequence, default None
Column label for index column(s). If None is given (default) and index is True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.

chunksize : int, optional
Rows will be written in batches of this size at a time. By default, all rows will be written at once.

dtype : dict, optional
Specifying the datatype for columns. The keys should be the column names and the values should be the SQLAlchemy types or strings for the sqlite3 legacy mode.

**Raises** ValueError

When the table already exists and `if_exists` is ‘fail’ (the default).

**See also:**

`pandas.read_sql` read a DataFrame from a table

**References**

[R16], [R17]

**Examples**

Create an in-memory SQLite database.

```python
>>> from sqlalchemy import create_engine
>>> engine = create_engine('sqlite://', echo=False)
```

Create a table from scratch with 3 rows.

```python
>>> df = pd.DataFrame({'name' : ['User 1', 'User 2', 'User 3']})
>>> df
    name
0  User 1
1  User 2
2  User 3
```

```python
>>> df.to_sql('users', con=engine)
>>> engine.execute("SELECT * FROM users").fetchall()
[(0, 'User 1'), (1, 'User 2'), (2, 'User 3')]
```

```python
>>> df1 = pd.DataFrame({'name' : ['User 4', 'User 5']})
>>> df1.to_sql('users', con=engine, if_exists='append')
>>> engine.execute("SELECT * FROM users").fetchall()
[(0, 'User 1'), (1, 'User 2'), (2, 'User 3'),
 (0, 'User 4'), (1, 'User 5')]
```

Overwrite the table with just `df1`.

```python
>>> df1.to_sql('users', con=engine, if_exists='replace',
...           index_label='id')
>>> engine.execute("SELECT * FROM users").fetchall()
[(0, 'User 4'), (1, 'User 5')]
```

Specify the dtype (especially useful for integers with missing values). Notice that while pandas is forced to store the data as floating point, the database supports nullable integers. When fetching the data with Python, we get back integer scalars.

```python
>>> df = pd.DataFrame("A": [1, None, 2])
>>> df
    A
0  1
1  None
2  2
```
>>> from sqlalchemy.types import Integer

>>> df.to_sql('integers', con=engine, index=False, 
... dtype={'A': Integer()})

>>> engine.execute("SELECT * FROM integers").fetchall()
[[1,], [None,], [2,]]

Note: The function read_sql() is a convenience wrapper around read_sql_table() and read_sql_query() (and for backward compatibility) and will delegate to specific function depending on the provided input (database table name or sql query). Table names do not need to be quoted if they have special characters.

In the following example, we use the SQLite SQL database engine. You can use a temporary SQLite database where data are stored in “memory”.

To connect with SQLAlchemy you use the create_engine() function to create an engine object from database URI. You only need to create the engine once per database you are connecting to. For more information on create_engine() and the URI formatting, see the examples below and the SQLAlchemy documentation.

In [527]: from sqlalchemy import create_engine
# Create your engine.
In [528]: engine = create_engine('sqlite:///:memory:)

If you want to manage your own connections you can pass one of those instead:

with engine.connect() as conn, conn.begin():
    data = pd.read_sql_table('data', conn)

24.11.5 Writing DataFrames

Assuming the following data is in a DataFrame data, we can insert it into the database using to_sql().

<table>
<thead>
<tr>
<th>id</th>
<th>Date</th>
<th>Col_1</th>
<th>Col_2</th>
<th>Col_3</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>2012-10-18</td>
<td>X</td>
<td>25.7</td>
<td>True</td>
</tr>
<tr>
<td>42</td>
<td>2012-10-19</td>
<td>Y</td>
<td>-12.4</td>
<td>False</td>
</tr>
<tr>
<td>63</td>
<td>2012-10-20</td>
<td>Z</td>
<td>5.73</td>
<td>True</td>
</tr>
</tbody>
</table>

In [529]: data.to_sql('data', engine)

With some databases, writing large DataFrames can result in errors due to packet size limitations being exceeded. This can be avoided by setting the chunksize parameter when calling to_sql. For example, the following writes data to the database in batches of 1000 rows at a time:

In [530]: data.to_sql('data_chunked', engine, chunksize=1000)
to_sql() will try to map your data to an appropriate SQL data type based on the dtype of the data. When you have columns of dtype object, pandas will try to infer the data type.

You can always override the default type by specifying the desired SQL type of any of the columns by using the dtype argument. This argument needs a dictionary mapping column names to SQLAlchemy types (or strings for the sqlite3 fallback mode). For example, specifying to use the sqlalchemy String type instead of the default Text type for string columns:

```python
In [531]: from sqlalchemy.types import String
In [532]: data.to_sql('data_dtype', engine, dtype={'Col_1': String})
```

**Note:** Due to the limited support for timedelta’s in the different database flavors, columns with type timedelta64 will be written as integer values as nanoseconds to the database and a warning will be raised.

**Note:** Columns of category dtype will be converted to the dense representation as you would get with np.asarray(categorical) (e.g. for string categories this gives an array of strings). Because of this, reading the database table back in does not generate a categorical.

### 24.11.6 Reading Tables

`read_sql_table()` will read a database table given the table name and optionally a subset of columns to read.

**Note:** In order to use `read_sql_table()`, you must have the SQLAlchemy optional dependency installed.

```python
In [533]: pd.read_sql_table('data', engine)
Out[533]:
   index  id     Date    Col_1 Col_2 Col_3
0      0  26 2010-10-18     X  27.50   True
1      1  42 2010-10-19     Y -12.50  False
2      2  63 2010-10-20     Z   5.73   True
```

You can also specify the name of the column as the DataFrame index, and specify a subset of columns to be read.

```python
In [534]: pd.read_sql_table('data', engine, index_col='id')
Out[534]:
      index     Date    Col_1 Col_2 Col_3
id
26  0 2010-10-18     X  27.50   True
42  1 2010-10-19     Y -12.50  False
63  2 2010-10-20     Z   5.73   True
```

```python
In [535]: pd.read_sql_table('data', engine, columns=['Col_1', 'Col_2'])
```

And you can explicitly force columns to be parsed as dates:
In [536]: pd.read_sql_table('data', engine, parse_dates=['Date'])

Out[536]:

<table>
<thead>
<tr>
<th></th>
<th>id</th>
<th>Date</th>
<th>Col_1</th>
<th>Col_2</th>
<th>Col_3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>2010-10-18</td>
<td>X 27.50</td>
<td>True</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>2010-10-19</td>
<td>Y -12.50</td>
<td>False</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2010-10-20</td>
<td>Z 5.73</td>
<td>True</td>
<td></td>
</tr>
</tbody>
</table>

If needed you can explicitly specify a format string, or a dict of arguments to pass to pandas.to_datetime():

```python
pd.read_sql_table('data', engine, parse_dates={'Date': '%Y-%m-%d'})
pd.read_sql_table('data', engine, parse_dates={'Date': {'format': '%Y-%m-%d %H:%M:%S'}})
```

You can check if a table exists using has_table()

### 24.11.7 Schema support

Reading from and writing to different schema's is supported through the schema keyword in the read_sql_table() and to_sql() functions. Note however that this depends on the database flavor (sqlite does not have schema's). For example:

```python
df.to_sql('table', engine, schema='other_schema')
pd.read_sql_table('table', engine, schema='other_schema')
```

### 24.11.8 Querying

You can query using raw SQL in the read_sql_query() function. In this case you must use the SQL variant appropriate for your database. When using SQLAlchemy, you can also pass SQLAlchemy Expression language constructs, which are database-agnostic.

In [537]: pd.read_sql_query('SELECT * FROM data', engine)

Out[537]:

<table>
<thead>
<tr>
<th></th>
<th>id</th>
<th>Date</th>
<th>Col_1</th>
<th>Col_2</th>
<th>Col_3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>2010-10-18</td>
<td>X 27.50</td>
<td>True</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>2010-10-19</td>
<td>Y -12.50</td>
<td>False</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2010-10-20</td>
<td>Z 5.73</td>
<td>True</td>
<td></td>
</tr>
</tbody>
</table>

Of course, you can specify a more “complex” query.

In [538]: pd.read_sql_query("SELECT id, Col_1, Col_2 FROM data WHERE id = 42;", engine)

Out[538]:

<table>
<thead>
<tr>
<th>id</th>
<th>Col_1</th>
<th>Col_2</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>Y</td>
<td>-12.5</td>
</tr>
</tbody>
</table>

The read_sql_query() function supports a chunksize argument. Specifying this will return an iterator through chunks of the query result:

In [539]: df = pd.DataFrame(np.random.randn(20, 3), columns=list('abc'))

In [540]: df.to_sql('data_chunks', engine, index=False)

24.11. SQL Queries
You can also run a plain query without creating a DataFrame with `execute()`. This is useful for queries that don’t return values, such as `INSERT`. This is functionally equivalent to calling `execute` on the SQLAlchemy engine or db connection object. Again, you must use the SQL syntax variant appropriate for your database.

```python
from pandas.io import sql
sql.execute('SELECT * FROM table_name', engine)
sql.execute('INSERT INTO table_name VALUES(?, ?, ?)', engine, params=[('id', 1, 12.2, True)])
```

### 24.11.9 Engine connection examples

To connect with SQLAlchemy you use the `create_engine()` function to create an engine object from database URI. You only need to create the engine once per database you are connecting to.

```python
from sqlalchemy import create_engine
engine = create_engine('postgresql://scott:tiger@localhost:5432/mydatabase')

engine = create_engine('mysql+mysqldb://scott:tiger@localhost/foo')

engine = create_engine('oracle://scott:tiger@127.0.0.1:1521/sidname')

engine = create_engine('mssql+pyodbc://mydsn')

# sqlite:///<nohostname>/<path>
# where <path> is relative:
```

(continues on next page)
engine = create_engine('sqlite:///foo.db')

# or absolute, starting with a slash:
engine = create_engine('sqlite:///absolute/path/to/foo.db')

For more information see the examples the SQLAlchemy documentation

### 24.11.10 Advanced SQLAlchemy queries

You can use SQLAlchemy constructs to describe your query.

Use `sqlalchemy.text()` to specify query parameters in a backend-neutral way

```
In [542]: import sqlalchemy as sa

In [543]: pd.read_sql(sa.text('SELECT * FROM data where Col_1=:col1'),
.....: engine, params={'col1': 'X'})
.....:
Out[543]:

index id Date Col_1 Col_2 Col_3
0 0 26 2010-10-18 00:00:00.000000 X 27.5 1
```

If you have an SQLAlchemy description of your database you can express where conditions using SQLAlchemy expressions

```
In [544]: metadata = sa.MetaData()

In [545]: data_table = sa.Table('data', metadata,
.....:     sa.Column('index', sa.Integer),
.....:     sa.Column('Date', sa.DateTime),
.....:     sa.Column('Col_1', sa.String),
.....:     sa.Column('Col_2', sa.Float),
.....:     sa.Column('Col_3', sa.Boolean),
.....: )

In [546]: pd.read_sql(sa.select([data_table]).where(data_table.c.Col_3 == True),
.....:     engine)
Out[546]:

index Date Col_1 Col_2 Col_3
0 0 2010-10-18 X 27.50 True
1 2 2010-10-20 Z 5.73 True
```

You can combine SQLAlchemy expressions with parameters passed to `read_sql()` using `sqlalchemy.bindparam()`

```
In [547]: import datetime as dt

In [548]: expr = sa.select([data_table]).where(data_table.c.Date > sa.bindparam('date'))

In [549]: pd.read_sql(expr, engine, params={'date': dt.datetime(2010, 10, 18)})
Out[549]:

index Date Col_1 Col_2 Col_3
0 1 2010-10-19 Y -12.50 False
1 2 2010-10-20 Z 5.73 True
```
24.11.11 Sqlite fallback

The use of sqlite is supported without using SQLAlchemy. This mode requires a Python database adapter which respect the Python DB-API.

You can create connections like so:

```python
import sqlite3
con = sqlite3.connect(':memory:)
```

And then issue the following queries:

```python
data.to_sql('data', cnx)
pd.read_sql_query("SELECT * FROM data", con)
```

24.12 Google BigQuery

**Warning:** Starting in 0.20.0, pandas has split off Google BigQuery support into the separate package pandas-gbq. You can pip install pandas-gbq to get it.

The pandas-gbq package provides functionality to read/write from Google BigQuery.

pandas integrates with this external package. if pandas-gbq is installed, you can use the pandas methods `pd.read_gbq` and `DataFrame.to_gbq`, which will call the respective functions from pandas-gbq.

Full documentation can be found here.

24.13 Stata Format

24.13.1 Writing to Stata format

The method `to_stata()` will write a DataFrame into a .dta file. The format version of this file is always 115 (Stata 12).

```python
In [550]: df = pd.DataFrame(randn(10, 2), columns=list('AB'))
In [551]: df.to_stata('stata.dta')
```

Stata data files have limited data type support; only strings with 244 or fewer characters, int8, int16, int32, float32 and float64 can be stored in .dta files. Additionally, Stata reserves certain values to represent missing data. Exporting a non-missing value that is outside of the permitted range in Stata for a particular data type will retype the variable to the next larger size. For example, int8 values are restricted to lie between -127 and 100 in Stata, and so variables with values above 100 will trigger a conversion to int16. nan values in floating points data types are stored as the basic missing data type ( . in Stata).

**Note:** It is not possible to export missing data values for integer data types.

The Stata writer gracefully handles other data types including int64, bool, uint8, uint16, uint32 by casting to the smallest supported type that can represent the data. For example, data with a type of uint8 will be cast to
int8 if all values are less than 100 (the upper bound for non-missing int8 data in *Stata*), or, if values are outside of this range, the variable is cast to int16.

**Warning:** Conversion from int64 to float64 may result in a loss of precision if int64 values are larger than \(2^{53}\).

**Warning:** StataWriter and to_stata() only support fixed width strings containing up to 244 characters, a limitation imposed by the version 115 dta file format. Attempting to write *Stata* dta files with strings longer than 244 characters raises a ValueError.

### 24.13.2 Reading from Stata format

The top-level function read_stata will read a dta file and return either a DataFrame or a StataReader that can be used to read the file incrementally.

```python
In [552]: pd.read_stata('stata.dta')
Out[552]:
       A         B
   0 1.810535  -1.305727
   1 -0.344987  -0.230840
   2 -2.793085   1.937529
   3  0.366332  -1.044589
   4  2.051173   0.585662
   5  0.429526  -0.606998
   6  0.106223  -1.525680
   7  0.795026  -0.374438
   8  0.134048   1.202055
   9  0.284748   0.262467
```

Specifying a chunksize yields a StataReader instance that can be used to read chunksize lines from the file at a time. The StataReader object can be used as an iterator.

```python
In [553]: reader = pd.read_stata('stata.dta', chunksize=3)
In [554]: for df in reader:
   ....:     print(df.shape)
   ....:         (3, 3)
   ....:         (3, 3)
   ....:         (1, 3)
```

For more fine-grained control, use iterator=True and specify chunksize with each call to read().

```python
In [555]: reader = pd.read_stata('stata.dta', iterator=True)
In [556]: chunk1 = reader.read(5)
In [557]: chunk2 = reader.read(5)
```

Currently the index is retrieved as a column. The parameter convert_categoricals indicates whether value labels should be read and used to create a
**Categorical** variable from them. Value labels can also be retrieved by the function `value_labels`, which requires `read()` to be called before use.

The parameter `convert_missing` indicates whether missing value representations in Stata should be preserved. If `False` (the default), missing values are represented as `np.nan`. If `True`, missing values are represented using `StataMissingValue` objects, and columns containing missing values will have `object` data type.

**Note:** `read_stata()` and `StataReader` support .dta formats 113-115 (Stata 10-12), 117 (Stata 13), and 118 (Stata 14).

**Note:** Setting `preserve_dtypes=False` will upcast to the standard pandas data types: `int64` for all integer types and `float64` for floating point data. By default, the Stata data types are preserved when importing.

**24.13.2.1 Categorical Data**

Categorical data can be exported to Stata data files as value labeled data. The exported data consists of the underlying category codes as integer data values and the categories as value labels. Stata does not have an explicit equivalent to a **Categorical** and information about whether the variable is ordered is lost when exporting.

**Warning:** Stata only supports string value labels, and so `str` is called on the categories when exporting data. Exporting **Categorical** variables with non-string categories produces a warning, and can result a loss of information if the `str` representations of the categories are not unique.

Labeled data can similarly be imported from Stata data files as **Categorical** variables using the keyword argument `convert_categoricals` (True by default). The keyword argument `order_categoricals` (True by default) determines whether imported **Categorical** variables are ordered.

**Note:** When importing categorical data, the values of the variables in the Stata data file are not preserved since **Categorical** variables always use integer data types between `-1` and `n-1` where `n` is the number of categories. If the original values in the Stata data file are required, these can be imported by setting `convert_categoricals=False`, which will import original data (but not the variable labels). The original values can be matched to the imported categorical data since there is a simple mapping between the original Stata data values and the category codes of imported **Categorical** variables: missing values are assigned code `-1`, and the smallest original value is assigned `0`, the second smallest is assigned `1` and so on until the largest original value is assigned the code `n-1`.

**Note:** Stata supports partially labeled series. These series have value labels for some but not all data values. Importing a partially labeled series will produce a **Categorical** with string categories for the values that are labeled and numeric categories for values with no label.

**24.14 SAS Formats**

The top-level function `read_sas()` can read (but not write) SAS `xport` (.XPT) and (since v0.18.0) `SAS7BDAT` (.sas7bdat) format files.
SAS files only contain two value types: ASCII text and floating point values (usually 8 bytes but sometimes truncated). For xport files, there is no automatic type conversion to integers, dates, or categoricals. For SAS7BDAT files, the format codes may allow date variables to be automatically converted to dates. By default the whole file is read and returned as a DataFrame.

Specify a chunksize or use iterator=True to obtain reader objects (XportReader or SAS7BDATReader) for incrementally reading the file. The reader objects also have attributes that contain additional information about the file and its variables.

Read a SAS7BDAT file:

```python
df = pd.read_sas('sas_data.sas7bdat')
```

Obtain an iterator and read an XPORT file 100,000 lines at a time:

```python
rdr = pd.read_sas('sas_xport.xpt', chunk=100000)
for chunk in rdr:
    do_something(chunk)
```

The specification for the xport file format is available from the SAS web site.

No official documentation is available for the SAS7BDAT format.

### 24.15 Other file formats

pandas itself only supports IO with a limited set of file formats that map cleanly to its tabular data model. For reading and writing other file formats into and from pandas, we recommend these packages from the broader community.

#### 24.15.1 netCDF

xarray provides data structures inspired by the pandas DataFrame for working with multi-dimensional datasets, with a focus on the netCDF file format and easy conversion to and from pandas.

### 24.16 Performance Considerations

This is an informal comparison of various IO methods, using pandas 0.20.3. Timings are machine dependent and small differences should be ignored.

```python
In [1]: sz = 1000000
In [3]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000000 entries, 0 to 999999
Data columns (total 2 columns):
A 1000000 non-null float64
B 1000000 non-null int64
dtypes: float64(1), int64(1)
memory usage: 15.3 MB
```

When writing, the top-three functions in terms of speed are test_pickle_write, test_feather_write and test_hdf_fixed_write_compress.
When reading, the top three are `test_feather_read`, `test_pickle_read` and `test_hdf_fixed_read`.

Space on disk (in bytes)
And here's the code:

```python
import os
import pandas as pd
import sqlite3
from numpy.random import randn
from pandas.io import sql

sz = 1000000

def test_sql_write(df):
    if os.path.exists('test.sql'):
        os.remove('test.sql')
    sql_db = sqlite3.connect('test.sql')
    df.to_sql(name='test_table', con=sql_db)
    sql_db.close()

def test_sql_read():
    sql_db = sqlite3.connect('test.sql')
    pd.read_sql_query("select * from test_table", sql_db)
    sql_db.close()

def test_hdf_fixed_write(df):
    df.to_hdf('test_fixed.hdf', 'test', mode='w')

def test_hdf_fixed_read():
    pd.read_hdf('test_fixed.hdf', 'test')

def test_hdf_fixed_write_compress(df):
    df.to_hdf('test_fixed_compress.hdf', 'test', mode='w', complib='blosc')

def test_hdf_fixed_read_compress():
    pd.read_hdf('test_fixed_compress.hdf', 'test')

def test_hdf_table_write(df):
    df.to_hdf('test_table.hdf', 'test', mode='w', format='table')

def test_hdf_table_read():
    pd.read_hdf('test_table.hdf', 'test')

def test_hdf_table_write_compress(df):
    df.to_hdf('test_table_compress.hdf', 'test', mode='w', complib='blosc', format='table')

def test_hdf_table_read_compress():
    pd.read_hdf('test_table_compress.hdf', 'test')
```

(continues on next page)
```python
def test_csv_write(df):
    df.to_csv('test.csv', mode='w')

def test_csv_read():
    pd.read_csv('test.csv', index_col=0)

def test_feather_write(df):
    df.to_feather('test.feather')

def test_feather_read():
    pd.read_feather('test.feather')

def test_pickle_write(df):
    df.to_pickle('test.pkl')

def test_pickle_read():
    pd.read_pickle('test.pkl')

def test_pickle_write_compress(df):
    df.to_pickle('test.pkl.compress', compression='xz')

def test_pickle_read_compress():
    pd.read_pickle('test.pkl.compress', compression='xz')
```

(continued from previous page)
In this part of the tutorial, we will investigate how to speed up certain functions operating on pandas DataFrames using three different techniques: Cython, Numba and pandas.eval(). We will see a speed improvement of \( \sim 200 \) when we use Cython and Numba on a test function operating row-wise on the DataFrame. Using pandas.eval() we will speed up a sum by an order of \( \sim 2 \).

25.1 Cython (Writing C extensions for pandas)

For many use cases writing pandas in pure Python and NumPy is sufficient. In some computationally heavy applications however, it can be possible to achieve sizeable speed-ups by offloading work to cython.

This tutorial assumes you have refactored as much as possible in Python, for example by trying to remove for-loops and making use of NumPy vectorization. It's always worth optimising in Python first.

This tutorial walks through a “typical” process of cythonizing a slow computation. We use an example from the Cython documentation but in the context of pandas. Our final cythonized solution is around 100 times faster than the pure Python solution.

25.1.1 Pure python

We have a DataFrame to which we want to apply a function row-wise.

```python
In [1]: df = pd.DataFrame({'a': np.random.randn(1000),
                      ...
                      'b': np.random.randn(1000),
                      ...
                      'N': np.random.randint(100, 1000, (1000)),
                      ...
                      'x': 'x'})
...
```

```python
In [2]: df
Out[2]:
   a          b        N   x
0  0.469112 -0.218470  585  x
1 -0.282863 -0.061645  841  x
2 -1.509059 -0.723780  251  x
3 -1.135632  0.551225  972  x
4  1.212112 -0.497767  181  x
..       ...    ...   ...
993 0.131892  0.290162  190  x
994 0.342097  0.215341  931  x
```

(continues on next page)
Here’s the function in pure Python:

```python
In [3]: def f(x):
    ...:     return x * (x - 1)
    ...

In [4]: def integrate_f(a, b, N):
    ...:     s = 0
    ...:     dx = (b - a) / N
    ...:     for i in range(N):
    ...:         s += f(a + i * dx)
    ...:     return s * dx
    ...
```

We achieve our result by using `apply` (row-wise):

```python
In [7]: %timeit df.apply(lambda x: integrate_f(x['a'], x['b'], x['N']), axis=1)
10 loops, best of 3: 174 ms per loop
```

But clearly this isn’t fast enough for us. Let’s take a look and see where the time is spent during this operation (limited to the most time consuming four calls) using the `prun` ipython magic function:

```python
In [5]: %prun -l 4 df.apply(lambda x: integrate_f(x['a'], x['b'], x['N']), axis=1)
```

By far the majority of time is spend inside either `integrate_f` or `f`, hence we’ll concentrate our efforts cythonizing these two functions.

**Note:** In Python 2 replacing the `range` with its generator counterpart (`xrange`) would mean the `range` line would vanish. In Python 3 `range` is already a generator.

### 25.1.2 Plain Cython

First we’re going to need to import the Cython magic function to ipython:
Now, let’s simply copy our functions over to Cython as is (the suffix is here to distinguish between function versions):

```python
In [7]: %%cython
   ...: def f_plain(x):
   ...:     return x * (x - 1)
   ...:
   ...: def integrate_f_plain(a, b, N):
   ...:     s = 0
   ...:     dx = (b - a) / N
   ...:     for i in range(N):
   ...:         s += f_plain(a + i * dx)
   ...:     return s * dx
   ...
```

**Note:** If you’re having trouble pasting the above into your ipython, you may need to be using bleeding edge ipython for paste to play well with cell magics.

```python
In [4]: %timeit df.apply(lambda x: integrate_f_plain(x['a'], x['b'], x['N']), axis=1)
10 loops, best of 3: 85.5 ms per loop
```

Already this has shaved a third off, not too bad for a simple copy and paste.

### 25.1.3 Adding type

We get another huge improvement simply by providing type information:

```python
In [8]: %%cython
   ...: cdef double f_typed(double x) except? -2:
   ...:     return x * (x - 1)
   ...:
   ...: cpdef double integrate_f_typed(double a, double b, int N):
   ...:     cdef int i
   ...:     cdef double s, dx
   ...:     s = 0
   ...:     dx = (b - a) / N
   ...:     for i in range(N):
   ...:         s += f_typed(a + i * dx)
   ...:     return s * dx
   ...
```

```python
In [4]: %timeit df.apply(lambda x: integrate_f_typed(x['a'], x['b'], x['N']), axis=1)
10 loops, best of 3: 20.3 ms per loop
```

Now, we’re talking! It’s now over ten times faster than the original python implementation, and we haven’t *really* modified the code. Let’s have another look at what’s eating up time:

```bash
In [9]: %prun -l 4 df.apply(lambda x: integrate_f_typed(x['a'], x['b'], x['N']), axis=1)
119288 function calls (114268 primitive calls) in 0.055 seconds

Ordered by: internal time
List reduced from 211 to 4 due to restriction <4>
```

(continues on next page)
25.1.4 Using ndarray

It’s calling series... a lot! It’s creating a Series from each row, and getting from both the index and the series (three times for each row). Function calls are expensive in Python, so maybe we could minimize these by cythonizing the apply part.

Note: We are now passing ndarrays into the Cython function, fortunately Cython plays very nicely with NumPy.

```python
In [10]: %%cython
   ....: cimport numpy as np
   ....: import numpy as np
   ....: cdef double f_typed(double x) except? -2:
   ....:     return x * (x - 1)
   ....: cdef double integrate_f_typed(double a, double b, int N):
   ....:     cdef int i
   ....:     cdef double s, dx
   ....:     s = 0
   ....:     dx = (b - a) / N
   ....:     for i in range(N):
   ....:         s += f_typed(a + i * dx)
   ....:     return s * dx
   ....: cpdef np.ndarray[double] apply_integrate_f(np.ndarray col_a, np.ndarray col_b, np.ndarray col_N):
   ....:     assert (col_a.dtype == np.float and col_b.dtype == np.float and col_N.dtype == np.int)
   ....:     cdef Py_ssize_t i, n = len(col_N)
   ....:     assert (len(col_a) == len(col_b) == n)
   ....:     cdef np.ndarray[double] res = np.empty(n)
   ....:     for i in range(len(col_a)):
   ....:         res[i] = integrate_f_typed(col_a[i], col_b[i], col_N[i])
   ....:     return res
   ....: 
```

The implementation is simple, it creates an array of zeros and loops over the rows, applying our integrate_f_typed, and putting this in the zeros array.

Warning: You can **not pass** a Series directly as a ndarray typed parameter to a Cython function. Instead pass the actual ndarray using the .values attribute of the Series. The reason is that the Cython definition is specific to an ndarray and not the passed Series.

So, do not do this:

```python
apply_integrate_f(df['a'], df['b'], df['N'])
```

But rather, use .values to get the underlying ndarray:

```python
apply_integrate_f(df['a'].values, df['b'].values, df['N'].values)
```
Note: Loops like this would be extremely slow in Python, but in Cython looping over NumPy arrays is fast.

```
In [4]: %timeit apply_integrate_f(df['a'].values, df['b'].values, df['N'].values)
1000 loops, best of 3: 1.25 ms per loop
```

We’ve gotten another big improvement. Let’s check again where the time is spent:

```
In [11]: %prun -l 4 apply_integrate_f(df['a'].values, df['b'].values, df['N'].values)
215 function calls in 0.001 seconds
Ordered by: internal time
List reduced from 55 to 4 due to restriction <4>
ncalls  tottime  percall  cumtime  percall filename:lineno(function)
1 0.001    0.001  0.001    0.001 {built-in method _cython_magic_
→039cb0af339d11610fbd07bd4033a1cf.apply_integrate_f}
1 0.000    0.000  0.001    0.001 {built-in method builtins.exec}
3 0.000    0.000  0.000    0.000 internals.py:4137(iget)
3 0.000    0.000  0.000    0.000 generic.py:2484(_get_item_cache)
```

As one might expect, the majority of the time is now spent in `apply_integrate_f`, so if we wanted to make anymore efficiencies we must continue to concentrate our efforts here.

### 25.1.5 More advanced techniques

There is still hope for improvement. Here’s an example of using some more advanced Cython techniques:

```
In [12]: @@cython
......: cimport cython
......: cimport numpy as np
......: import numpy as np
......: cdef double f_typed(double x) except? -2:
......:     return x * (x - 1)
......: cpdef double integrate_f_typed(double a, double b, int N):
......:     cdef int i
......:     cdef double s, dx
......:     s = 0
......:     dx = (b - a) / N
......:     for i in range(N):
......:         s += f_typed(a + i * dx)
......:     return s * dx
......: @cython.boundscheck(False)
......: @cython.wraparound(False)
......:     cdef int i, n = len(col_N)
......:     assert len(col_a) == len(col_b) == n
......:     cdef np.ndarray[double] res = np.empty(n)
......:     for i in range(n):
......:         res[i] = integrate_f_typed(col_a[i], col_b[i], col_N[i])
......:     return res
......:
```

25.1. Cython (Writing C extensions for pandas)
Even faster, with the caveat that a bug in our Cython code (an off-by-one error, for example) might cause a segfault because memory access isn’t checked. For more about boundscheck and wraparound, see the Cython docs on compiler directives.

25.2 Using Numba

A recent alternative to statically compiling Cython code, is to use a dynamic jit-compiler, Numba.

Numba gives you the power to speed up your applications with high performance functions written directly in Python. With a few annotations, array-oriented and math-heavy Python code can be just-in-time compiled to native machine instructions, similar in performance to C, C++ and Fortran, without having to switch languages or Python interpreters.

Numba works by generating optimized machine code using the LLVM compiler infrastructure at import time, runtime, or statically (using the included pycc tool). Numba supports compilation of Python to run on either CPU or GPU hardware, and is designed to integrate with the Python scientific software stack.

Note: You will need to install Numba. This is easy with conda, by using: conda install numba, see installing using miniconda.

Note: As of Numba version 0.20, pandas objects cannot be passed directly to Numba-compiled functions. Instead, one must pass the NumPy array underlying the pandas object to the Numba-compiled function as demonstrated below.

25.2.1 Jit

We demonstrate how to use Numba to just-in-time compile our code. We simply take the plain Python code from above and annotate with the @jit decorator.

```python
import numba

@numba.jit
def f_plain(x):
    return x * (x - 1)

@numba.jit
def integrate_f_numba(a, b, N):
    s = 0
    dx = (b - a) / N
    for i in range(N):
        s += f_plain(a + i * dx)
    return s * dx

@numba.jit
def apply_integrate_f_numba(col_a, col_b, col_N):
    n = len(col_N)
    result = np.empty(n, dtype='float64')
    assert len(col_a) == len(col_b) == n
    for i in range(n):
        # (continues on next page)
```

(continues on next page)
result[i] = integrate_f_numba(col_a[i], col_b[i], col_N[i])
return result

def compute_numba(df):
    result = apply_integrate_f_numba(df['a'].values, df['b'].values, df['N'].values)
    return pd.Series(result, index=df.index, name='result')

Note that we directly pass NumPy arrays to the Numba function. compute_numba is just a wrapper that provides a nicer interface by passing/returning pandas objects.

In [4]: %timeit compute_numba(df)
1000 loops, best of 3: 798 us per loop

In this example, using Numba was faster than Cython.

### 25.2.2 Vectorize

Numba can also be used to write vectorized functions that do not require the user to explicitly loop over the observations of a vector; a vectorized function will be applied to each row automatically. Consider the following toy example of doubling each observation:

```python
import numba
def double_every_value_nonumba(x):
    return x*2
@numba.vectorize
def double_every_value_withnumba(x):
    return x*2

# Custom function without numba
In [5]: %timeit df['col1_doubled'] = df.a.apply(double_every_value_nonumba)
1000 loops, best of 3: 797 us per loop

# Standard implementation (faster than a custom function)
In [6]: %timeit df['col1_doubled'] = df.a*2
1000 loops, best of 3: 233 us per loop

# Custom function with numba
In [7]: %timeit df['col1_doubled'] = double_every_value_withnumba(df.a.values)
1000 loops, best of 3: 145 us per loop
```

### 25.2.3 Caveats

**Note:** Numba will execute on any function, but can only accelerate certain classes of functions.

Numba is best at accelerating functions that apply numerical functions to NumPy arrays. When passed a function that only uses operations it knows how to accelerate, it will execute in nopython mode.

If Numba is passed a function that includes something it doesn’t know how to work with – a category that currently includes sets, lists, dictionaries, or string functions – it will revert to object mode. In object mode, Numba
will execute but your code will not speed up significantly. If you would prefer that Numba throw an error if it cannot
compile a function in a way that speeds up your code, pass Numba the argument nopython=True (e.g. @numba.
jit(nopython=True)). For more on troubleshooting Numba modes, see the Numba troubleshooting page.
Read more in the Numba docs.

25.3 Expression Evaluation via eval()

The top-level function pandas.eval() implements expression evaluation of Series and DataFrame objects.

Note: To benefit from using eval() you need to install numexpr. See the recommended dependencies section
for more details.

The point of using eval() for expression evaluation rather than plain Python is two-fold: 1) large DataFrame
objects are evaluated more efficiently and 2) large arithmetic and boolean expressions are evaluated all at once by the
underlying engine (by default numexpr is used for evaluation).

Note: You should not use eval() for simple expressions or for expressions involving small DataFrames. In fact,
eval() is many orders of magnitude slower for smaller expressions/objects than plain ol’ Python. A good rule of
thumb is to only use eval() when you have a DataFrame with more than 10,000 rows.

eval() supports all arithmetic expressions supported by the engine in addition to some extensions available only in
pandas.

Note: The larger the frame and the larger the expression the more speedup you will see from using eval().

25.3.1 Supported Syntax

These operations are supported by pandas.eval():

• Arithmetic operations except for the left shift (<<) and right shift (>>) operators, e.g., df + 2 * pi / s
  ** 4 % 42 - the_golden_ratio
• Comparison operations, including chained comparisons, e.g., 2 < df < df2
• Boolean operations, e.g., df < df2 and df3 < df4 or not df_bool
• list and tuple literals, e.g., [1, 2] or (1, 2)
• Attribute access, e.g., df.a
• Subscript expressions, e.g., df[0]
• Simple variable evaluation, e.g., pd.eval('df') (this is not very useful)
• Math functions: sin, cos, exp, log, expm1, log1p, sqrt, sinh, cosh, tanh, arccos, arccos, arctan, arccosh, arcsinh,
  arctanh, abs and arctan2.

This Python syntax is not allowed:

• Expressions
  – Function calls other than math functions.
- is/is not operations
- if expressions
- lambda expressions
- list/set/dict comprehensions
- Literal dict and set expressions
- yield expressions
- Generator expressions
- Boolean expressions consisting of only scalar values

- Statements
  - Neither simple nor compound statements are allowed. This includes things like for, while, and if.

### 25.3.2 `eval()` Examples

`pandas.eval()` works well with expressions containing large arrays.

First let’s create a few decent-sized arrays to play with:

```python
In [13]: nrows, ncols = 20000, 100
In [14]: df1, df2, df3, df4 = [pd.DataFrame(np.random.randn(nrows, ncols)) for _ in range(4)]
```

Now let’s compare adding them together using plain ol’ Python versus `eval()`:

```python
In [15]: %timeit df1 + df2 + df3 + df4
11.5 ms +- 845 us per loop (mean +- std. dev. of 7 runs, 100 loops each)

In [16]: %timeit pd.eval('df1 + df2 + df3 + df4')
9.79 ms +- 612 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

Now let’s do the same thing but with comparisons:

```python
In [17]: %timeit (df1 > 0) & (df2 > 0) & (df3 > 0) & (df4 > 0)
31.3 ms +- 4.21 ms per loop (mean +- std. dev. of 7 runs, 10 loops each)

In [18]: %timeit pd.eval('(df1 > 0) & (df2 > 0) & (df3 > 0) & (df4 > 0)')
10.4 ms +- 469 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

`eval()` also works with unaligned pandas objects:

```python
In [19]: s = pd.Series(np.random.randn(50))
In [20]: %timeit df1 + df2 + df3 + df4 + s
21.4 ms +- 2.16 ms per loop (mean +- std. dev. of 7 runs, 10 loops each)

In [21]: %timeit pd.eval('(df1 + df2 + df3 + df4 + s)')
9.26 ms +- 788 us per loop (mean +- std. dev. of 7 runs, 100 loops each)
```

**Note:** Operations such as
should be performed in Python. An exception will be raised if you try to perform any boolean/bitwise operations with scalar operands that are not of type `bool` or `np.bool_`. Again, you should perform these kinds of operations in plain Python.

### 25.3.3 The `DataFrame.eval` method

In addition to the top level `pandas.eval()` function you can also evaluate an expression in the “context” of a `DataFrame`.

```python
In [22]: df = pd.DataFrame(np.random.randn(5, 2), columns=['a', 'b'])
In [23]: df.eval('a + b')
Out[23]:
   0   1   2   3   4
0 0.15 -0.24 -0.58 -1.08  0.69
1 0.10  0.30  0.16 -0.98 -0.84
2 0.92  1.14  0.86  0.54  0.69
3 0.31  0.78  1.35  0.71  0.49
4 -0.93  0.48  0.12  0.57  0.85
dtype: float64
```

Any expression that is a valid `pandas.eval()` expression is also a valid `DataFrame.eval()` expression, with the added benefit that you don’t have to prefix the name of the `DataFrame` to the column(s) you’re interested in evaluating.

In addition, you can perform assignment of columns within an expression. This allows for *formulaic evaluation*. The assignment target can be a new column name or an existing column name, and it must be a valid Python identifier.

New in version 0.18.0.

The `inplace` keyword determines whether this assignment will performed on the original `DataFrame` or return a copy with the new column.

**Warning:** For backwards compatibility, `inplace` defaults to `True` if not specified. This will change in a future version of pandas - if your code depends on an inplace assignment you should update to explicitly set `inplace=True`.

```python
In [24]: df = pd.DataFrame(dict(a=range(5), b=range(5, 10)))
In [25]: df.eval('c = a + b', inplace=True)
In [26]: df.eval('d = a + b + c', inplace=True)
In [27]: df.eval('a = 1', inplace=True)
In [28]: df
Out[28]:
   a  b  c  d
0 0  5  5 10
1 1  6  7 14
```

(continues on next page)
When `inplace` is set to `False`, a copy of the DataFrame with the new or modified columns is returned and the original frame is unchanged.

```python
In [29]: df
Out[29]:
   a  b  c  d
0  1  5  5 10
1  1  6  7 14
2  1  7  9 18
3  1  8 11 22
4  1  9 13 26

In [30]: df.eval('e = a - c', inplace=False)
   →
   a  b  c  d  e
0  1  5  5 10 -4
1  1  6  7 14 -6
2  1  7  9 18 -8
3  1  8 11 22 -10
4  1  9 13 26 -12

In [31]: df
   →
   a  b  c  d
0  1  5  5 10
1  1  6  7 14
2  1  7  9 18
3  1  8 11 22
4  1  9 13 26
```

New in version 0.18.0.

As a convenience, multiple assignments can be performed by using a multi-line string.

```python
In [32]: df.eval(""
.....: c = a + b
.....: d = a + b + c
.....: a = 1""", inplace=False)
.....:
Out[32]:
   a  b  c  d
0  1  5  6 12
1  1  6  7 14
2  1  7  8 16
3  1  8  9 18
4  1  9 10 20
```

The equivalent in standard Python would be

```python
In [33]: df = pd.DataFrame(dict(a=range(5), b=range(5, 10)))
```

(continues on next page)
In [34]: df['c'] = df.a + df.b

In [35]: df['d'] = df.a + df.b + df.c

In [36]: df['a'] = 1

In [37]: df
Out[37]:
   a  b  c  d
0  1  5  5 10
1  1  6  7 14
2  1  7  9 18
3  1  8 11 22
4  1  9 13 26

New in version 0.18.0.

The query method gained the inplace keyword which determines whether the query modifies the original frame.

In [38]: df = pd.DataFrame(dict(a=range(5), b=range(5, 10)))

In [39]: df.query('a > 2')
Out[39]:
   a  b
3  3  8
4  4  9

In [40]: df.query('a > 2', inplace=True)

In [41]: df
Out[41]:
   a  b
3  3  8
4  4  9

Warning: Unlike with eval, the default value for inplace for query is False. This is consistent with prior versions of pandas.

25.3.4 Local Variables

You must explicitly reference any local variable that you want to use in an expression by placing the @ character in front of the name. For example,

In [42]: df = pd.DataFrame(np.random.randn(5, 2), columns=list('ab'))

In [43]: newcol = np.random.randn(len(df))

In [44]: df.eval('b + @newcol')
Out[44]:
   0  -0.173926
   1   2.493083
   2  -0.881831
   3  -0.691045
   4  -0.248521
If you don’t prefix the local variable with @, pandas will raise an exception telling you the variable is undefined.

When using `DataFrame.eval()` and `DataFrame.query()`, this allows you to have a local variable and a `DataFrame` column with the same name in an expression.

```python
In [46]: a = np.random.randn()
In [47]: df.query('@a < a')
Out[47]:
   a    b
0  0.863987 -0.115998

In [48]: df.loc[a < df.a]  # same as the previous expression
Out[48]:
   a    b
0  0.863987 -0.115998
```

With `pandas.eval()` you cannot use the @ prefix at all, because it isn’t defined in that context. pandas will let you know this if you try to use @ in a top-level call to `pandas.eval()`. For example,

```python
In [49]: a, b = 1, 2
In [50]: pd.eval('@a + b')
```

```
Traceback (most recent call last):
    exec(code_obj, self.user_global_ns, self.user_ns)
  File "<ipython-input-50-af17947a194f>", line 1, in <module>
    pd.eval('@a + b')
  File "/Users/taugspurger/sandbox/pandas-release/pandas-docs/pandas/core/computation/eval.py", line 283, in eval
    _check_for_locals(expr, level, parser)
  File "/Users/taugspurger/sandbox/pandas-release/pandas-docs/pandas/core/computation/eval.py", line 150, in _check_for_locals
    raise SyntaxError(msg)
SyntaxError: The '@' prefix is not allowed in top-level eval calls, please refer to your variables by name without the '@' prefix
```

In this case, you should simply refer to the variables like you would in standard Python.
25.3.5 pandas.eval() Parsers

There are two different parsers and two different engines you can use as the backend.

The default 'pandas' parser allows a more intuitive syntax for expressing query-like operations (comparisons, conjunctions and disjunctions). In particular, the precedence of the & and | operators is made equal to the precedence of the corresponding boolean operations and and or.

For example, the above conjunction can be written without parentheses. Alternatively, you can use the 'python' parser to enforce strict Python semantics.

The same expression can be “anded” together with the word and as well:

The and and or operators here have the same precedence that they would in vanilla Python.

25.3.6 pandas.eval() Backends

There’s also the option to make eval() operate identical to plain ol’ Python.

Note: Using the 'python' engine is generally not useful, except for testing other evaluation engines against it. You will achieve no performance benefits using eval() with engine='python' and in fact may incur a performance hit.

You can see this by using pandas.eval() with the 'python' engine. It is a bit slower (not by much) than evaluating the same expression in Python.
25.3.7 pandas.eval() Performance

eval() is intended to speed up certain kinds of operations. In particular, those operations involving complex
expressions with large DataFrame/Series objects should see a significant performance benefit. Here is a plot showing
the running time of pandas.eval() as function of the size of the frame involved in the computation. The two lines
are two different engines.

Note: Operations with smallish objects (around 15k-20k rows) are faster using plain Python:

This plot was created using a DataFrame with 3 columns each containing floating point values generated using
numpy.random.randn().
25.3.8 Technical Minutia Regarding Expression Evaluation

Expressions that would result in an object dtype or involve datetime operations (because of NaT) must be evaluated in Python space. The main reason for this behavior is to maintain backwards compatibility with versions of NumPy < 1.7. In those versions of NumPy a call to ndarray.astype(str) will truncate any strings that are more than 60 characters in length. Second, we can’t pass object arrays to numexpr thus string comparisons must be evaluated in Python space.

The upshot is that this only applies to object-dtype’d expressions. So, if you have an expression—for example

```
In [64]: df = pd.DataFrame({'strings': np.repeat(list('cba'), 3),
                     'nums': np.repeat(range(3), 3)})
In [65]: df
Out[65]:
     strings  nums
   0      c     0
   1      c     0
   2      c     0
   3      b     1
   4      b     1
   5      b     1
   6      a     2
   7      a     2
   8      a     2
In [66]: df.query('strings == "a" and nums == 1')
```

→ Empty DataFrame
Columns: [strings, nums]
Index: []

the numeric part of the comparison (nums == 1) will be evaluated by numexpr.

In general, DataFrame.query() / pandas.eval() will evaluate the subexpressions that can be evaluated by numexpr and those that must be evaluated in Python space transparently to the user. This is done by inferring the result type of an expression from its arguments and operators.
SPARSE DATA STRUCTURES

Note: The SparsePanel class has been removed in 0.19.0

We have implemented “sparse” versions of Series and DataFrame. These are not sparse in the typical “mostly 0”. Rather, you can view these objects as being “compressed” where any data matching a specific value (NaN / missing value, though any value can be chosen) is omitted. A special SparseIndex object tracks where data has been “sparsified”. This will make much more sense with an example. All of the standard pandas data structures have a to_sparse method:

```python
In [1]: ts = pd.Series(randn(10))
In [2]: ts[2:-2] = np.nan
In [3]: sts = ts.to_sparse()
In [4]: sts
Out[4]:
   0   0.469112
   1  -0.282863
   2   NaN
   3   NaN
   4   NaN
   5   NaN
   6   NaN
   7   NaN
   8  -0.861849
   9  -2.104569
```

The to_sparse method takes a kind argument (for the sparse index, see below) and a fill_value. So if we had a mostly zero Series, we could convert it to sparse with fill_value=0:

```python
In [5]: ts.fillna(0).to_sparse(fill_value=0)
Out[5]:
   0   0.469112
   1  -0.282863
   2   0.000000
   3   0.000000
   4   0.000000
   5   0.000000
```

(continues on next page)
The sparse objects exist for memory efficiency reasons. Suppose you had a large, mostly NA DataFrame:

```
In [6]: df = pd.DataFrame(randn(10000, 4))
In [7]: df.iloc[:9998] = np.nan
In [8]: sdf = df.to_sparse()
In [9]: sdf
Out[9]:
     0       1       2       3
0  NaN  NaN  NaN  NaN
1  NaN  NaN  NaN  NaN
2  NaN  NaN  NaN  NaN
3  NaN  NaN  NaN  NaN
4  NaN  NaN  NaN  NaN
5  NaN  NaN  NaN  NaN
...  ...  ...  ...  ...
9993  NaN  NaN  NaN  NaN
9994  NaN  NaN  NaN  NaN
9995  NaN  NaN  NaN  NaN
9996  NaN  NaN  NaN  NaN
9997  NaN  NaN  NaN  NaN
9998  0.509184 -0.774928 -1.369894 -0.382141
9999  0.280249 -1.648493 1.490865 -0.890819

[10000 rows x 4 columns]
```

As you can see, the density (% of values that have not been “compressed”) is extremely low. This sparse object takes up much less memory on disk (pickled) and in the Python interpreter. Functionally, their behavior should be nearly identical to their dense counterparts.

Any sparse object can be converted back to the standard dense form by calling `to_dense`:

```
In [11]: sts.to_dense()
Out[11]:
       0       1       2       3
0  0.469112  NaN  NaN  NaN
1 -0.282863  NaN  NaN  NaN
2  NaN  NaN  NaN  NaN
3  NaN  NaN  NaN  NaN
4  NaN  NaN  NaN  NaN
5  NaN  NaN  NaN  NaN
6  NaN  NaN  NaN  NaN
```

(continues on next page)
26.1 SparseArray

SparseArray is the base layer for all of the sparse indexed data structures. It is a 1-dimensional ndarray-like object storing only values distinct from the fill_value:

```python
In [12]: arr = np.random.randn(10)
In [14]: sparr = pd.SparseArray(arr)
In [15]: sparr
```

```
Out[15]:
[-1.9557, -1.6589, nan, nan, nan, 1.1589, 0.1453, nan, 0.606, 1.3342]
Fill: nan
IntIndex
Indices: array([0, 1, 5, 6, 8, 9], dtype=int32)
```

Like the indexed objects (SparseSeries, SparseDataFrame), a SparseArray can be converted back to a regular ndarray by calling `to_dense`:

```python
In [16]: sparr.to_dense()
Out[16]:
array([-1.9557, -1.6589, nan, nan, nan, 1.1589, 0.1453, nan, 0.606, 1.3342])
```

26.2 SparseIndex objects

Two kinds of SparseIndex are implemented, block and integer. We recommend using block as it’s more memory efficient. The integer format keeps an arrays of all of the locations where the data are not equal to the fill value. The block format tracks only the locations and sizes of blocks of data.

26.3 Sparse Dtypes

Sparse data should have the same dtype as its dense representation. Currently, float64, int64 and bool dtypes are supported. Depending on the original dtype, fill_value default changes:

- float64: np.nan
- int64: 0
- bool: False
In [17]: s = pd.Series([1, np.nan, np.nan])

In [18]: s
Out[18]:
0    1.0
1    NaN
2    NaN
dtype: float64

In [19]: s.to_sparse()
Out[19]:
0    1.0
1    NaN
2    NaN
dtype: float64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([1], dtype=int32)

In [20]: s = pd.Series([1, 0, 0])

In [21]: s
Out[21]:
0    1
1    0
2    0
dtype: int64

In [22]: s.to_sparse()
Out[22]:
0    1
1    0
2    0
dtype: int64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([1], dtype=int32)

In [23]: s = pd.Series([True, False, True])

In [24]: s
Out[24]:
0   True
1   False
2   True
dtype: bool

In [25]: s.to_sparse()
Out[25]:
0   True
1   False
2   True
dtype: bool
BlockIndex
Block locations: array([0, 2], dtype=int32)
Block lengths: array([1, 1], dtype=int32)

You can change the dtype using .astype(), the result is also sparse. Note that .astype() also affects to the
fill_value to keep its dense representation.

```
In [26]: s = pd.Series([1, 0, 0, 0, 0])

In [27]: s
Out[27]:
0   1
1   0
2   0
3   0
4   0
dtype: int64

In [28]: ss = s.to_sparse()

In [29]: ss
Out[29]:
0  1
1  0
2  0
3  0
4  0
dtype: int64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([1], dtype=int32)

In [30]: ss.astype(np.float64)
```

```
  0   1.0
  1   0.0
  2   0.0
  3   0.0
  4   0.0
dtype: float64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([1], dtype=int32)
```

It raises if any value cannot be coerced to specified dtype.

```
In [1]: ss = pd.Series([1, np.nan, np.nan]).to_sparse()
0   1.0
1   NaN
2   NaN
dtype: float64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([1], dtype=int32)

In [2]: ss.astype(np.int64)
ValueError: unable to coerce current fill_value nan to int64 dtype
```
26.4 Sparse Calculation

You can apply NumPy ufuncs to SparseArray and get a SparseArray as a result.

```python
In [31]: arr = pd.SparseArray([1., np.nan, np.nan, -2., np.nan])
In [32]: np.abs(arr)
Out[32]:
[1.0, nan, nan, 2.0, nan]
Fill: nan
IntIndex
Indices: array([0, 3], dtype=int32)
```

The ufunc is also applied to fill_value. This is needed to get the correct dense result.

```python
In [33]: arr = pd.SparseArray([1., -1, -2., -1], fill_value=-1)
In [34]: np.abs(arr)
Out[34]:
[1.0, 1.0, 1.0, 2.0, 1.0]
Fill: 1
IntIndex
Indices: array([0, 3], dtype=int32)
```

26.5 Interaction with scipy.sparse

26.5.1 SparseDataFrame

New in version 0.20.0.

Pandas supports creating sparse dataframes directly from scipy.sparse matrices.

```python
In [36]: from scipy.sparse import csr_matrix
In [37]: arr = np.random.random(size=(1000, 5))
In [38]: arr[arr < .9] = 0
In [39]: sp_arr = csr_matrix(arr)
In [40]: sp_arr
Out[40]:<1000x5 sparse matrix of type '<class 'numpy.float64'>'
with 517 stored elements in Compressed Sparse Row format>
In [41]: sdf = pd.SparseDataFrame(sp_arr)
In [42]: sdf
Out[42]:
0 1 2 3 4
```

(continues on next page)
All sparse formats are supported, but matrices that are not in COOrdinate format will be converted, copying data as needed. To convert a SparseDataFrame back to sparse SciPy matrix in COO format, you can use the SparseDataFrame.to_coo() method:

```
In [43]: sdf.to_coo()
Out[43]:
<1000x5 sparse matrix of type '<class 'numpy.float64'>'
    with 517 stored elements in COOrdinate format>
```

### 26.5.2 SparseSeries

A SparseSeries.to_coo() method is implemented for transforming a SparseSeries indexed by a MultiIndex to a scipy.sparse.coo_matrix.

The method requires a MultiIndex with two or more levels.

```
In [44]: s = pd.Series([3.0, np.nan, 1.0, 3.0, np.nan, np.nan])
In [45]: s.index = pd.MultiIndex.from_tuples([(1, 2, 'a', 0),
          ....:       (1, 2, 'a', 1),
          ....:       (1, 1, 'b', 0),
          ....:       (1, 1, 'b', 1),
          ....:       (2, 1, 'b', 0),
          ....:       (2, 1, 'b', 1)],
          ....:       names=['A', 'B', 'C', 'D'])
In [46]: s
Out[46]:
A  B  C  D
1  2  a  0  3.0
    1  NaN
1  b  0  1.0
    1  3.0
2  1  b  0  NaN
    1  NaN
dtype: float64
```
In the example below, we transform the `SparseSeries` to a sparse representation of a 2-d array by specifying that the first and second `MultiIndex` levels define labels for the rows and the third and fourth levels define labels for the columns. We also specify that the column and row labels should be sorted in the final sparse representation.

```
In [49]: A, rows, columns = ss.to_coo(row_levels=['A', 'B'],
   ...:   column_levels=['C', 'D'],
   ...:   sort_labels=True)
   ...

In [50]: A
Out[50]:
<3x4 sparse matrix of type '<class 'numpy.float64'>'
with 3 stored elements in COOrdinate format>

In [51]: A.todense()

→
matrix([[ 0., 0., 1., 3.],
         [ 3., 0., 0., 0.],
         [ 0., 0., 0., 0.]])

In [52]: rows
→[(1, 1), (1, 2), (2, 1)]

In [53]: columns
→[('a', 0), ('a', 1), ('b', 0), ('b', 1)]
```

Specifying different row and column labels (and not sorting them) yields a different sparse matrix:

```
In [54]: A, rows, columns = ss.to_coo(row_levels=['A', 'B', 'C'],
   ...:   column_levels=['D'],
   ...:   sort_labels=False)
   ...

In [55]: A
Out[55]:
```
<3x2 sparse matrix of type '<class 'numpy.float64'>'
with 3 stored elements in COOrdinate format>

In [56]: A.todense()
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →

In [57]: rows
   →[(1, 2, 'a'), (1, 1, 'b'), (2, 1, 'b')]

In [58]: columns
   →[0, 1]

A convenience method `SparseSeries.from_coo()` is implemented for creating a `SparseSeries` from a scipy.sparse.coo_matrix.

In [59]: from scipy import sparse
In [60]: A = sparse.coo_matrix(((3.0, 1.0, 2.0), ([1, 0, 0], [0, 2, 3])), shape=(3, 4))
In [61]: A
   Out[61]:
   <3x4 sparse matrix of type '<class 'numpy.float64'>'
   with 3 stored elements in COOrdinate format>

In [62]: A.todense()
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →
   ⏯
   →

The default behaviour (with dense_index=False) simply returns a `SparseSeries` containing only the non-null entries.

In [63]: ss = pd.SparseSeries.from_coo(A)
In [64]: ss
   Out[64]:
   0 2 1.0
   3 2.0
   1 0 3.0
dtype: float64
BlockIndex
Block locations: array([0], dtype=int32)
Block lengths: array([3], dtype=int32)

Specifying dense_index=True will result in an index that is the Cartesian product of the row and columns coordinates of the matrix. Note that this will consume a significant amount of memory (relative to dense_index=False) if the sparse matrix is large (and sparse) enough.
In [65]: ss_dense = pd.SparseSeries.from_coo(A, dense_index=True)

In [66]: ss_dense
Out[66]:
   0    NaN
   1    NaN
   2    1.0
   3    2.0
   1    3.0
   1    NaN
   2    NaN
   3    NaN
   2    NaN
   1    NaN
   2    NaN
   3    NaN
      dtype: float64

BlockIndex
Block locations: array([2], dtype=int32)
Block lengths: array([3], dtype=int32)
FREQUENTLY ASKED QUESTIONS (FAQ)

27.1 DataFrame memory usage

The memory usage of a DataFrame (including the index) is shown when calling the `info()`. A configuration option, `display.memory_usage` (see the list of options), specifies if the DataFrame’s memory usage will be displayed when invoking the `df.info()` method.

For example, the memory usage of the DataFrame below is shown when calling `info()`:

```python
In [1]: dtypes = ['int64', 'float64', 'datetime64[ns]', 'timedelta64[ns]',
...:       'complex128', 'object', 'bool']
...:
In [2]: n = 5000
In [3]: data = dict([(t, np.random.randint(100, size=n).astype(t))
...:       for t in dtypes])
...:
In [4]: df = pd.DataFrame(data)
In [5]: df['categorical'] = df['object'].astype('category')
In [6]: df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5000 entries, 0 to 4999
Data columns (total 8 columns):
int64 5000 non-null int64
float64 5000 non-null float64
datetime64[ns] 5000 non-null datetime64[ns]
timedelta64[ns] 5000 non-null timedelta64[ns]
complex128 5000 non-null complex128
object 5000 non-null object
bool 5000 non-null bool
categorical 5000 non-null category
dtypes: bool(1), category(1), complex128(1), datetime64[ns](1), float64(1), int64(1),
timedelta64[ns](1)
memory usage: 289.1+ KB
```

The `+` symbol indicates that the true memory usage could be higher, because pandas does not count the memory used by values in columns with `dtype=object`.

Passing `memory_usage='deep'` will enable a more accurate memory usage report, accounting for the full usage of the contained objects. This is optional as it can be expensive to do this deeper introspection.
In [7]: df.info(memory_usage='deep')
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5000 entries, 0 to 4999
Data columns (total 8 columns):
    dtypes: bool(1), category(1), complex128(1), datetime64[ns](1), float64(1), int64(1),
    object(1), timedelta64[ns](1)
memory usage: 425.6 KB

By default the display option is set to True but can be explicitly overridden by passing the memory_usage argument when invoking df.info().

The memory usage of each column can be found by calling the memory_usage() method. This returns a Series with an index represented by column names and memory usage of each column shown in bytes. For the DataFrame above, the memory usage of each column and the total memory usage can be found with the memory_usage method:

In [8]: df.memory_usage()
Out[8]:
    Index   80
    int64   40000
    float64 40000
    datetime64[ns]  40000
    timedelta64[ns] 40000
    complex128 80000
    object   40000
    bool     5000
    categorical 10920
    dtype: int64

# total memory usage of dataframe
In [9]: df.memory_usage().sum()

296000

By default the memory usage of the DataFrame’s index is shown in the returned Series, the memory usage of the index can be suppressed by passing the index=False argument:

In [10]: df.memory_usage(index=False)
Out[10]:
    int64   40000
    float64 40000
    datetime64[ns]  40000
    timedelta64[ns] 40000
    complex128 80000
    object   40000
    bool     5000
    categorical 10920
    dtype: int64

The memory usage displayed by the info() method utilizes the memory_usage() method to determine the memory usage of a DataFrame while also formatting the output in human-readable units (base-2 representation; i.e. 1KB
27.2 Using If/Truth Statements with pandas

pandas follows the NumPy convention of raising an error when you try to convert something to a `bool`. This happens in an `if`-statement or when using the boolean operations: `and`, `or`, and `not`. It is not clear what the result of the following code should be:

```python
>>> if pd.Series([False, True, False]):
    ...
```

Should it be `True` because it’s not zero-length, or `False` because there are `False` values? It is unclear, so instead, pandas raises a `ValueError`:

```python
>>> if pd.Series([False, True, False]):
    print("I was true")
Traceback
...  
ValueError: The truth value of an array is ambiguous. Use a.empty, a.any() or a.all().
```

You need to explicitly choose what you want to do with the DataFrame, e.g. use `any()`, `all()` or `empty()`. Alternatively, you might want to compare if the pandas object is `None`:

```python
>>> if pd.Series([False, True, False]) is not None:
    print("I was not None")
>>> I was not None
```

Below is how to check if any of the values are `True`:

```python
>>> if pd.Series([False, True, False]).any():
    print("I am any")
>>> I am any
```

To evaluate single-element pandas objects in a boolean context, use the method `bool()`:

```python
In [11]: pd.Series([True]).bool()
Out[11]: True

In [12]: pd.Series([False]).bool()
Out[12]: False

In [13]: pd.DataFrame([[True]]).bool()
Out[13]: True

In [14]: pd.DataFrame([[False]]).bool()
Out[14]: False
```

27.2.1 Bitwise boolean

Bitwise boolean operators like `==` and `!=` return a boolean `Series`, which is almost always what you want anyways.
>>> s = pd.Series(range(5))
>>> s == 4
0    False
1    False
2    False
3    False
4     True
dtype: bool

See boolean comparisons for more examples.

### 27.2.2 Using the in operator

Using the Python in operator on a Series tests for membership in the index, not membership among the values.

```
In [15]: s = pd.Series(range(5), index=list('abcde'))
In [16]: 2 in s
Out[16]: False
In [17]: 'b' in s
Out[17]: True
```

If this behavior is surprising, keep in mind that using in on a Python dictionary tests keys, not values, and Series are dict-like. To test for membership in the values, use the method isin():

```
In [18]: s.isin([2])
Out[18]:
   a   False
   b   False
   c   True
   d   False
   e   False
dtype: bool
In [19]: s.isin([2]).any()
Out[19]: True
```

For DataFrames, likewise, in applies to the column axis, testing for membership in the list of column names.

### 27.3 NaN, Integer NA values and NA type promotions

#### 27.3.1 Choice of NA representation

For lack of NA (missing) support from the ground up in NumPy and Python in general, we were given the difficult choice between either:

- A masked array solution: an array of data and an array of boolean values indicating whether a value is there or is missing.
- Using a special sentinel value, bit pattern, or set of sentinel values to denote NA across the dtypes.

For many reasons we chose the latter. After years of production use it has proven, at least in my opinion, to be the best decision given the state of affairs in NumPy and Python in general. The special value NaN (Not-A-Number) is used
everywhere as the NA value, and there are API functions `isna` and `notna` which can be used across the dtypes to detect NA values.

However, it comes with it a couple of trade-offs which I most certainly have not ignored.

### 27.3.2 Support for integer NA

In the absence of high performance NA support being built into NumPy from the ground up, the primary casualty is the ability to represent NAs in integer arrays. For example:

```
In [20]: s = pd.Series([1, 2, 3, 4, 5], index=list('abcde'))
In [21]: s
Out[21]:
    a  1
    b  2
    c  3
    d  4
    e  5
    dtype: int64
In [22]: s.dtype
Out[22]: dtype('int64')
In [23]: s2 = s.reindex(['a', 'b', 'c', 'f', 'u'])
In [24]: s2
Out[24]:
    a  1.0
    b  2.0
    c  3.0
    f  NaN
    u  NaN
    dtype: float64
In [25]: s2.dtype
Out[25]: dtype('float64')
```

This trade-off is made largely for memory and performance reasons, and also so that the resulting `Series` continues to be “numeric”. One possibility is to use `dtype=object` arrays instead.

### 27.3.3 NA type promotions

When introducing NAs into an existing `Series` or `DataFrame` via `reindex()` or some other means, boolean and integer types will be promoted to a different dtype in order to store the NAs. The promotions are summarized in this table:

<table>
<thead>
<tr>
<th>Typeclass</th>
<th>Promotion dtype for storing NAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>floating</td>
<td>no change</td>
</tr>
<tr>
<td>object</td>
<td>no change</td>
</tr>
<tr>
<td>integer</td>
<td>cast to float64</td>
</tr>
<tr>
<td>boolean</td>
<td>cast to object</td>
</tr>
</tbody>
</table>

---

27.3. NaN, Integer NA values and NA type promotions  1271
While this may seem like a heavy trade-off, I have found very few cases where this is an issue in practice i.e. storing values greater than \(2^{53}\). Some explanation for the motivation is in the next section.

### 27.3.4 Why not make NumPy like R?

Many people have suggested that NumPy should simply emulate the \(\text{NA}\) support present in the more domain-specific statistical programming language R. Part of the reason is the NumPy type hierarchy:

<table>
<thead>
<tr>
<th>Typeclass</th>
<th>Dtype</th>
</tr>
</thead>
<tbody>
<tr>
<td>numpy.floating</td>
<td>float16, float32, float64, float128</td>
</tr>
<tr>
<td>numpy.integer</td>
<td>int8, int16, int32, int64</td>
</tr>
<tr>
<td>numpy.unsignedinteger</td>
<td>uint8, uint16, uint32, uint64</td>
</tr>
<tr>
<td>numpy.object_</td>
<td>object_</td>
</tr>
<tr>
<td>numpy.bool_</td>
<td>bool_</td>
</tr>
<tr>
<td>numpy.character</td>
<td>string_, unicode_</td>
</tr>
</tbody>
</table>

The R language, by contrast, only has a handful of built-in data types: integer, numeric (floating-point), character, and boolean. \(\text{NA}\) types are implemented by reserving special bit patterns for each type to be used as the missing value. While doing this with the full NumPy type hierarchy would be possible, it would be a more substantial trade-off (especially for the 8- and 16-bit data types) and implementation undertaking.

An alternate approach is that of using masked arrays. A masked array is an array of data with an associated boolean mask denoting whether each value should be considered \(\text{NA}\) or not. I am personally not in love with this approach as I feel that overall it places a fairly heavy burden on the user and the library implementer. Additionally, it exacts a fairly high performance cost when working with numerical data compared with the simple approach of using \(\text{NaN}\). Thus, I have chosen the Pythonic “practicality beats purity” approach and traded integer \(\text{NA}\) capability for a much simpler approach of using a special value in float and object arrays to denote \(\text{NA}\), and promoting integer arrays to floating when NAs must be introduced.

### 27.4 Differences with NumPy

For Series and DataFrame objects, \(\text{var()}\) normalizes by \(N-1\) to produce unbiased estimates of the sample variance, while NumPy’s \(\text{var}\) normalizes by \(N\), which measures the variance of the sample. Note that \(\text{cov()}\) normalizes by \(N-1\) in both pandas and NumPy.

### 27.5 Thread-safety

As of pandas 0.11, pandas is not 100% thread safe. The known issues relate to the \(\text{copy()}\) method. If you are doing a lot of copying of DataFrame objects shared among threads, we recommend holding locks inside the threads where the data copying occurs.

See this link for more information.

### 27.6 Byte-Ordering Issues

Occasionally you may have to deal with data that were created on a machine with a different byte order than the one on which you are running Python. A common symptom of this issue is an error like:
Traceback
...
ValueError: Big-endian buffer not supported on little-endian compiler

To deal with this issue you should convert the underlying NumPy array to the native system byte order before passing it to Series or DataFrame constructors using something similar to the following:

In [26]: x = np.array(list(range(10)), '>i4')  # big endian
In [27]: newx = x.byteswap().newbyteorder()  # force native byteorder
In [28]: s = pd.Series(newx)

See the NumPy documentation on byte order for more details.
rpy2 is an interface to R running embedded in a Python process, and also includes functionality to deal with pandas DataFrames. Converting data frames back and forth between rpy2 and pandas should be largely automated (no need to convert explicitly, it will be done on the fly in most rpy2 functions). To convert explicitly, the functions are pandas2ri.py2ri() and pandas2ri.ri2py().

See also the documentation of the rpy2 project: https://rpy2.readthedocs.io.

In the remainder of this page, a few examples of explicit conversion is given. The pandas conversion of rpy2 needs first to be activated:

```python
In [1]: from rpy2.robjects import r, pandas2ri
In [2]: pandas2ri.activate()
```

### 28.1 Transferring R data sets into Python

Once the pandas conversion is activated (pandas2ri.activate()), many conversions of R to pandas objects will be done automatically. For example, to obtain the ‘iris’ dataset as a pandas DataFrame:

```python
In [3]: r.data('iris')
Out[3]:
R object with classes: ('character',) mapped to:
<StrVector - Python:0x1c3987a8c8 / R:0x7fb4bc93d8e8> ['iris']
```
If the pandas conversion was not activated, the above could also be accomplished by explicitly converting it with the pandas2ri.ri2py function (pandas2ri.ri2py(r['iris'])).

28.2 Converting DataFrames into R objects

The pandas2ri.py2ri function support the reverse operation to convert DataFrames into the equivalent R object (that is, data.frame):

```python
In [5]: df = pd.DataFrame({'A': [1, 2, 3], 'B': [4, 5, 6], 'C': [7, 8, 9]},
                      index=['one', 'two', 'three'])

In [6]: r_dataframe = pandas2ri.py2ri(df)

In [7]: print(type(r_dataframe))
<class 'rpy2.robjects.vectors.DataFrame'>

In [8]: print(r_dataframe)
               A B C
one 1 4 7
two 2 5 8
three 3 6 9
```

The DataFrame’s index is stored as the rownames attribute of the data.frame instance.
Increasingly, packages are being built on top of pandas to address specific needs in data preparation, analysis and visualization. This is encouraging because it means pandas is not only helping users to handle their data tasks but also that it provides a better starting point for developers to build powerful and more focused data tools. The creation of libraries that complement pandas’ functionality also allows pandas development to remain focused around it’s original requirements.

This is an in-exhaustive list of projects that build on pandas in order to provide tools in the PyData space.

We’d like to make it easier for users to find these project, if you know of other substantial projects that you feel should be on this list, please let us know.

### 29.1 Statistics and Machine Learning

#### 29.1.1 Statsmodels

Statsmodels is the prominent Python “statistics and econometrics library” and it has a long-standing special relationship with pandas. Statsmodels provides powerful statistics, econometrics, analysis and modeling functionality that is out of pandas’ scope. Statsmodels leverages pandas objects as the underlying data container for computation.

#### 29.1.2 sklearn-pandas

Use pandas DataFrames in your scikit-learn ML pipeline.

#### 29.1.3 Featuretools

Featuretools is a Python library for automated feature engineering built on top of pandas. It excels at transforming temporal and relational datasets into feature matrices for machine learning using reusable feature engineering “primitives”. Users can contribute their own primitives in Python and share them with the rest of the community.

### 29.2 Visualization

#### 29.2.1 Bokeh

Bokeh is a Python interactive visualization library for large datasets that natively uses the latest web technologies. Its goal is to provide elegant, concise construction of novel graphics in the style of Protovis/D3, while delivering high-performance interactivity over large data to thin clients.
29.2.2 seaborn

Seaborn is a Python visualization library based on matplotlib. It provides a high-level, dataset-oriented interface for creating attractive statistical graphics. The plotting functions in seaborn understand pandas objects and leverage pandas grouping operations internally to support concise specification of complex visualizations. Seaborn also goes beyond matplotlib and pandas with the option to perform statistical estimation while plotting, aggregating across observations and visualizing the fit of statistical models to emphasize patterns in a dataset.

29.2.3 yhat/ggplot

Hadley Wickham’s ggplot2 is a foundational exploratory visualization package for the R language. Based on “The Grammar of Graphics” it provides a powerful, declarative and extremely general way to generate bespoke plots of any kind of data. It’s really quite incredible. Various implementations to other languages are available, but a faithful implementation for Python users has long been missing. Although still young (as of Jan-2014), the yhat/ggplot project has been progressing quickly in that direction.

29.2.4 Vincent

The Vincent project leverages Vega (that in turn, leverages d3) to create plots. Although functional, as of Summer 2016 the Vincent project has not been updated in over two years and is unlikely to receive further updates.

29.2.5 IPython Vega

Like Vincent, the IPython Vega project leverages Vega to create plots, but primarily targets the IPython Notebook environment.

29.2.6 Plotly

Plotly’s Python API enables interactive figures and web shareability. Maps, 2D, 3D, and live-streaming graphs are rendered with WebGL and D3.js. The library supports plotting directly from a pandas DataFrame and cloud-based collaboration. Users of matplotlib, ggplot for Python, and Seaborn can convert figures into interactive web-based plots. Plots can be drawn in IPython Notebooks, edited with R or MATLAB, modified in a GUI, or embedded in apps and dashboards. Plotly is free for unlimited sharing, and has cloud, offline, or on-premise accounts for private use.

29.2.7 QtPandas

Spun off from the main pandas library, the qtpandas library enables DataFrame visualization and manipulation in PyQt4 and PySide applications.

29.3 IDE

29.3.1 IPython

IPython is an interactive command shell and distributed computing environment. IPython Notebook is a web application for creating IPython notebooks. An IPython notebook is a JSON document containing an ordered list of input/output cells which can contain code, text, mathematics, plots and rich media. IPython notebooks can be converted to a number of open standard output formats (HTML, HTML presentation slides, LaTeX, PDF, ReStructuredText, Markdown, Python) through ‘Download As’ in the web interface and ipython nbconvert in a shell.
Pandas DataFrames implement \_repr_html\_ methods which are utilized by IPython Notebook for displaying (abbreviated) HTML tables. (Note: HTML tables may or may not be compatible with non-HTML IPython output formats.)

### 29.3.2 quantopian/qgrid

qgrid is “an interactive grid for sorting and filtering DataFrames in IPython Notebook” built with SlickGrid.

### 29.3.3 Spyder

Spyder is a cross-platform Qt-based open-source Python IDE with editing, testing, debugging, and introspection features. Spyder can now introspect and display Pandas DataFrames and show both “column wise min/max and global min/max coloring.”

### 29.4 API

#### 29.4.1 pandas-datareader

pandas-datareader is a remote data access library for pandas (PyPI:pandas-datareader). It is based on functionality that was located in pandas.io.data and pandas.io.wb but was split off in v0.19. See more in the pandas-datareader docs:

The following data feeds are available:

- Yahoo! Finance
- Google Finance
- FRED
- Fama/French
- World Bank
- OECD
- Eurostat
- EDGAR Index

#### 29.4.2 quandl/Python

Quandl API for Python wraps the Quandl REST API to return Pandas DataFrames with timeseries indexes.

#### 29.4.3 pydatastream

PyDatastream is a Python interface to the Thomson Dataworks Enterprise (DWE/Datastream) SOAP API to return indexed Pandas DataFrames or Panels with financial data. This package requires valid credentials for this API (non free).
29.4.4 pandaSDMX

pandaSDMX is a library to retrieve and acquire statistical data and metadata disseminated in SDMX 2.1, an ISO-standard widely used by institutions such as statistics offices, central banks, and international organisations. pandaSDMX can expose datasets and related structural metadata including dataflows, code-lists, and datastructure definitions as pandas Series or multi-indexed DataFrames.

29.4.5 fredapi

fredapi is a Python interface to the Federal Reserve Economic Data (FRED) provided by the Federal Reserve Bank of St. Louis. It works with both the FRED database and ALFRED database that contains point-in-time data (i.e. historic data revisions). fredapi provides a wrapper in Python to the FRED HTTP API, and also provides several convenient methods for parsing and analyzing point-in-time data from ALFRED. fredapi makes use of pandas and returns data in a Series or DataFrame. This module requires a FRED API key that you can obtain for free on the FRED website.

29.5 Domain Specific

29.5.1 Geopandas

Geopandas extends pandas data objects to include geographic information which support geometric operations. If your work entails maps and geographical coordinates, and you love pandas, you should take a close look at Geopandas.

29.5.2 xarray

xarray brings the labeled data power of pandas to the physical sciences by providing N-dimensional variants of the core pandas data structures. It aims to provide a pandas-like and pandas-compatible toolkit for analytics on multi-dimensional arrays, rather than the tabular data for which pandas excels.

29.6 Out-of-core

29.6.1 Dask

Dask is a flexible parallel computing library for analytics. Dask provides a familiar DataFrame interface for out-of-core, parallel and distributed computing.

29.6.2 Dask-ML

Dask-ML enables parallel and distributed machine learning using Dask alongside existing machine learning libraries like Scikit-Learn, XGBoost, and TensorFlow.

29.6.3 Blaze

Blaze provides a standard API for doing computations with various in-memory and on-disk backends: NumPy, Pandas, SQLAlchemy, MongoDB, PyTables, PySpark.
29.6.4 Odo

Odo provides a uniform API for moving data between different formats. It uses pandas own `read_csv` for CSV IO and leverages many existing packages such as PyTables, h5py, and pymongo to move data between non pandas formats. Its graph based approach is also extensible by end users for custom formats that may be too specific for the core of odo.

29.7 Data validation

29.7.1 Engarde

Engarde is a lightweight library used to explicitly state your assumptions about your datasets and check that they’re actually true.

29.8 Extension Data Types

Pandas provides an interface for defining extension types to extend NumPy’s type system. The following libraries implement that interface to provide types not found in NumPy or pandas, which work well with pandas’ data containers.

29.8.1 cyberpandas

Cyberpandas provides an extension type for storing arrays of IP Addresses. These arrays can be stored inside pandas’ Series and DataFrame.

29.9 Accessors

A directory of projects providing extension accessors. This is for users to discover new accessors and for library authors to coordinate on the namespace.

<table>
<thead>
<tr>
<th>Library</th>
<th>Accessor</th>
<th>Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>cyberpandas</td>
<td>ip</td>
<td>Series</td>
</tr>
<tr>
<td>pdvega</td>
<td>vgplot</td>
<td>Series, DataFrame</td>
</tr>
</tbody>
</table>
COMPARISON WITH R / R LIBRARIES

Since pandas aims to provide a lot of the data manipulation and analysis functionality that people use R for, this page was started to provide a more detailed look at the R language and its many third party libraries as they relate to pandas. In comparisons with R and CRAN libraries, we care about the following things:

- **Functionality / flexibility**: what can/cannot be done with each tool
- **Performance**: how fast are operations. Hard numbers/benchmarks are preferable
- **Ease-of-use**: Is one tool easier/harder to use (you may have to be the judge of this, given side-by-side code comparisons)

This page is also here to offer a bit of a translation guide for users of these R packages.

For transfer of DataFrame objects from pandas to R, one option is to use HDF5 files, see External Compatibility for an example.

### 30.1 Quick Reference

We’ll start off with a quick reference guide pairing some common R operations using dplyr with pandas equivalents.

#### 30.1.1 Querying, Filtering, Sampling

<table>
<thead>
<tr>
<th>R</th>
<th>pandas</th>
</tr>
</thead>
<tbody>
<tr>
<td>dim(df)</td>
<td>df.shape</td>
</tr>
<tr>
<td>head(df)</td>
<td>df.head()</td>
</tr>
<tr>
<td>slice(df, 1:10)</td>
<td>df.iloc[:9]</td>
</tr>
<tr>
<td>filter(df, col1 == 1, col2 == 1)</td>
<td>df.query('col1 == 1 &amp; col2 == 1')</td>
</tr>
<tr>
<td>df[df$col1 == 1 &amp; df$col2 == 1,]</td>
<td>df[(df.col1 == 1) &amp; (df.col2 == 1)]</td>
</tr>
<tr>
<td>select(df, col1, col2)</td>
<td>df[['col1', 'col2']]</td>
</tr>
<tr>
<td>select(df, col1:col3)</td>
<td>df.loc[:, 'col1':'col3']</td>
</tr>
<tr>
<td>select(df, -(col1:col3))</td>
<td>df.drop(cols_to_drop, axis=1) but see¹</td>
</tr>
<tr>
<td>distinct(select(df, col1))</td>
<td>df[['col1']].drop_duplicates()</td>
</tr>
<tr>
<td>distinct(select(df, col1:col2))</td>
<td>df[['col1', 'col2']].drop_duplicates()</td>
</tr>
<tr>
<td>sample_n(df, 10)</td>
<td>df.sample(n=10)</td>
</tr>
<tr>
<td>sample_frac(df, 0.01)</td>
<td>df.sample(frac=0.01)</td>
</tr>
</tbody>
</table>

¹ R’s shorthand for a subrange of columns (select(df, col1:col3)) can be approached cleanly in pandas, if you have the list of columns, for example df[cols[1:3]] or df.drop(cols[1:3]), but doing this by column name is a bit messy.
30.1.2 Sorting

<table>
<thead>
<tr>
<th>R</th>
<th>pandas</th>
</tr>
</thead>
<tbody>
<tr>
<td>arrange(df, col1, col2)</td>
<td>df.sort_values(['col1', 'col2'])</td>
</tr>
<tr>
<td>arrange(df, desc(col1))</td>
<td>df.sort_values('col1', ascending=False)</td>
</tr>
</tbody>
</table>

30.1.3 Transforming

<table>
<thead>
<tr>
<th>R</th>
<th>pandas</th>
</tr>
</thead>
<tbody>
<tr>
<td>select(df, col_one = col1)</td>
<td>df.rename(columns={'col1': 'col_one'})['col_one']</td>
</tr>
<tr>
<td>rename(df, col_one = col1)</td>
<td>df.rename(columns={'col1': 'col_one'})</td>
</tr>
<tr>
<td>mutate(df, c=a-b)</td>
<td>df.assign(c=df.a-df.b)</td>
</tr>
</tbody>
</table>

30.1.4 Grouping and Summarizing

<table>
<thead>
<tr>
<th>R</th>
<th>pandas</th>
</tr>
</thead>
<tbody>
<tr>
<td>summary(df)</td>
<td>df.describe()</td>
</tr>
<tr>
<td>gdf &lt;- group_by(df, col1)</td>
<td>gdf = df.groupby('col1')</td>
</tr>
<tr>
<td>summarise(gdf, avg=mean(col1, na.rm=TRUE))</td>
<td>df.groupby('col1').agg({'col1': 'mean'})</td>
</tr>
<tr>
<td>summarise(gdf, total=sum(col1))</td>
<td>df.groupby('col1').sum()</td>
</tr>
</tbody>
</table>

30.2 Base R

30.2.1 Slicing with R's `c`

R makes it easy to access data.frame columns by name

```r
df <- data.frame(a=rnorm(5), b=rnorm(5), c=rnorm(5), d=rnorm(5), e=rnorm(5))
df[, c("a", "c", "e")]
```

or by integer location

```r
df <- data.frame(matrix(rnorm(1000), ncol=100))
df[, c(1:10, 25:30, 40, 50:100)]
```

Selecting multiple columns by name in pandas is straightforward

```r
In [1]: df = pd.DataFrame(np.random.randn(10, 3), columns=list('abc'))
In [2]: df[['a', 'c']]
Out[2]:
    a     c
0 -1.039575 -0.424972
1  0.567020 -1.087401
2 -0.673690 -1.478427
```

(continues on next page)
Selecting multiple noncontiguous columns by integer location can be achieved with a combination of the `iloc` indexer attribute and `numpy.r_`.

```python
In [4]: names = list('abcdefg')
In [5]: n = 30
In [6]: columns = names + np.arange(len(names), n).tolist()
In [7]: df = pd.DataFrame(np.random.randn(n, n), columns=columns)
In [8]: df.iloc[:, np.r_[10:24, 24:30]]
Out[8]:
    0    1    2    3    4    5    6    7    8    9  
   --- --- --- --- --- --- --- --- --- --- ---
 0 -0.013960 -0.362543 -0.006154 -0.923061 0.895717 ... -2.211372 0.974466 -2.  
 1 -0.06747 -0.410001 -0.078638 -0.826591 -0.345352 -1.281247 ... -0.826591 -0.345352 -1.281247 
 2 0.545952 -1.219217 -1.226825 0.769804 -1.281247 ... -0.826591 -0.345352 -1.281247 
 3 0.314232 0.690579 0.995761 -0.299368 -0.863838 0.   
 4 0.690579 -0.964980 -0.845696 -0.744471 0.758527 1.   
 5 1.262731 1.289997 0.082423 ... -0.744471 0.758527 1.   
 6 0.729689 -0.964980 -0.845696 -0.744471 0.758527 1.   
 7 0.299368 -0.863838 0.   0.744471 0.758527 1.   
 8 0.299368 -0.863838 0.   0.744471 0.758527 1.   
 9 0.299368 -0.863838 0.   0.744471 0.758527 1.   
```

(continues on next page)
### 30.2.2 aggregate

In R you may want to split data into subsets and compute the mean for each. Using a data.frame called `df` and splitting it into groups `by1` and `by2`:

```r
df <- data.frame(  
  v1 = c(1,3,5,7,8,3,5,NA,4,5,7,9),  
  v2 = c(11,33,55,77,88,33,55,NA,44,55,77,99),  
  by1 = c("red", "blue", 1, 2, NA, "big", 1, 2, "red", 1, NA, 12),  
  by2 = c("wet", "dry", 99, 95, NA, "damp", 95, 99, "red", 99, NA, NA))
aggregate(x=df[, c("v1", "v2")], by=list(mydf2$by1, mydf2$by2), FUN=mean)
```

The `groupby()` method is similar to base R `aggregate` function.

```r
In [9]: df = pd.DataFrame({  
...:     'v1': [1,3,5,7,8,3,5,np.nan,4,5,7,9],  
...:     'v2': [11,33,55,77,88,33,55,NA,44,55,77,99],  
...:     'by1': ["red", "blue", 1, 2, NA, "big", 1, 2, "red", 1, NA, 12],  
...:     'by2': ["wet", "dry", 99, 95, NA, "damp", 95, 99, "red", 99, NA, NA],  
...: })
...:
In [10]: g = df.groupby(["by1","by2"])
In [11]: g["v1","v2"].mean()
```

For more details and examples see the `groupby` documentation.
### 30.2.3 match / %in%

A common way to select data in R is using `%in%` which is defined using the function `match`. The operator `%in%` is used to return a logical vector indicating if there is a match or not:

```r
s <- 0:4
s %in% c(2,4)
```

The `isin()` method is similar to R `%in%` operator:

```r
In [12]: s = pd.Series(np.arange(5), dtype=np.float32)
In [13]: s.isin([2, 4])
Out[13]:
0    False
1    False
2     True
3    False
4     True
dtype: bool
```

The `match` function returns a vector of the positions of matches of its first argument in its second:

```r
s <- 0:4
match(s, c(2,4))
```

For more details and examples see the reshaping documentation.

### 30.2.4 tapply

tapply is similar to `aggregate`, but data can be in a ragged array, since the subclass sizes are possibly irregular. Using a data.frame called `baseball`, and retrieving information based on the array `team`:

```r
baseball <-
data.frame(  
  team = gl(5, 5,  
            labels = paste("Team", LETTERS[1:5])),  
  player = sample(letters, 25),  
  batting.average = runif(25, .200, .400)
)
tapply(baseball$batting.average, baseball.example$team, max)
```

In pandas we may use `pivot_table()` method to handle this:

```r
In [14]: import random
In [15]: import string
In [16]: baseball = pd.DataFrame({  
      ....:   'team': ["team \%d" % (x+1) for x in range(5)]*5,  
      ....:   'player': random.sample(list(string.ascii_lowercase),25),  
      ....:   'batting avg': np.random.uniform(.200, .400, 25)  
      ....: })
      ....: 
In [17]: baseball.pivot_table(values='batting avg', columns='team', aggfunc=np.max)
(continues on next page)
```
30.2.5 subset

The `query()` method is similar to the base R `subset` function. In R you might want to get the rows of a `data.frame` where one column’s values are less than another column’s values:

```r
df <- data.frame(a=rnorm(10), b=rnorm(10))
subset(df, a <= b)
```

In pandas, there are a few ways to perform subsetting. You can use `query()` or pass an expression as if it were an index/slice as well as standard boolean indexing:

```python
In [18]: df = pd.DataFrame({'a': np.random.randn(10), 'b': np.random.randn(10)})
In [19]: df.query('a <= b')
Out[19]:
   a      b
0 -1.003505 -0.990738
1  0.083515  0.548796
3 -0.524392  0.904400
4 -0.837804  0.746374
8 -0.507219  0.245479
```

For more details and examples see the `query` documentation.

30.2.6 with

An expression using a `data.frame` called `df` in R with the columns `a` and `b` would be evaluated using `with` like so:
df <- data.frame(a=rnorm(10), b=rnorm(10))
with(df, a + b)
df$a + df$b  # same as the previous expression

In pandas the equivalent expression, using the eval() method, would be:

In [22]: df = pd.DataFrame({'a': np.random.randn(10), 'b': np.random.randn(10)})
In [23]: df.eval('a + b')
Out[23]:
   0  -0.920205
   1  -0.860236
   2   1.154370
   3   0.188140
   4  -1.163718
   5   0.001397
   6  -0.825694
   7  -1.138198
   8  -1.708034
   9   1.148616

In [24]: df.a + df.b  # same as the previous expression
   →
   0  -0.920205
   1  -0.860236
   2   1.154370
   3   0.188140
   4  -1.163718
   5   0.001397
   6  -0.825694
   7  -1.138198
   8  -1.708034
   9   1.148616

dtype: float64

In certain cases eval() will be much faster than evaluation in pure Python. For more details and examples see the eval documentation.

### 30.3 plyr

plyr is an R library for the split-apply-combine strategy for data analysis. The functions revolve around three data structures in R, a for arrays, l for lists, and d for data.frame. The table below shows how these data structures could be mapped in Python.

<table>
<thead>
<tr>
<th>R</th>
<th>Python</th>
</tr>
</thead>
<tbody>
<tr>
<td>array</td>
<td>list</td>
</tr>
<tr>
<td>lists</td>
<td>dictionary or list of objects</td>
</tr>
<tr>
<td>data.frame</td>
<td>dataframe</td>
</tr>
</tbody>
</table>
### 30.3.1 ddply

An expression using a data.frame called `df` in R where you want to summarize `x` by `month`:

```r
require(plyr)

df <- data.frame(
  x = runif(120, 1, 168),
  y = runif(120, 7, 334),
  z = runif(120, 1.7, 20.7),
  month = rep(c(5, 6, 7, 8), 30),
  week = sample(1:4, 120, TRUE)
)

ddply(df, .(month, week), summarize,
  mean = round(mean(x), 2),
  sd = round(sd(x), 2))
```

In pandas the equivalent expression, using the `groupby()` method, would be:

```python
In [25]: df = pd.DataFrame({
    ....: 'x': np.random.uniform(1., 168., 120),
    ....: 'y': np.random.uniform(7., 334., 120),
    ....: 'z': np.random.uniform(1.7, 20.7, 120),
    ....: 'month': [5, 6, 7, 8]*30,
    ....: 'week': np.random.randint(1, 4, 120)
    ....: })

In [26]: grouped = df.groupby(['month', 'week'])

In [27]: grouped['x'].agg([np.mean, np.std])
Out[27]:
       mean     std
    month week  
   5     1  71.840596  52.886392
      2  71.904794  55.786805
      3  89.845632  49.892367
   6     1  97.730877  52.442172
      2  93.369836  47.178389
      3  96.592088  58.773744
   7     1  59.255715  43.442336
      2  69.634012  28.607369
      3  84.510992  59.761096
   8     1 104.787666  31.745437
      2  69.717872  53.747188
      3  79.892221  52.950459
```

For more details and examples see the `groupby documentation`.

### 30.4 reshape / reshape2

#### 30.4.1 melt.array

An expression using a 3 dimensional array called `a` in R where you want to melt it into a data.frame:
a <- array(c(1:23, NA), c(2,3,4))
data.frame(melt(a))

In Python, since `a` is a list, you can simply use list comprehension.

```python
In [28]: a = np.array(list(range(1,24))+[np.NAN]).reshape(2,3,4)
In [29]: pd.DataFrame([tuple(list(x)+[val]) for x, val in np.ndenumerate(a)])
Out[29]:
   0 1 2 3
0 0 0 0 1.0
1 0 0 1 2.0
2 0 0 2 3.0
3 0 0 3 4.0
4 0 1 0 5.0
5 0 1 1 6.0
6 0 1 2 7.0
... ... ... ...
17 1 1 1 18.0
18 1 1 2 19.0
19 1 1 3 20.0
20 1 2 0 21.0
21 1 2 1 22.0
22 1 2 2 23.0
23 1 2 3 NaN
[24 rows x 4 columns]
```

### 30.4.2 melt.list

An expression using a list called `a` in R where you want to melt it into a data.frame:

```r
a <- as.list(c(1:4, NA))
data.frame(melt(a))
```

In Python, this list would be a list of tuples, so `DataFrame()` method would convert it to a dataframe as required.

```python
In [30]: a = list(enumerate(list(range(1,5))+[np.NAN]))
In [31]: pd.DataFrame(a)
Out[31]:
   0 1
0 0 1.0
1 1 2.0
2 2 3.0
3 3 4.0
4 4 NaN
```

For more details and examples see [the Intro to Data Structures documentation](#).

### 30.4.3 melt.data.frame

An expression using a data.frame called `cheese` in R where you want to reshape the data.frame:

```r
30.4. reshape / reshape2 1291```
In Python, the `melt()` method is the R equivalent:

```python
In [32]: cheese = pd.DataFrame({'first' : ['John', 'Mary'],
                        'last' : ['Doe', 'Bo'],
                        'height' : [5.5, 6.0],
                        'weight' : [130, 150]})

In [33]: pd.melt(cheese, id_vars=['first', 'last'])
```

<table>
<thead>
<tr>
<th>first</th>
<th>last</th>
<th>variable</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>John</td>
<td>Doe</td>
<td>height</td>
<td>5.5</td>
</tr>
<tr>
<td>Mary</td>
<td>Bo</td>
<td>height</td>
<td>6.0</td>
</tr>
<tr>
<td>John</td>
<td>Doe</td>
<td>weight</td>
<td>130.0</td>
</tr>
<tr>
<td>Mary</td>
<td>Bo</td>
<td>weight</td>
<td>150.0</td>
</tr>
</tbody>
</table>

```python
In [34]: cheese.set_index(['first', 'last']).stack()  # alternative way
```

<table>
<thead>
<tr>
<th>first</th>
<th>last</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>John</td>
<td>Doe</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>130.0</td>
</tr>
<tr>
<td>Mary</td>
<td>Bo</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>150.0</td>
</tr>
</tbody>
</table>

dtype: float64

For more details and examples see the reshaping documentation.

### 30.4.4 cast

In R acast is an expression using a data.frame called df in R to cast into a higher dimensional array:

```r
df <- data.frame(x = runif(12, 1, 168),
                 y = runif(12, 7, 334),
                 z = runif(12, 1.7, 20.7),
                 month = rep(c(5,6,7),4),
                 week = rep(c(1,2), 6))

mdf <- melt(df, id=c("month", "week"))
acast(mdf, week ~ month ~ variable, mean)
```

In Python the best way is to make use of `pivot_table()`:

```python
In [35]: df = pd.DataFrame({
                        'x': np.random.uniform(1., 168., 12),
                        'y': np.random.uniform(7., 334., 12),
                        ...
})
```
Similarly for `dcast` which uses a data.frame called `df` in R to aggregate information based on `Animal` and `FeedType`:

```r
df <- data.frame(
  Animal = c('Animal1', 'Animal2', 'Animal3', 'Animal2', 'Animal1',
             'Animal2', 'Animal3'),
  FeedType = c('A', 'B', 'A', 'A', 'B', 'B', 'A'),
  Amount = c(10, 7, 4, 2, 5, 6, 2)
)
dcast(df, Animal ~ FeedType, sum, fill=NaN)
# Alternative method using base R
with(df, tapply(Amount, list(Animal, FeedType), sum))
```

Python can approach this in two different ways. Firstly, similar to above using `pivot_table()`:

```python
In [38]: df = pd.DataFrame({
    ....:     'Animal': ['Animal1', 'Animal2', 'Animal3', 'Animal2', 'Animal1',
    ....:                    'Animal2', 'Animal3'],
    ....:     'FeedType': ['A', 'B', 'A', 'A', 'B', 'B', 'A'],
    ....:     'Amount': [10, 7, 4, 2, 5, 6, 2],
    ....: })

In [39]: df.pivot_table(values='Amount', index='Animal', columns='FeedType', aggfunc=
    ....:     'sum')
Out[39]:
FeedType  A  B
Animal
Animal1  10.0  5.0
Animal2  2.0  13.0
Animal3  6.0  NaN
```

The second approach is to use the `groupby()` method:
For more details and examples see the reshaping documentation or the groupby documentation.

### 30.4.5 factor

pandas has a data type for categorical data.

```python
cut(c(1,2,3,4,5,6), 3)
factor(c(1,2,3,2,2,3))
```

In pandas this is accomplished with `pd.cut` and `astype("category")`:

```python
In [41]: pd.cut(pd.Series([1,2,3,4,5,6]), 3)
Out[41]:
0   (0.995, 2.667]
1   (0.995, 2.667]
2   (2.667, 4.333]
3   (2.667, 4.333]
4   (4.333, 6.0]
5   (4.333, 6.0]
```

```python
In [42]: pd.Series([1,2,3,2,2,3]).astype("category")
```

For more details and examples see categorical introduction and the API documentation. There is also a documentation regarding the differences to R’s factor.
Since many potential pandas users have some familiarity with SQL, this page is meant to provide some examples of how various SQL operations would be performed using pandas.

If you’re new to pandas, you might want to first read through 10 Minutes to pandas to familiarize yourself with the library.

As is customary, we import pandas and NumPy as follows:

```python
In [1]: import pandas as pd
In [2]: import numpy as np
```

Most of the examples will utilize the `tips` dataset found within pandas tests. We’ll read the data into a DataFrame called `tips` and assume we have a database table of the same name and structure.

```python
In [3]: url = 'https://raw.github.com/pandas-dev/pandas/master/pandas/tests/data/tips.csv'
In [4]: tips = pd.read_csv(url)
In [5]: tips.head()
Out[5]:
     total_bill  tip  sex  smoker  day  time  size
0      16.99  1.01  Female  No  Sun  Dinner    2
1      10.34  1.66   Male  No  Sun  Dinner    3
2      21.01  3.50   Male  No  Sun  Dinner    3
3      23.68  3.31   Male  No  Sun  Dinner    2
4      24.59  3.61  Female  No  Sun  Dinner    4
```

### 31.1 SELECT

In SQL, selection is done using a comma-separated list of columns you’d like to select (or a * to select all columns):

```
SELECT total_bill, tip, smoker, time
FROM tips
LIMIT 5;
```

With pandas, column selection is done by passing a list of column names to your DataFrame:

```python
In [6]: tips[['total_bill', 'tip', 'smoker', 'time']].head(5)
Out[6]:
    total_bill  tip  smoker  time
0    16.99  1.01  Female  Dinner
1    10.34  1.66   Male  Dinner
2    21.01  3.50   Male  Dinner
3    23.68  3.31   Male  Dinner
4    24.59  3.61  Female  Dinner
```
Calling the DataFrame without the list of column names would display all columns (akin to SQL’s `*`).

### 31.2 WHERE

Filtering in SQL is done via a WHERE clause.

```sql
SELECT *
FROM tips
WHERE time = 'Dinner'
LIMIT 5;
```

DataFrames can be filtered in multiple ways; the most intuitive of which is using boolean indexing.

```python
In [7]: tips[tips['time'] == 'Dinner'].head(5)
Out[7]:
      total_bill  tip    sex smoker day     time  size
0     16.99  1.01 Female No  Sun  Dinner    2
1     10.34  1.66   Male  No  Sun  Dinner    3
2     21.01  3.50   Male  No  Sun  Dinner    3
3     23.68  3.31   Male  No  Sun  Dinner    2
4     24.59  3.61 Female No  Sun  Dinner    4
```

The above statement is simply passing a `Series` of True/False objects to the DataFrame, returning all rows with True.

```python
In [8]: is_dinner = tips['time'] == 'Dinner'
In [9]: is_dinner.value_counts()
Out[9]:
       True    176
      False     68
Name: time, dtype: int64
```

```python
In [10]: tips[is_dinner].head(5)
```

```text
0 16.99 1.01 Female No Sun Dinner 2
1 10.34 1.66 Male No Sun Dinner 3
2 21.01 3.50 Male No Sun Dinner 3
3 23.68 3.31 Male No Sun Dinner 2
4 24.59 3.61 Female No Sun Dinner 4
```

Just like SQL’s OR and AND, multiple conditions can be passed to a DataFrame using | (OR) and & (AND).

```sql
-- tips of more than $5.00 at Dinner meals
SELECT *
FROM tips
WHERE time = 'Dinner' AND tip > 5.00;
```
# tips of more than $5.00 at Dinner meals
In [11]: tips[(tips['time'] == 'Dinner') & (tips['tip'] > 5.00)]
Out[11]:

<table>
<thead>
<tr>
<th>total_bill</th>
<th>tip</th>
<th>sex</th>
<th>smoker</th>
<th>day</th>
<th>time</th>
<th>size</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>39.42</td>
<td>7.58</td>
<td>Male</td>
<td>No</td>
<td>Sat</td>
<td>Dinner 4</td>
</tr>
<tr>
<td>44</td>
<td>30.40</td>
<td>5.60</td>
<td>Male</td>
<td>No</td>
<td>Sun</td>
<td>Dinner 4</td>
</tr>
<tr>
<td>47</td>
<td>32.40</td>
<td>6.00</td>
<td>Male</td>
<td>No</td>
<td>Sun</td>
<td>Dinner 4</td>
</tr>
<tr>
<td>52</td>
<td>34.81</td>
<td>5.20</td>
<td>Female</td>
<td>No</td>
<td>Sun</td>
<td>Dinner 4</td>
</tr>
<tr>
<td>59</td>
<td>48.27</td>
<td>6.73</td>
<td>Male</td>
<td>No</td>
<td>Sat</td>
<td>Dinner 4</td>
</tr>
<tr>
<td>116</td>
<td>29.93</td>
<td>5.07</td>
<td>Male</td>
<td>No</td>
<td>Sun</td>
<td>Dinner 4</td>
</tr>
<tr>
<td>155</td>
<td>29.85</td>
<td>5.14</td>
<td>Female</td>
<td>No</td>
<td>Sun</td>
<td>Dinner 5</td>
</tr>
<tr>
<td>170</td>
<td>50.81</td>
<td>10.00</td>
<td>Male</td>
<td>Yes</td>
<td>Sat</td>
<td>Dinner 3</td>
</tr>
<tr>
<td>172</td>
<td>7.25</td>
<td>5.15</td>
<td>Male</td>
<td>Yes</td>
<td>Sun</td>
<td>Dinner 2</td>
</tr>
<tr>
<td>181</td>
<td>23.33</td>
<td>5.65</td>
<td>Male</td>
<td>Yes</td>
<td>Sun</td>
<td>Dinner 2</td>
</tr>
<tr>
<td>183</td>
<td>23.17</td>
<td>6.50</td>
<td>Male</td>
<td>Yes</td>
<td>Sun</td>
<td>Dinner 4</td>
</tr>
<tr>
<td>211</td>
<td>25.89</td>
<td>5.16</td>
<td>Male</td>
<td>Yes</td>
<td>Sat</td>
<td>Dinner 4</td>
</tr>
<tr>
<td>212</td>
<td>48.33</td>
<td>9.00</td>
<td>Male</td>
<td>No</td>
<td>Sat</td>
<td>Dinner 4</td>
</tr>
<tr>
<td>214</td>
<td>28.17</td>
<td>6.50</td>
<td>Female</td>
<td>Yes</td>
<td>Sun</td>
<td>Dinner 3</td>
</tr>
<tr>
<td>211</td>
<td>25.89</td>
<td>5.16</td>
<td>Male</td>
<td>Yes</td>
<td>Sat</td>
<td>Dinner 4</td>
</tr>
<tr>
<td>212</td>
<td>48.33</td>
<td>9.00</td>
<td>Male</td>
<td>No</td>
<td>Sat</td>
<td>Dinner 4</td>
</tr>
<tr>
<td>214</td>
<td>28.17</td>
<td>6.50</td>
<td>Female</td>
<td>Yes</td>
<td>Sun</td>
<td>Dinner 3</td>
</tr>
<tr>
<td>216</td>
<td>28.15</td>
<td>3.00</td>
<td>Male</td>
<td>Yes</td>
<td>Sat</td>
<td>Dinner 5</td>
</tr>
</tbody>
</table>

-- tips by parties of at least 5 diners OR bill total was more than $45

SELECT *
FROM tips
WHERE size >= 5 OR total_bill > 45;

# tips by parties of at least 5 diners OR bill total was more than $45
In [12]: tips[(tips['size'] >= 5) | (tips['total_bill'] > 45)]
Out[12]:

<table>
<thead>
<tr>
<th>total_bill</th>
<th>tip</th>
<th>sex</th>
<th>smoker</th>
<th>day</th>
<th>time</th>
<th>size</th>
</tr>
</thead>
<tbody>
<tr>
<td>59</td>
<td>48.27</td>
<td>6.73</td>
<td>Male</td>
<td>No</td>
<td>Sat</td>
<td>Dinner 4</td>
</tr>
<tr>
<td>125</td>
<td>29.80</td>
<td>4.20</td>
<td>Female</td>
<td>No</td>
<td>Thur</td>
<td>Lunch 6</td>
</tr>
<tr>
<td>141</td>
<td>34.30</td>
<td>6.70</td>
<td>Male</td>
<td>No</td>
<td>Thur</td>
<td>Lunch 6</td>
</tr>
<tr>
<td>142</td>
<td>41.19</td>
<td>5.00</td>
<td>Male</td>
<td>No</td>
<td>Thur</td>
<td>Lunch 5</td>
</tr>
<tr>
<td>143</td>
<td>27.05</td>
<td>5.00</td>
<td>Female</td>
<td>No</td>
<td>Thur</td>
<td>Lunch 6</td>
</tr>
<tr>
<td>155</td>
<td>29.85</td>
<td>5.14</td>
<td>Female</td>
<td>No</td>
<td>Sun</td>
<td>Dinner 5</td>
</tr>
<tr>
<td>156</td>
<td>48.17</td>
<td>5.00</td>
<td>Male</td>
<td>No</td>
<td>Sun</td>
<td>Dinner 6</td>
</tr>
<tr>
<td>170</td>
<td>50.81</td>
<td>10.00</td>
<td>Male</td>
<td>Yes</td>
<td>Sat</td>
<td>Dinner 3</td>
</tr>
<tr>
<td>185</td>
<td>20.69</td>
<td>5.00</td>
<td>Male</td>
<td>No</td>
<td>Sun</td>
<td>Dinner 5</td>
</tr>
<tr>
<td>187</td>
<td>30.46</td>
<td>2.00</td>
<td>Male</td>
<td>Yes</td>
<td>Sun</td>
<td>Dinner 5</td>
</tr>
<tr>
<td>212</td>
<td>48.33</td>
<td>9.00</td>
<td>Male</td>
<td>No</td>
<td>Sat</td>
<td>Dinner 4</td>
</tr>
<tr>
<td>216</td>
<td>28.15</td>
<td>3.00</td>
<td>Male</td>
<td>Yes</td>
<td>Sat</td>
<td>Dinner 5</td>
</tr>
</tbody>
</table>

NULL checking is done using the \texttt{notna()} and \texttt{isna()} methods.

                             'col2': ['F', np.NaN, 'G', 'H', 'I']})

In [14]: frame
Out[14]:

<table>
<thead>
<tr>
<th>col1</th>
<th>col2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>F</td>
</tr>
<tr>
<td>B</td>
<td>NaN</td>
</tr>
<tr>
<td>NaN</td>
<td>G</td>
</tr>
<tr>
<td>C</td>
<td>H</td>
</tr>
<tr>
<td>D</td>
<td>I</td>
</tr>
</tbody>
</table>
Assume we have a table of the same structure as our DataFrame above. We can see only the records where `col2` IS NULL with the following query:

```sql
SELECT *
FROM frame
WHERE col2 IS NULL;
```

```python
In [15]: frame[frame['col2'].isna()]
Out[15]:
   col1  col2
0   B  NaN
```

Getting items where `col1` IS NOT NULL can be done with `notna()`.

```sql
SELECT *
FROM frame
WHERE col1 IS NOT NULL;
```

```python
In [16]: frame[frame['col1'].notna()]
Out[16]:
   col1  col2
0   A   F
1   B  NaN
3   C   H
4   D   I
```

### 31.3 GROUP BY

In pandas, SQL's GROUP BY operations are performed using the similarly named `groupby()` method. `groupby()` typically refers to a process where we'd like to split a dataset into groups, apply some function (typically aggregation), and then combine the groups together.

A common SQL operation would be getting the count of records in each group throughout a dataset. For instance, a query getting us the number of tips left by sex:

```sql
SELECT sex, count(*)
FROM tips
GROUP BY sex;
```

```sql
/*
Female  87
Male 157
*/
```

The pandas equivalent would be:

```python
In [17]: tips.groupby('sex').size()
Out[17]:
sex
Female  87
Male  157
dtype: int64
```

Notice that in the pandas code we used `size()` and not `count()`. This is because `count()` applies the function to each column, returning the number of not null records within each.
In [18]: tips.groupby('sex').count()
Out[18]:

<table>
<thead>
<tr>
<th>total_bill</th>
<th>tip</th>
<th>smoker</th>
<th>day</th>
<th>time</th>
<th>size</th>
</tr>
</thead>
<tbody>
<tr>
<td>sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>87</td>
<td>87</td>
<td>87</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td>Male</td>
<td>157</td>
<td>157</td>
<td>157</td>
<td>157</td>
<td>157</td>
</tr>
</tbody>
</table>

Alternatively, we could have applied the `count()` method to an individual column:

In [19]: tips.groupby('sex')['total_bill'].count()
Out[19]:

<table>
<thead>
<tr>
<th>sex</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>87</td>
</tr>
<tr>
<td>Male</td>
<td>157</td>
</tr>
</tbody>
</table>

Name: total_bill, dtype: int64

Multiple functions can also be applied at once. For instance, say we’d like to see how tip amount differs by day of the week - `agg()` allows you to pass a dictionary to your grouped DataFrame, indicating which functions to apply to specific columns.

```sql
SELECT day, AVG(tip), COUNT(*)
FROM tips
GROUP BY day;
/*
Fri 2.734737 19
Sat 2.993103 87
Sun 3.255132 76
Thur 2.771452 62
*/
```

In [20]: tips.groupby('day').agg({'tip': np.mean, 'day': np.size})
Out[20]:

<table>
<thead>
<tr>
<th>tip</th>
<th>day</th>
</tr>
</thead>
<tbody>
<tr>
<td>day</td>
<td></td>
</tr>
<tr>
<td>Fri</td>
<td>2.734737 19</td>
</tr>
<tr>
<td>Sat</td>
<td>2.993103 87</td>
</tr>
<tr>
<td>Sun</td>
<td>3.255132 76</td>
</tr>
<tr>
<td>Thur</td>
<td>2.771452 62</td>
</tr>
</tbody>
</table>

Grouping by more than one column is done by passing a list of columns to the `groupby()` method.

```sql
SELECT smoker, day, COUNT(*), AVG(tip)
FROM tips
GROUP BY smoker, day;
/*
smoker day
No  Fri  4  2.812500
    Sat  45 3.102889
    Sun  57 3.167895
    Thur 45 2.673778
Yes Fri 15 2.714000
    Sat  42 2.875476
    Sun  19 3.516842
    Thur 17 3.030000
*/
```
In [21]: tips.groupby(['smoker', 'day']).agg({'tip': [np.size, np.mean]})
Out[21]:
    tip
smoker day    size  mean
      No Fri 4.0  2.812500
      Sat 45.0  3.102889
      Sun 57.0  3.167895
     Thur 45.0  2.673778
      Yes Fri 15.0  2.714000
     Sat 42.0  2.875476
    Sun 19.0  3.516842
   Thur 17.0  3.030000

31.4 JOIN

JOINs can be performed with join() or merge(). By default, join() will join the DataFrames on their indices. Each method has parameters allowing you to specify the type of join to perform (LEFT, RIGHT, INNER, FULL) or the columns to join on (column names or indices).

In [22]: df1 = pd.DataFrame({'key': ['A', 'B', 'C', 'D'],
                     ....:   'value': np.random.randn(4)})
In [23]: df2 = pd.DataFrame({'key': ['B', 'D', 'D', 'E'],
                     ....:   'value': np.random.randn(4)})
Assume we have two database tables of the same name and structure as our DataFrames.
Now let's go over the various types of JOINs.

31.4.1 INNER JOIN

SELECT *
FROM df1
INNER JOIN df2
    ON df1.key = df2.key;

# merge performs an INNER JOIN by default
In [24]: pd.merge(df1, df2, on='key')
Out[24]:
     key  value_x  value_y
0   B     0.8252  -0.532299
1   D     2.3453  -0.232477
2   D    -0.0409   0.159845

merge() also offers parameters for cases when you’d like to join one DataFrame’s column with another DataFrame’s index.

In [25]: indexed_df2 = df2.set_index('key')
In [26]: pd.merge(df1, indexed_df2, left_on='key', right_index=True)

(continues on next page)
pandas: powerful Python data analysis toolkit, Release 0.23.2

(continued from previous page)

31.4.2 LEFT OUTER JOIN

```sql
-- show all records from df1
SELECT *
FROM df1
LEFT OUTER JOIN df2
  ON df1.key = df2.key;
```

```python
# show all records from df1
In [27]: pd.merge(df1, df2, on='key', how='left')
Out[27]:
  key  value_x  value_y
0 A  0.116174   NaN
1 B -0.318214 0.543581
2 C  0.285261   NaN
3 D  2.169960 -0.426067
4 D  2.169960  1.138079
```

31.4.3 RIGHT JOIN

```sql
-- show all records from df2
SELECT *
FROM df1
RIGHT OUTER JOIN df2
  ON df1.key = df2.key;
```

```python
# show all records from df2
In [28]: pd.merge(df1, df2, on='key', how='right')
Out[28]:
  key  value_x  value_y
0 B -0.318214 0.543581
1 D  2.169960 -0.426067
2 D  2.169960  1.138079
3 E   NaN  0.086073
```

31.4.4 FULL JOIN

pandas also allows for FULL JOINs, which display both sides of the dataset, whether or not the joined columns find a match. As of writing, FULL JOINs are not supported in all RDBMS (MySQL).

```sql
-- show all records from both tables
SELECT *
FROM df1
FULL OUTER JOIN df2
  ON df1.key = df2.key;
```

31.4. JOIN
# show all records from both frames
In [29]: pd.merge(df1, df2, on='key', how='outer')
Out[29]:
   key  value_x  value_y
0 A  0.116174  NaN
1 B -0.318214  0.543581
2 C  0.285261  NaN
3 D  2.169960 -0.426067
4 D  2.169960  1.138079
5 E  NaN       0.086073

## 31.5 UNION

UNION ALL can be performed using `concat()`.

```python
In [30]: df1 = pd.DataFrame({'city': ['Chicago', 'San Francisco', 'New York City'],
                           'rank': range(1, 4)})
In [31]: df2 = pd.DataFrame({'city': ['Chicago', 'Boston', 'Los Angeles'],
                           'rank': [1, 4, 5]})
SELECT city, rank
FROM df1
UNION ALL
SELECT city, rank
FROM df2;

/*
   city  rank
Chicago  1
San Francisco  2
New York City  3
Chicago  1
Boston  4
Los Angeles  5
*/
```

```python
In [32]: pd.concat([df1, df2])
Out[32]:
   city   rank
0  Chicago    1
1  San Francisco    2
2  New York City    3
0  Chicago    1
1  Boston    4
2  Los Angeles    5
```

SQL's UNION is similar to UNION ALL, however UNION will remove duplicate rows.

```sql
SELECT city, rank
FROM df1
UNION
SELECT city, rank
```
FROM df2;
-- notice that there is only one Chicago record this time
/*
  city rank
    Chicago 1
    San Francisco 2
    New York City 3
    Boston 4
    Los Angeles 5
*/

In pandas, you can use `concat()` in conjunction with `drop_duplicates()`.

```
In [33]: pd.concat([df1, df2]).drop_duplicates()
Out[33]:
   city    rank
0  Chicago      1
1   San Francisco  2
2    New York City  3
1       Boston      4
2     Los Angeles    5
```

### 31.6 Pandas equivalents for some SQL analytic and aggregate functions

#### 31.6.1 Top N rows with offset

-- MySQL
```sql
SELECT * FROM tips
ORDER BY tip DESC
LIMIT 10 OFFSET 5;
```

```
In [34]: tips.nlargest(10+5, columns='tip').tail(10)
Out[34]:
<table>
<thead>
<tr>
<th>total_bill</th>
<th>tip</th>
<th>sex</th>
<th>smoker</th>
<th>day</th>
<th>time</th>
<th>size</th>
</tr>
</thead>
<tbody>
<tr>
<td>183</td>
<td>23.17</td>
<td>Male</td>
<td>Yes</td>
<td>Sun</td>
<td>Dinner</td>
<td>4</td>
</tr>
<tr>
<td>214</td>
<td>28.17</td>
<td>Male</td>
<td>Yes</td>
<td>Sat</td>
<td>Dinner</td>
<td>3</td>
</tr>
<tr>
<td>47</td>
<td>32.40</td>
<td>Male</td>
<td>No</td>
<td>Sun</td>
<td>Dinner</td>
<td>4</td>
</tr>
<tr>
<td>239</td>
<td>29.03</td>
<td>Male</td>
<td>No</td>
<td>Sat</td>
<td>Dinner</td>
<td>3</td>
</tr>
<tr>
<td>88</td>
<td>24.71</td>
<td>Male</td>
<td>No</td>
<td>Thur</td>
<td>Lunch</td>
<td>2</td>
</tr>
<tr>
<td>181</td>
<td>23.33</td>
<td>Male</td>
<td>Yes</td>
<td>Sun</td>
<td>Dinner</td>
<td>2</td>
</tr>
<tr>
<td>44</td>
<td>30.40</td>
<td>Male</td>
<td>No</td>
<td>Sun</td>
<td>Dinner</td>
<td>4</td>
</tr>
<tr>
<td>52</td>
<td>34.81</td>
<td>Female</td>
<td>No</td>
<td>Sun</td>
<td>Dinner</td>
<td>4</td>
</tr>
<tr>
<td>85</td>
<td>34.83</td>
<td>Female</td>
<td>No</td>
<td>Thur</td>
<td>Lunch</td>
<td>4</td>
</tr>
<tr>
<td>211</td>
<td>25.89</td>
<td>Male</td>
<td>Yes</td>
<td>Sat</td>
<td>Dinner</td>
<td>4</td>
</tr>
</tbody>
</table>
```

#### 31.6.2 Top N rows per group

-- Oracle's `ROW_NUMBER()` analytic function
```sql
SELECT * FROM ( (continued on next page)```
pandas: powerful Python data analysis toolkit, Release 0.23.2

SELECT
t.*, 
ROW_NUMBER() OVER(PARTITION BY day ORDER BY total_bill DESC) AS rn
FROM tips t
WHERE rn < 3
ORDER BY day, rn;

In [35]: (tips.assign(rn=tips.sort_values(['total_bill'], ascending=False)
    ....:     .groupby(['day'])
    ....:     .cumcount() + 1)
    ....:     .query('rn < 3')
    ....:     .sort_values(['day','rn'])
    ....: )
    ....:
Out[35]:

  total_bill  tip  sex  smoker  day  time  size  rn
95  40.17  4.73  Male   Yes  Fri  Dinner   4  1
90  28.97  3.00  Male   Yes  Fri  Dinner   2  2
170 50.81 10.00  Male   Yes  Sat  Dinner   3  1
212 48.33  9.00  Male    No  Sat  Dinner   4  2
156 48.17  5.00  Male    No  Sun  Dinner   6  1
182 45.35  3.50  Male   Yes  Sun  Dinner   3  2
197 43.11  5.00  Female  Yes  Thur  Lunch   4  1
142 41.19  5.00  Male    No  Thur  Lunch   5  2

the same using rank(method='first') function

In [36]: (tips.assign(rnk=tips.groupby(['day'])[['total_bill']]
    ....:     .rank(method='first', ascending=False))
    ....:     .query('rnk < 3')
    ....:     .sort_values(['day','rnk'])
    ....: )
    ....:
Out[36]:

  total_bill  tip  sex  smoker  day  time  size  rnk
95  40.17  4.73  Male   Yes  Fri  Dinner   4  1.0
90  28.97  3.00  Male   Yes  Fri  Dinner   2  2.0
170 50.81 10.00  Male   Yes  Sat  Dinner   3  1.0
212 48.33  9.00  Male    No  Sat  Dinner   4  2.0
156 48.17  5.00  Male    No  Sun  Dinner   6  1.0
182 45.35  3.50  Male   Yes  Sun  Dinner   3  2.0
197 43.11  5.00  Female  Yes  Thur  Lunch   4  1.0
142 41.19  5.00  Male    No  Thur  Lunch   5  2.0

-- Oracle’s RANK() analytic function

SELECT * FROM (  
  SELECT  
    t.*,  
    RANK() OVER(PARTITION BY sex ORDER BY tip) AS rnk
  FROM tips t  
  WHERE tip < 2
)  
WHERE rnk < 3  
ORDER BY sex, rnk;

Let’s find tips with (rank < 3) per gender group for (tips < 2). Notice that when using rank(method='min')
function \textit{rnk\_min} remains the same for the same \textit{tip} (as Oracle’s RANK() function)

\begin{Verbatim}
In [37]: (tips[tips['tip'] < 2]
    ....:   .assign(rnk_min=tips.groupby(['sex'])['tip']
    ....:       .rank(method='min'))
    ....:   .query('rnk\_min < 3')
    ....:   .sort_values(['sex','rnk\_min'])
    ....: )

Out[37]:
    total_bill  tip    sex   smoker day     time  size  rnk\_min
  67     3.07  1.00  Female   Yes   Sat  Dinner   1   1.0
  92     5.75  1.00  Female   Yes   Fri  Dinner   2   1.0
 111     7.25  1.00  Female    No   Sat  Dinner   1   1.0
 236    12.60  1.00   Male    Yes   Sat  Dinner   2   1.0
 237    32.83  1.17   Male    Yes   Sat  Dinner   2   2.0
\end{Verbatim}

\section{31.7 UPDATE}

\begin{Verbatim}
UPDATE tips
SET tip = tip*2
WHERE tip < 2;
\end{Verbatim}

\begin{Verbatim}
In [38]: tips.loc[tips['tip'] < 2, 'tip'] *= 2
\end{Verbatim}

\section{31.8 DELETE}

\begin{Verbatim}
DELETE FROM tips
WHERE tip > 9;
\end{Verbatim}

In pandas we select the rows that should remain, instead of deleting them

\begin{Verbatim}
In [39]: tips = tips.loc[tips['tip'] <= 9]
\end{Verbatim}
COMPARISON WITH SAS

For potential users coming from SAS this page is meant to demonstrate how different SAS operations would be performed in pandas.

If you’re new to pandas, you might want to first read through 10 Minutes to pandas to familiarize yourself with the library.

As is customary, we import pandas and NumPy as follows:

```
In [1]: import pandas as pd
In [2]: import numpy as np
```

**Note:** Throughout this tutorial, the pandas DataFrame will be displayed by calling `df.head()`, which displays the first N (default 5) rows of the DataFrame. This is often used in interactive work (e.g. Jupyter notebook or terminal) - the equivalent in SAS would be:

```
proc print data=df(obs=5);
run;
```

### 32.1 Data Structures

#### 32.1.1 General Terminology Translation

<table>
<thead>
<tr>
<th>pandas</th>
<th>SAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame</td>
<td>data set</td>
</tr>
<tr>
<td>column</td>
<td>variable</td>
</tr>
<tr>
<td>row</td>
<td>observation</td>
</tr>
<tr>
<td>groupby</td>
<td>BY-group</td>
</tr>
<tr>
<td>NaN</td>
<td>.</td>
</tr>
</tbody>
</table>

#### 32.1.2 DataFrame / Series

A DataFrame in pandas is analogous to a SAS data set - a two-dimensional data source with labeled columns that can be of different types. As will be shown in this document, almost any operation that can be applied to a data set using SAS’s DATA step, can also be accomplished in pandas.
A Series is the data structure that represents one column of a DataFrame. SAS doesn’t have a separate data structure for a single column, but in general, working with a Series is analogous to referencing a column in the DATA step.

### 32.1.3 Index

Every DataFrame and Series has an Index - which are labels on the rows of the data. SAS does not have an exactly analogous concept. A data set’s rows are essentially unlabeled, other than an implicit integer index that can be accessed during the DATA step (_N_).

In pandas, if no index is specified, an integer index is also used by default (first row = 0, second row = 1, and so on). While using a labeled Index or MultiIndex can enable sophisticated analyses and is ultimately an important part of pandas to understand, for this comparison we will essentially ignore the Index and just treat the DataFrame as a collection of columns. Please see the indexing documentation for much more on how to use an Index effectively.

### 32.2 Data Input / Output

#### 32.2.1 Constructing a DataFrame from Values

A SAS data set can be built from specified values by placing the data after a datalines statement and specifying the column names.

```sas
data df;
  input x y;
  datalines;
  1 2
  3 4
  5 6
; run;
```

A pandas DataFrame can be constructed in many different ways, but for a small number of values, it is often convenient to specify it as a Python dictionary, where the keys are the column names and the values are the data.

```python
In [3]: df = pd.DataFrame({
    ...:     'x': [1, 3, 5],
    ...:     'y': [2, 4, 6]})
```

```python
In [4]: df
Out[4]:
   x  y
0  1  2
1  3  4
2  5  6
```

#### 32.2.2 Reading External Data

Like SAS, pandas provides utilities for reading in data from many formats. The tips dataset, found within the pandas tests (csv) will be used in many of the following examples.

SAS provides PROC IMPORT to read csv data into a data set.
The pandas method is `read_csv()`, which works similarly.

Like PROC IMPORT, `read_csv` can take a number of parameters to specify how the data should be parsed. For example, if the data was instead tab delimited, and did not have column names, the pandas command would be:

```python
tips = pd.read_csv('tips.csv', sep='\t', header=None)
```

In addition to text/csv, pandas supports a variety of other data formats such as Excel, HDF5, and SQL databases. These are all read via a `pd.read_*` function. See the IO documentation for more details.

### 32.2.3 Exporting Data

The inverse of PROC IMPORT in SAS is PROC EXPORT

```python
proc export data=tips outfile='tips2.csv' dbms=csv;
run;
```

Similarly in pandas, the opposite of `read_csv` is `to_csv()`, and other data formats follow a similar api.

```python
tips.to_csv('tips2.csv')
```

### 32.3 Data Operations

#### 32.3.1 Operations on Columns

In the DATA step, arbitrary math expressions can be used on new or existing columns.

```python
data tips;
    set tips;
    total_bill = total_bill - 2;
    new_bill = total_bill / 2;
run;
```
pandas provides similar vectorized operations by specifying the individual Series in the DataFrame. New columns can be assigned in the same way.

```
In [8]: tips['total_bill'] = tips['total_bill'] - 2

In [9]: tips['new_bill'] = tips['total_bill'] / 2.0

In [10]: tips.head()
Out[10]:
          total_bill  tip  sex  smoker day  time  size  new_bill
0       14.99  1.01  Female    No  Sun  Dinner    2    7.495
1        8.34  1.66    Male    No  Sun  Dinner    3    4.170
2       19.01  3.50    Male    No  Sun  Dinner    3    9.505
3       21.68  3.31    Male    No  Sun  Dinner    2   10.840
4       22.59  3.61  Female    No  Sun  Dinner    4   11.295
```

### 32.3.2 Filtering

Filtering in SAS is done with an `if` or `where` statement, on one or more columns.

```
data tips;
  set tips;
  if total_bill > 10;
run;
```

```
data tips;
  set tips;
  where total_bill > 10;
  /* equivalent in this case - where happens before the
     DATA step begins and can also be used in PROC statements */
run;
```

DataFrames can be filtered in multiple ways; the most intuitive of which is using boolean indexing.

```
In [11]: tips[tips['total_bill'] > 10].head()
Out[11]:
          total_bill  tip  sex    smoker day  time  size
0      14.99  1.01  Female  No    Sun  Dinner    2
1      8.34  1.66    Male  No    Sun  Dinner    3
2    19.01  3.50    Male  No    Sun  Dinner    3
3    21.68  3.31    Male  No    Sun  Dinner    2
4    22.59  3.61  Female  No    Sun  Dinner    4
```

### 32.3.3 If/Then Logic

In SAS, if/then logic can be used to create new columns.

```
data tips;
  set tips;
  format bucket $4.;
  if total_bill < 10 then bucket = 'low';
  else bucket = 'high';
run;
```
The same operation in pandas can be accomplished using the `where` method from `numpy`.

```python
In [12]: tips['bucket'] = np.where(tips['total_bill'] < 10, 'low', 'high')
```

```python
In [13]: tips.head()
Out[13]:
     total_bill  tip    sex smoker  day  time  size  bucket
0      14.99  1.01  Female    No  Sun  Dinner    2   high
1       8.34  1.66    Male    No  Sun  Dinner    3    low
2      19.01  3.50    Male    No  Sun  Dinner    3   high
3      21.68  3.31    Male    No  Sun  Dinner    2   high
4      22.59  3.61  Female    No  Sun  Dinner    4   high
```

### 32.3.4 Date Functionality

SAS provides a variety of functions to do operations on date/datetime columns.

```sas
data tips;
   set tips;
   format date1 date2 date1_plusmonth mmdudy10.;
   date1 = mdy(1, 15, 2013);
   date2 = mdy(2, 15, 2015);
   date1_year = year(date1);
   date2_month = month(date2);
   * shift date to beginning of next interval;
   date1_next = intnx('MONTH', date1, 1);
   * count intervals between dates;
   months_between = intck('MONTH', date1, date2);
run;
```

The equivalent pandas operations are shown below. In addition to these functions pandas supports other Time Series features not available in Base SAS (such as resampling and custom offsets) - see the `timeseries documentation` for more details.

```python
In [14]: tips['date1'] = pd.Timestamp('2013-01-15')
In [15]: tips['date2'] = pd.Timestamp('2015-02-15')
In [16]: tips['date1_year'] = tips['date1'].dt.year
In [17]: tips['date2_month'] = tips['date2'].dt.month
In [18]: tips['date1_next'] = tips['date1'] + pd.offsets.MonthBegin()
In [19]: tips['months_between'] = (tips['date2'].dt.to_period('M') -
                              tips['date1'].dt.to_period('M'))
In [20]: tips[['date1', 'date2', 'date1_year', 'date2_month',
                           'date1_next', 'months_between']].head()
Out[20]:
    date1   date2  date1_year  date2_month  date1_next  months_between
```

(continues on next page)
32.3.5 Selection of Columns

SAS provides keywords in the `DATA` step to select, drop, and rename columns.

```sas
* keep;
data tips;
   set tips;
   keep sex total_bill tip;
run;
```

```sas
* drop;
data tips;
   set tips;
   drop sex;
run;
```

```sas
* rename;
data tips;
   set tips;
   rename total_bill=total_bill_2;
run;
```

The same operations are expressed in pandas below.

```python
# keep
In [21]: tips[['sex', 'total_bill', 'tip']].head()
Out[21]:
   sex  total_bill  tip
0  Female    14.99  1.01
1   Male     8.34  1.66
2   Male    19.01  3.50
3   Male   21.68  3.31
4  Female   22.59  3.61

# drop
In [22]: tips.drop('sex', axis=1).head()
   total_bill  tip  smoker  day  time  size
0    14.99  1.01  No Sun  Dinner  2
1     8.34  1.66  No Sun  Dinner  3
2    19.01  3.50  No Sun  Dinner  3
3    21.68  3.31  No Sun  Dinner  2
4    22.59  3.61  No Sun  Dinner  4

# rename
In [23]: tips.rename(columns={'total_bill':'total_bill_2'}).head()
   total_bill_2  tip  sex  smoker  day  time  size
0    14.99  1.01  Female  No Sun  Dinner  2
1     8.34  1.66   Male  No Sun  Dinner  3
2    19.01  3.50   Male  No Sun  Dinner  3
3    21.68  3.31   Male  No Sun  Dinner  2
4    22.59  3.61  Female  No Sun  Dinner  4
```
32.3.6 Sorting by Values

Sorting in SAS is accomplished via PROC SORT

```
proc sort data=tips;
  by sex total_bill;
run;
```

Pandas objects have a `sort_values()` method, which takes a list of columns to sort by.

```
In [24]: tips = tips.sort_values(['sex', 'total_bill'])
In [25]: tips.head()
Out[25]:
total_bill  tip  sex  smoker  day  time  size
67  1.07  1.00  Female  Yes  Sat  Dinner  1
92  3.75  1.00  Female  Yes  Fri  Dinner  2
111 5.25  1.00  Female   No  Sat  Dinner  1
145 6.35  1.50  Female   No  Thur  Lunch  2
135 6.51  1.25  Female   No  Thur  Lunch  2
```

32.4 String Processing

32.4.1 Length

SAS determines the length of a character string with the `LENGTHN` and `LENGTHC` functions. `LENGTHN` excludes trailing blanks and `LENGTHC` includes trailing blanks.

```
data _null_
  set tips;
  put (LENGTHN(time));
  put (LENGTHC(time));
run;
```

Python determines the length of a character string with the `len` function. `len` includes trailing blanks. Use `len` and `rstrip` to exclude trailing blanks.

```
In [26]: tips['time'].str.len().head()
Out[26]:
67    6
92    6
111   6
145   5
135   5
Name: time, dtype: int64
```
```
In [27]: tips['time'].str.rstrip().str.len().head()
\                                      Out[27]:
\                                      →
67    6
92    6
111   6
145   5
135   5
Name: time, dtype: int64
```

32.4.2 Find

SAS determines the position of a character in a string with the `FINDW` function. `FINDW` takes the string defined by the first argument and searches for the first position of the substring you supply as the second argument.

```python
data _null_;  
set tips;  
put (FINDW(sex,'ale'));  
run;
```

Python determines the position of a character in a string with the `find` function. `find` searches for the first position of the substring. If the substring is found, the function returns its position. Keep in mind that Python indexes are zero-based and the function will return -1 if it fails to find the substring.

```python
In [28]: tips['sex'].str.find("ale").head()
Out[28]:
   67    3
   92    3
  111    3
  145    3
  135    3
Name: sex, dtype: int64
```

32.4.3 Substring

SAS extracts a substring from a string based on its position with the `SUBSTR` function.

```python
data _null_;  
set tips;  
put (substr(sex,1,1));  
run;
```

With pandas you can use `[]` notation to extract a substring from a string by position locations. Keep in mind that Python indexes are zero-based.

```python
In [29]: tips['sex'].str[0:1].head()
Out[29]:
   67    F
   92    F
  111    F
  145    F
  135    F
Name: sex, dtype: object
```

32.4.4 Scan

The SAS `SCAN` function returns the nth word from a string. The first argument is the string you want to parse and the second argument specifies which word you want to extract.

```python
data firstlast;  
input String $60.;  
First_Name = scan(string, 1);  
Last_Name = scan(string, -1);  
datalines2;
```
Python extracts a substring from a string based on its text by using regular expressions. There are much more powerful approaches, but this just shows a simple approach.

```python
In [30]: firstlast = pd.DataFrame({'String': ['John Smith', 'Jane Cook']})
In [31]: firstlast['First_Name'] = firstlast['String'].str.split(" ", expand=True)[0]
In [32]: firstlast['Last_Name'] = firstlast['String'].str.rsplit(" ", expand=True)[0]
In [33]: firstlast
Out[33]:
    String  First_Name  Last_Name
0  John Smith      John      John
1    Jane Cook      Jane      Jane
```

### 32.4.5 Upcase, Lowcase, and Propcase

The SAS `UPCASE LOWCASE` and `PROPCASE` functions change the case of the argument.

```plaintext
data firstlast;
input String $60.;
string_up = UPCASE(string);
string_low = LOWCASE(string);
string_prop = PROPCASE(string);
datalines2;
John Smith;
Jane Cook;
;;;
run;
```

The equivalent Python functions are `upper`, `lower`, and `title`.

```python
In [34]: firstlast = pd.DataFrame({'String': ['John Smith', 'Jane Cook']})
In [35]: firstlast['string_up'] = firstlast['String'].str.upper()
In [36]: firstlast['string_low'] = firstlast['String'].str.lower()
In [37]: firstlast['string_prop'] = firstlast['String'].str.title()
In [38]: firstlast
Out[38]:
    String string_up string_low string_prop
0  John Smith   JOHN SMITH      john smith      John Smith
1    Jane Cook   JANE COOK      jane cook      Jane Cook
```
32.5 Merging

The following tables will be used in the merge examples

```python
In [39]: df1 = pd.DataFrame({'key': ['A', 'B', 'C', 'D'],
                        'value': np.random.randn(4)})

In [40]: df1
Out[40]:
   key    value
0   A  -0.857326
1   B   1.075416
2   C   0.371727
3   D   1.065735
```

```python
In [41]: df2 = pd.DataFrame({'key': ['B', 'D', 'D', 'E'],
                        'value': np.random.randn(4)})

In [42]: df2
Out[42]:
   key    value
0   B  -0.227314
1   D   2.102726
2   D  -0.092796
3   E   0.094694
```

In SAS, data must be explicitly sorted before merging. Different types of joins are accomplished using the `in=` dummy variables to track whether a match was found in one or both input frames.

```sas
proc sort data=df1;
  by key;
run;
proc sort data=df2;
  by key;
run;
data left_join inner_join right_join outer_join;
  merge df1(in=a) df2(in=b);
  if a and b then output inner_join;
  if a then output left_join;
  if b then output right_join;
  if a or b then output outer_join;
run;
```

pandas DataFrames have a `merge()` method, which provides similar functionality. Note that the data does not have to be sorted ahead of time, and different join types are accomplished via the `how` keyword.

```python
In [43]: inner_join = df1.merge(df2, on='key', how='inner')

In [44]: inner_join
Out[44]:
   key    value_x    value_y
0   B  1.075416  -0.227314
```

(continues on next page)
1 D 1.065735 2.102726
2 D 1.065735 -0.092796

In [45]: left_join = df1.merge(df2, on=['key'], how='left')

In [46]: left_join
Out[46]:
   key  value_x  value_y
0   A  -0.857326   NaN
1   B   1.075416 -0.227314
2   C   0.371727   NaN
3   D  1.065735  2.102726
4   D  1.065735 -0.092796

In [47]: right_join = df1.merge(df2, on=['key'], how='right')

In [48]: right_join
Out[48]:
   key  value_x  value_y
0   B   1.075416 -0.227314
1   D   1.065735  2.102726
2   D   1.065735 -0.092796
3   E    NaN    0.094694

In [49]: outer_join = df1.merge(df2, on=['key'], how='outer')

In [50]: outer_join
Out[50]:
   key  value_x  value_y
0   A  -0.857326   NaN
1   B   1.075416 -0.227314
2   C   0.371727   NaN
3   D   1.065735  2.102726
4   D   1.065735 -0.092796
5   E    NaN    0.094694

32.6 Missing Data

Like SAS, pandas has a representation for missing data - which is the special float value NaN (not a number). Many of the semantics are the same, for example missing data propagates through numeric operations, and is ignored by default for aggregations.

In [51]: outer_join
Out[51]:
   key  value_x  value_y
0   A  -0.857326   NaN
1   B   1.075416 -0.227314
2   C   0.371727   NaN
3   D   1.065735  2.102726
4   D   1.065735 -0.092796
5   E    NaN    0.094694

In [52]: outer_join['value_x'] + outer_join['value_y']

32.6. Missing Data
One difference is that missing data cannot be compared to its sentinel value. For example, in SAS you could do this to filter missing values.

```r
data outer_join_nulls;
  set outer_join;
  if value_x = .;
run;

data outer_join_no_nulls;
  set outer_join;
  if value_x ^= .;
run;
```

Which doesn’t work in pandas. Instead, the `pd.isna` or `pd.notna` functions should be used for comparisons.

```r
In [54]: outer_join[pd.isna(outer_join['value_x'])]
Out[54]:
key   value_x  value_y
5     E       NaN  0.094694

In [55]: outer_join[pd.notna(outer_join['value_x'])]
```

pandas also provides a variety of methods to work with missing data - some of which would be challenging to express in SAS. For example, there are methods to drop all rows with any missing values, replacing missing values with a specified value, like the mean, or forward filling from previous rows. See the `missing data documentation` for more.

```r
In [56]: outer_join.dropna()
Out[56]:
key   value_x  value_y
1     B  1.075416 -0.227314
2     C  0.371727
3     D  1.065735  2.102726
4     D  1.065735 -0.092796

In [57]: outer_join.fillna(method='ffill')
```

(continues on next page)
32.7 GroupBy

32.7.1 Aggregation

SAS’s PROC SUMMARY can be used to group by one or more key variables and compute aggregations on numeric columns.

```plaintext
proc summary data=tips nway;
   class sex smoker;
   var total_bill tip;
   output out=tips_summed sum=
run;
```

pandas provides a flexible `groupby` mechanism that allows similar aggregations. See the `groupby documentation` for more details and examples.

```plaintext
In [59]: tips_summed = tips.groupby(["sex", 'smoker'])[['total_bill', 'tip']].sum()

In [60]: tips_summed.head()
Out[60]:
   total_bill  tip
     sex  smoker
         Female No     869.68 149.77
          Yes     527.27   96.74
         Male No    1725.75 302.00
          Yes    1217.07 183.07
```

32.7.2 Transformation

In SAS, if the group aggregations need to be used with the original frame, it must be merged back together. For example, to subtract the mean for each observation by smoker group.
pandas: powerful Python data analysis toolkit, Release 0.23.2

```plaintext
proc summary data=tips missing nway;
   class smoker;
   var total_bill;
   output out=smoker_means mean(total_bill)=group_bill;
run;

proc sort data=tips;
   by smoker;
run;

data tips;
   merge tips(in=a) smoker_means(in=b);
   by smoker;
   adj_total_bill = total_bill - group_bill;
   if a and b;
run;
```

pandas `groupby` provides a transform mechanism that allows these type of operations to be succinctly expressed in one operation.

```
In [61]: gb = tips.groupby('smoker')['total_bill']
In [62]: tips['adj_total_bill'] = tips['total_bill'] - gb.transform('mean')
In [63]: tips.head()
Out[63]:
   total_bill  tip  sex  smoker  day  time  size  adj_total_bill
   67    1.07  1.00  Female  Yes  Sat  Dinner  1  -17.686344
   92    3.75  1.00  Female  Yes  Fri  Dinner  2  -15.006344
  111    5.25  1.00  Female  No  Sat  Dinner  1  -11.938278
  145    6.35  1.50  Female  No  Thur  Lunch  2  -10.838278
  135    6.51  1.25  Female  No  Thur  Lunch  2  -10.678278
```

### 32.7.3 By Group Processing

In addition to aggregation, pandas `groupby` can be used to replicate most other by group processing from SAS. For example, this `DATA` step reads the data by sex/smoker group and filters to the first entry for each.

```plaintext
proc sort data=tips;
   by sex smoker;
run;

data tips_first;
   set tips;
   by sex smoker;
   if FIRST.sex or FIRST_smoker then output;
run;
```

In pandas this would be written as:

```
In [64]: tips.groupby(["sex", "smoker"]).first()
Out[64]:
   total_bill  tip  day  time  size  adj_total_bill
   sex  smoker
   Female  No  5.25  1.00  Sat  Dinner  1  -11.938278
```

(continues on next page)
32.8 Other Considerations

32.8.1 Disk vs Memory

pandas operates exclusively in memory, where a SAS data set exists on disk. This means that the size of data able to be loaded in pandas is limited by your machine's memory, but also that the operations on that data may be faster.

If out of core processing is needed, one possibility is the dask.dataframe library (currently in development) which provides a subset of pandas functionality for an on-disk DataFrame.

32.8.2 Data Interop

pandas provides a `read_sas()` method that can read SAS data saved in the XPORT or SAS7BDAT binary format.

```python
libname xportout xport 'transport-file.xpt';
data xportout.tips;
  set tips(rename=(total_bill=tbill));
  * xport variable names limited to 6 characters;
run;

df = pd.read_sas('transport-file.xpt')
df = pd.read_sas('binary-file.sas7bdat')
```

You can also specify the file format directly. By default, pandas will try to infer the file format based on its extension.

```python
def = pd.read_sas('transport-file.xpt', format='xport')
df = pd.read_sas('binary-file.sas7bdat', format='sas7bdat')
```

XPORT is a relatively limited format and the parsing of it is not as optimized as some of the other pandas readers. An alternative way to interop data between SAS and pandas is to serialize to csv.

```bash
# version 0.17, 10M rows
In [8]: %time df = pd.read_sas('big.xpt')
Wall time: 14.6 s

In [9]: %time df = pd.read_csv('big.csv')
Wall time: 4.86 s
```
For potential users coming from Stata this page is meant to demonstrate how different Stata operations would be performed in pandas.

If you’re new to pandas, you might want to first read through *10 Minutes to pandas* to familiarize yourself with the library.

As is customary, we import pandas and NumPy as follows. This means that we can refer to the libraries as `pd` and `np`, respectively, for the rest of the document.

```python
In [1]: import pandas as pd
In [2]: import numpy as np
```

Note: Throughout this tutorial, the pandas DataFrame will be displayed by calling `df.head()`, which displays the first N (default 5) rows of the DataFrame. This is often used in interactive work (e.g. Jupyter notebook or terminal) – the equivalent in Stata would be:

```stata
list in 1/5
```

### 33.1 Data Structures

#### 33.1.1 General Terminology Translation

<table>
<thead>
<tr>
<th>pandas</th>
<th>Stata</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame</td>
<td>data set</td>
</tr>
<tr>
<td>column</td>
<td>variable</td>
</tr>
<tr>
<td>row</td>
<td>observation</td>
</tr>
<tr>
<td>groupby</td>
<td>bysort</td>
</tr>
<tr>
<td>NaN</td>
<td>.</td>
</tr>
</tbody>
</table>

#### 33.1.2 DataFrame / Series

A `DataFrame` in pandas is analogous to a Stata data set – a two-dimensional data source with labeled columns that can be of different types. As will be shown in this document, almost any operation that can be applied to a data set in Stata can also be accomplished in pandas.
A **Series** is the data structure that represents one column of a **DataFrame**. Stata doesn’t have a separate data structure for a single column, but in general, working with a **Series** is analogous to referencing a column of a data set in Stata.

### 33.1.3 Index

Every **DataFrame** and **Series** has an **Index** – labels on the **rows** of the data. Stata does not have an exactly analogous concept. In Stata, a data set’s rows are essentially unlabeled, other than an implicit integer index that can be accessed with **_n**.

In pandas, if no index is specified, an integer index is also used by default (first row = 0, second row = 1, and so on). While using a labeled **Index** or **MultiIndex** can enable sophisticated analyses and is ultimately an important part of pandas to understand, for this comparison we will essentially ignore the **Index** and just treat the **DataFrame** as a collection of columns. Please see the *indexing documentation* for much more on how to use an **Index** effectively.

### 33.2 Data Input / Output

#### 33.2.1 Constructing a DataFrame from Values

A Stata data set can be built from specified values by placing the data after an **input** statement and specifying the column names.

```stata
input x y
1 2
3 4
5 6
end
```

A pandas **DataFrame** can be constructed in many different ways, but for a small number of values, it is often convenient to specify it as a Python dictionary, where the keys are the column names and the values are the data.

```python
In [3]: df = pd.DataFrame({'x': [1, 3, 5],
                        'y': [2, 4, 6]})

In [4]: df
Out[4]:
   x  y
0  1  2
1  3  4
2  5  6
```

#### 33.2.2 Reading External Data

Like Stata, pandas provides utilities for reading in data from many formats. The **tips** data set, found within the pandas tests (**csv**) will be used in many of the following examples.

Stata provides **import delimited** to read csv data into a data set in memory. If the **tips.csv** file is in the current working directory, we can import it as follows.

```python
import delimited tips.csv
```
The pandas method is `read_csv()`, which works similarly. Additionally, it will automatically download the data set if presented with a url.

```python
In [5]: url = 'https://raw.github.com/pandas-dev/pandas/master/pandas/tests/data/tips.csv'
In [6]: tips = pd.read_csv(url)
In [7]: tips.head()
```

```
Out[7]:
                      total_bill  tip   sex  smoker day time size
0     16.990000  1.010000 Female  No  Sun  Dinner  2
1     10.340000  1.660000  Male  No  Sun  Dinner  3
2     21.010000  3.500000  Male  No  Sun  Dinner  3
3     23.680000  3.310000  Male  No  Sun  Dinner  2
4     24.590000  3.610000 Female  No  Sun  Dinner  4
```

Like `import delimited`, `read_csv()` can take a number of parameters to specify how the data should be parsed. For example, if the data were instead tab delimited, did not have column names, and existed in the current working directory, the pandas command would be:

```python
tips = pd.read_csv('tips.csv', sep='\t', header=None)
# alternatively, read_table is an alias to read_csv with tab delimiter
# tips = pd.read_table('tips.csv', header=None)
```

Pandas can also read Stata data sets in `.dta` format with the `read_stata()` function.

```python
df = pd.read_stata('data.dta')
```

In addition to text/csv and Stata files, pandas supports a variety of other data formats such as Excel, SAS, HDF5, Parquet, and SQL databases. These are all read via a `pd.read_*` function. See the IO documentation for more details.

### 33.2.3 Exporting Data

The inverse of `import delimited` in Stata is `export delimited`

```bash
export delimited tips2.csv
```

Similarly in pandas, the opposite of `read_csv` is `DataFrame.to_csv()`.

```python
tips.to_csv('tips2.csv')
```

Pandas can also export to Stata file format with the `DataFrame.to_stata()` method.

```python
tips.to_stata('tips2.dta')
```

### 33.3 Data Operations

#### 33.3.1 Operations on Columns

In Stata, arbitrary math expressions can be used with the `generate` and `replace` commands on new or existing columns. The `drop` command drops the column from the data set.
pandas provides similar vectorized operations by specifying the individual Series in the DataFrame. New columns can be assigned in the same way. The `DataFrame.drop()` method drops a column from the DataFrame.

```python
In [8]: tips['total_bill'] = tips['total_bill'] - 2
In [9]: tips['new_bill'] = tips['total_bill'] / 2
In [10]: tips.head()
Out[10]:
   total_bill  tip  sex  smoker  day  time  size  new_bill
0     14.99  1.01  Female    No  Sun  Dinner     2   7.495
1      8.34  1.66    Male    No  Sun  Dinner     3   4.170
2     19.01  3.50    Male    No  Sun  Dinner     3   9.505
3     21.68  3.31    Male    No  Sun  Dinner     2  10.840
4     22.59  3.61  Female    No  Sun  Dinner     4  11.295
```

### 33.3.2 Filtering

Filtering in Stata is done with an `if` clause on one or more columns.

```stata
list if total_bill > 10
```

DataFrames can be filtered in multiple ways; the most intuitive of which is using boolean indexing.

```python
In [12]: tips[tips['total_bill'] > 10].head()
Out[12]:
   total_bill  tip  sex  smoker  day  time  size
0     14.99  1.01  Female    No  Sun  Dinner     2
2     19.01  3.50    Male    No  Sun  Dinner     3
3     21.68  3.31    Male    No  Sun  Dinner     2
4     22.59  3.61  Female    No  Sun  Dinner     4
```

### 33.3.3 If/Then Logic

In Stata, an `if` clause can also be used to create new columns.

```stata
generate bucket = "low" if total_bill < 10
replace bucket = "high" if total_bill >= 10
```

The same operation in pandas can be accomplished using the `where` method from numpy.

```python
In [13]: tips['bucket'] = np.where(tips['total_bill'] < 10, 'low', 'high')
In [14]: tips.head()
Out[14]:
   total_bill  tip  sex  smoker  day  time  size  bucket
0     14.99  1.01  Female    No  Sun  Dinner     2   high
```

(continues on next page)
### 33.3.4 Date Functionality

Stata provides a variety of functions to do operations on date/datetime columns.

```stata
generate date1 = mdy(1, 15, 2013)
generate date2 = date("Feb152015", "MDY")
generate date1_year = year(date1)
generate date2_month = month(date2)
+ shift date to beginning of next month
generate date1_next = mdy(month(date1) + 1, 1, year(date1)) if month(date1) != 12
replace date1_next = mdy(1, 1, year(date1) + 1) if month(date1) == 12
generate months_between = mofd(date2) - mofd(date1)
list date1 date2 date1_year date2_month date1_next months_between
```

The equivalent pandas operations are shown below. In addition to these functions, pandas supports other Time Series features not available in Stata (such as time zone handling and custom offsets) – see the [timeseries documentation](#) for more details.

```python
In [15]: tips['date1'] = pd.Timestamp('2013-01-15')
In [16]: tips['date2'] = pd.Timestamp('2015-02-15')
In [17]: tips['date1_year'] = tips['date1'].dt.year
In [18]: tips['date2_month'] = tips['date2'].dt.month
In [19]: tips['date1_next'] = tips['date1'] + pd.offsets.MonthBegin()
In [20]: tips['months_between'] = (tips['date2'].dt.to_period('M') -
                                tips['date1'].dt.to_period('M'))
In [21]: tips[['date1', 'date2', 'date1_year', 'date2_month', 'date1_next', 'months_between']].head()
```

### 33.3.5 Selection of Columns

Stata provides keywords to select, drop, and rename columns.
The same operations are expressed in pandas below. Note that in contrast to Stata, these operations do not happen in place. To make these changes persist, assign the operation back to a variable.

```python
# keep
In [22]: tips[['sex', 'total_bill', 'tip']].head()
Out[22]:
   sex  total_bill  tip
0  Female   14.99    1.01
1    Male     8.34    1.66
2    Male   19.01    3.50
3    Male   21.68    3.31
4  Female   22.59    3.61

# drop
In [23]: tips.drop('sex', axis=1).head()
    →
   total_bill  tip  smoker  day  time  size
0   14.99    1.01  No  Sun  Dinner  2
1    8.34    1.66  No  Sun  Dinner  3
2   19.01    3.50  No  Sun  Dinner  3
3   21.68    3.31  No  Sun  Dinner  2
4   22.59    3.61  No  Sun  Dinner  4

# rename
In [24]: tips.rename(columns={'total_bill': 'total_bill_2'}).head()
   →
   total_bill_2  tip  sex  smoker  day  time  size
0     14.99  1.01  Female  No  Sun  Dinner  2
1      8.34  1.66    Male  No  Sun  Dinner  3
2     19.01  3.50    Male  No  Sun  Dinner  3
3     21.68  3.31    Male  No  Sun  Dinner  2
4     22.59  3.61  Female  No  Sun  Dinner  4
```

33.3.6 Sorting by Values

Sorting in Stata is accomplished via `sort`.

```
sort sex total_bill
```

Pandas objects have a `DataFrame.sort_values()` method, which takes a list of columns to sort by.

```
In [25]: tips = tips.sort_values(['sex', 'total_bill'])
In [26]: tips.head()
Out[26]:
   total_bill  tip  sex  smoker  day  time  size
67     1.07  1.00  Female  Yes  Sat  Dinner  1
```
33.4 String Processing

33.4.1 Finding Length of String

Stata determines the length of a character string with the `strlen()` and `ustrlen()` functions for ASCII and Unicode strings, respectively.

```plaintext
generate strlen_time = strlen(time)
generate ustrlen_time = ustrlen(time)
```

Python determines the length of a character string with the `len` function. In Python 3, all strings are Unicode strings. `len` includes trailing blanks. Use `len` and `rstrip` to exclude trailing blanks.

```plaintext
In [27]: tips["time"].str.len().head()
Out[27]:
       67   6
       92   6
      111   6
      145   5
      135   5
Name: time, dtype: int64

In [28]: tips["time"].str.rstrip().str.len().head()
Out[28]:
         67   6
         92   6
        111   6
        145   5
        135   5
Name: time, dtype: int64
```

33.4.2 Finding Position of Substring

Stata determines the position of a character in a string with the `strpos()` function. This takes the string defined by the first argument and searches for the first position of the substring you supply as the second argument.

```plaintext
generate str_position = strpos(sex, "ale")
```

Python determines the position of a character in a string with the `find()` function. `find` searches for the first position of the substring. If the substring is found, the function returns its position. Keep in mind that Python indexes are zero-based and the function will return -1 if it fails to find the substring.

```plaintext
In [29]: tips["sex"].str.find("ale").head()
Out[29]:
   67   3
```

(continues on next page)
33.4.3 Extracting Substring by Position

Stata extracts a substring from a string based on its position with the `substr()` function.

```
generate short_sex = substr(sex, 1, 1)
```

With pandas you can use `[ ]` notation to extract a substring from a string by position locations. Keep in mind that Python indexes are zero-based.

```
In [30]: tips['sex'].str[0:1].head()
Out[30]:
         67    F
         92    F
        111    F
        145    F
        135    F
Name: sex, dtype: object
```

33.4.4 Extracting nth Word

The Stata `word()` function returns the nth word from a string. The first argument is the string you want to parse and the second argument specifies which word you want to extract.

```
clear
input str20 string
 "John Smith"
 "Jane Cook"
end

generate first_name = word(name, 1)

generate last_name = word(name, -1)
```

Python extracts a substring from a string based on its text by using regular expressions. There are much more powerful approaches, but this just shows a simple approach.

```
In [31]: firstlast = pd.DataFrame({'string': ['John Smith', 'Jane Cook']})
In [32]: firstlast['First_Name'] = firstlast['string'].str.split(" ", expand=True)[0]
In [33]: firstlast['Last_Name'] = firstlast['string'].str.rsplit(" ", expand=True)[0]
In [34]: firstlast
Out[34]:
         string First_Name Last_Name
0     John Smith       John       John
1      Jane Cook       Jane       Jane
```
33.4.5 Changing Case

The Stata `strupper()`, `strlower()`, `strproper()`, `ustrupper()`, `ustrlower()`, and `ustrtitle()` functions change the case of ASCII and Unicode strings, respectively.

```stata
clear
input str20 string
"John Smith"
"Jane Cook"
end
generate upper = strupper(string)
generate lower = strlower(string)
generate title = strproper(string)
list
```

The equivalent Python functions are `upper`, `lower`, and `title`.

```python
In [35]: firstlast = pd.DataFrame({'string': ['John Smith', 'Jane Cook']})
In [36]: firstlast['upper'] = firstlast['string'].str.upper()
In [37]: firstlast['lower'] = firstlast['string'].str.lower()
In [38]: firstlast['title'] = firstlast['string'].str.title()
In [39]: firstlast
Out[39]:
     string     upper     lower     title
0  John Smith  JOHN SMITH  john smith  John Smith
1    Jane Cook       JANE COOK  jane cook    Jane Cook
```

33.5 Merging

The following tables will be used in the merge examples

```python
In [40]: df1 = pd.DataFrame({'key': ['A', 'B', 'C', 'D'],
                      'value': np.random.randn(4)})
In [41]: df1
Out[41]:
     key    value
0    A  0.885906
1    B  0.794848
2    C -0.943848
3    D  0.328609
In [42]: df2 = pd.DataFrame({'key': ['B', 'D', 'D', 'E'],
                      'value': np.random.randn(4)})
In [43]: df2
Out[43]:
     key    value
0    B  0.043828
1    D  1.073388
2    D -0.138664
3    E  0.510937
```

(continues on next page)
In Stata, to perform a merge, one data set must be in memory and the other must be referenced as a file name on disk. In contrast, Python must have both DataFrame already in memory.

By default, Stata performs an outer join, where all observations from both data sets are left in memory after the merge. One can keep only observations from the initial data set, the merged data set, or the intersection of the two by using the values created in the `_merge` variable.

```stata
* First create df2 and save to disk
clear
input str1 key
B
D
D
E
end
generate value = rnormal()
save df2.dta

* Now create df1 in memory
clear
input str1 key
A
B
C
D
end
generate value = rnormal()

preserve

* Left join
merge 1:n key using df2.dta
keep if _merge == 1

* Right join
restore, preserve
merge 1:n key using df2.dta
keep if _merge == 2

* Inner join
restore, preserve
merge 1:n key using df2.dta
keep if _merge == 3

* Outer join
restore
merge 1:n key using df2.dta
```

pandas DataFrames have a `DataFrame.merge()` method, which provides similar functionality. Note that different join types are accomplished via the `how` keyword.
In [44]: inner_join = df1.merge(df2, on=['key'], how='inner')

In [45]: inner_join
Out[45]:
   key  value_x  value_y
0  B   0.794848 -1.634931
1  D   0.328609  2.197567
2  D   0.328609  0.054695

In [46]: left_join = df1.merge(df2, on=['key'], how='left')

In [47]: left_join
Out[47]:
   key  value_x  value_y
0  A   0.885906       NaN
1  B   0.794848 -1.634931
2  C  -0.943848       NaN
3  D   0.328609  2.197567
4  D   0.328609  0.054695
5  E       NaN   0.283297

In [48]: right_join = df1.merge(df2, on=['key'], how='right')

In [49]: right_join
Out[49]:
   key  value_x  value_y
0  B   0.794848 -1.634931
1  D   0.328609  2.197567
2  D   0.328609  0.054695
3  E       NaN   0.283297

In [50]: outer_join = df1.merge(df2, on=['key'], how='outer')

In [51]: outer_join
Out[51]:
   key  value_x  value_y
0  A   0.885906       NaN
1  B   0.794848 -1.634931
2  C  -0.943848       NaN
3  D   0.328609  2.197567
4  D   0.328609  0.054695
5  E       NaN   0.283297

33.6 Missing Data

Like Stata, pandas has a representation for missing data – the special float value NaN (not a number). Many of the semantics are the same; for example missing data propagates through numeric operations, and is ignored by default for aggregations.
In [53]: outer_join['value_x'] + outer_join['value_y']

<table>
<thead>
<tr>
<th>key</th>
<th>value_x</th>
<th>value_y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NaN</td>
<td>-0.840083</td>
</tr>
<tr>
<td>1</td>
<td>2.526176</td>
<td>NaN</td>
</tr>
<tr>
<td>2</td>
<td>0.383304</td>
<td>0.283297</td>
</tr>
<tr>
<td>3</td>
<td>NaN</td>
<td>2.197567</td>
</tr>
<tr>
<td>4</td>
<td>NaN</td>
<td>0.054695</td>
</tr>
</tbody>
</table>

dtype: float64

In [54]: outer_join['value_x'].sum()

-1.3941243310085349

One difference is that missing data cannot be compared to its sentinel value. For example, in Stata you could do this to filter missing values.

* Keep missing values

```plaintext
list if value_x == .
```

* Keep non-missing values

```plaintext
list if value_x != .
```

This doesn’t work in pandas. Instead, the `pd.isna()` or `pd.notna()` functions should be used for comparisons.

In [55]: outer_join[pd.isna(outer_join['value_x'])]

Out[55]:

<table>
<thead>
<tr>
<th>key</th>
<th>value_x</th>
<th>value_y</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>NaN</td>
<td>0.283297</td>
</tr>
</tbody>
</table>

In [56]: outer_join[pd.notna(outer_join['value_x'])]

Out[56]:

<table>
<thead>
<tr>
<th>key</th>
<th>value_x</th>
<th>value_y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.885906</td>
<td>NaN</td>
</tr>
<tr>
<td>1</td>
<td>0.794848</td>
<td>-1.634931</td>
</tr>
<tr>
<td>2</td>
<td>-0.943848</td>
<td>NaN</td>
</tr>
<tr>
<td>3</td>
<td>0.328609</td>
<td>2.197567</td>
</tr>
<tr>
<td>4</td>
<td>0.328609</td>
<td>0.054695</td>
</tr>
</tbody>
</table>

Pandas also provides a variety of methods to work with missing data – some of which would be challenging to express in Stata. For example, there are methods to drop all rows with any missing values, replacing missing values with a specified value, like the mean, or forward filling from previous rows. See the missing data documentation for more.

# Drop rows with any missing value
In [57]: outer_join.dropna()

Out[57]:

<table>
<thead>
<tr>
<th>key</th>
<th>value_x</th>
<th>value_y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.794848</td>
<td>-1.634931</td>
</tr>
<tr>
<td>3</td>
<td>0.328609</td>
<td>2.197567</td>
</tr>
<tr>
<td>4</td>
<td>0.328609</td>
<td>0.054695</td>
</tr>
</tbody>
</table>

# Fill forwards
In [58]: outer_join.fillna(method='ffill')
### 33.7 GroupBy

#### 33.7.1 Aggregation

Stata’s *collapse* can be used to group by one or more key variables and compute aggregations on numeric columns.

```
collapse (sum) total_bill tip, by(sex smoker)
```

Pandas provides a flexible `groupby` mechanism that allows similar aggregations. See the [groupby documentation](#) for more details and examples.

```
In [60]: tips_summed = tips.groupby(['sex', 'smoker'])[['total_bill', 'tip']].sum()

In [61]: tips_summed.head()
Out[61]:

<table>
<thead>
<tr>
<th>sex</th>
<th>smoker</th>
<th>total_bill</th>
<th>tip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>No</td>
<td>869.68</td>
<td>149.77</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>527.27</td>
<td>96.74</td>
</tr>
<tr>
<td>Male</td>
<td>No</td>
<td>1725.75</td>
<td>302.00</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>1217.07</td>
<td>183.07</td>
</tr>
</tbody>
</table>
```

#### 33.7.2 Transformation

In Stata, if the group aggregations need to be used with the original data set, one would usually use `bysort` with `egen()`. For example, to subtract the mean for each observation by smoker group.

```
bysort sex smoker: egen group_bill = mean(total_bill)
generate adj_total_bill = total_bill - group_bill
```
pandas groupby provides a transform mechanism that allows these type of operations to be succinctly expressed in one operation.

```python
In [62]: gb = tips.groupby('smoker')['total_bill']
In [63]: tips['adj_total_bill'] = tips['total_bill'] - gb.transform('mean')
In [64]: tips.head()
```

33.7.3 By Group Processing

In addition to aggregation, pandas groupby can be used to replicate most other bysort processing from Stata. For example, the following example lists the first observation in the current sort order by sex/smoker group.

```
bysort sex smoker: list if _n == 1
```

In pandas this would be written as:

```python
In [65]: tips.groupby(['sex','smoker']).first()
```

33.8 Other Considerations

33.8.1 Disk vs Memory

Pandas and Stata both operate exclusively in memory. This means that the size of data able to be loaded in pandas is limited by your machine’s memory. If out of core processing is needed, one possibility is the dask.dataframe library, which provides a subset of pandas functionality for an on-disk DataFrame.
This page gives an overview of all public pandas objects, functions and methods. All classes and functions exposed in pandas.* namespace are public.

Some subpackages are public which include pandas.errors, pandas.plotting, and pandas.testing. Public functions in pandas.io and pandas.tseries submodules are mentioned in the documentation. pandas.api.types subpackage holds some public functions related to data types in pandas.

**Warning:** The pandas.core, pandas.compat, and pandas.util top-level modules are PRIVATE. Stable functionality in such modules is not guaranteed.

### 34.1 Input/Output

#### 34.1.1 Pickling

**read_pickle**(path[, compression])  
Load pickled pandas object (or any object) from file.

**34.1.1.1 pandas.read_pickle**

pandas.read_pickle(path, compression='infer')  
Load pickled pandas object (or any object) from file.

**Warning:** Loading pickled data received from untrusted sources can be unsafe. See [here](#).

**Parameters**  

- **path**: str  
  File path where the pickled object will be loaded.

  For on-the-fly decompression of on-disk data. If ‘infer’, then use gzip, bz2, xz or zip if path ends in ‘.gz’, ‘.bz2’, ‘.xz’, or ‘.zip’ respectively, and no decompression otherwise. Set to None for no decompression.

**Returns**  

- **unpickled**: [type of object stored in file]  
  New in version 0.20.0.
See also:

Dataframe.to_pickle  Pickle (serialize) DataFrame object to file.
Series.to_pickle    Pickle (serialize) Series object to file.
read_hdf             Read HDF5 file into a DataFrame.
read_sql             Read SQL query or database table into a DataFrame.
read_parquet         Load a parquet object, returning a DataFrame.

Examples

```python
>>> original_df = pd.DataFrame({"foo": range(5), "bar": range(5, 10)})
>>> original_df
   foo  bar
0  0   5
1  1   6
2  2   7
3  3   8
4  4   9
>>> pd.to_pickle(original_df, ".\dummy.pkl")

>>> unpickled_df = pd.read_pickle("./dummy.pkl")
>>> unpickled_df
   foo  bar
0  0   5
1  1   6
2  2   7
3  3   8
4  4   9

>>> import os
>>> os.remove("./dummy.pkl")
```

34.1.2 Flat File

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>read_table(filepath_or_buffer[, sep,...])</td>
<td>Read general delimited file into DataFrame</td>
</tr>
<tr>
<td>read_csv(filepath_or_buffer[, sep,...])</td>
<td>Read CSV (comma-separated) file into DataFrame</td>
</tr>
<tr>
<td>read_fwf(filepath_or_buffer[, colspecs, widths])</td>
<td>Read a table of fixed-width formatted lines into DataFrame</td>
</tr>
<tr>
<td>read_msgpack(path_or_buf[, encoding, iterator])</td>
<td>Load msgpack pandas object from the specified file path</td>
</tr>
</tbody>
</table>
34.1.2.1 pandas.read_table

```python
pandas.read_table(filepath_or_buffer, sep='\t', delimiter=None, header='infer', names=None, index_col=None, usecols=None, squeeze=False, prefix=None, mangle_dupe_cols=True, dtype=None, engine=None, converters=None, true_values=None, false_values=None, skipinitialspace=False, skiprows=None, nrows=None, na_values=None, keep_default_na=True, na_filter=True, verbose=False, skip_blank_lines=True, parse_dates=False, infer_datetime_format=False, keep_date_col=False, date_parser=None, dayfirst=False, iterator=False, chunksize=None, compression='infer', thousands=None, decimal=b'. ', lineterminator=None, quoting=0, escapechar=None, comment=None, encoding=None, dialect=None, tupleize_cols=None, error_bad_lines=True, warn_bad_lines=True, skipfooter=0, doublequote=True, delim_whitespace=False, low_memory=True, memory_map=False, float_precision=None)
```

Read general delimited file into DataFrame

Also supports optionally iterating or breaking of the file into chunks.

Additional help can be found in the [online docs for IO Tools](https://pandas.pydata.org/pandas-docs/stable/user_guide/io.html#read-table).

**Parameters**

- **filepath_or_buffer** [str, pathlib.Path, py._path.local.LocalPath or any \]
  - object with a read() method (such as a file handle or StringIO)

  The string could be a URL. Valid URL schemes include http, ftp, s3, and file. For file URLs, a host is expected. For instance, a local file could be `file://localhost/path/to/table.csv`

- **sep** : str, default t (tab-stop)

  Delimiter to use. If sep is None, the C engine cannot automatically detect the separator, but the Python parsing engine can, meaning the latter will be used and automatically detect the separator by Python’s builtin sniffer tool, csv.Sniffer. In addition, separators longer than 1 character and different from ' \s+' will be interpreted as regular expressions and will also force the use of the Python parsing engine. Note that regex delimiters are prone to ignoring quoted data. Regex example: ' \t\t'

- **delimiter** : str, default None

  Alternative argument name for sep

- **delim_whitespace** : boolean, default False

  Specifies whether or not whitespace (e.g. ' ' or '	') will be used as the sep. Equivalent to setting `sep='\s+'`. If this option is set to True, nothing should be passed in for the `delimiter` parameter.

  New in version 0.18.1: support for the Python parser.

- **header** : int or list of ints, default ‘infer’

  Row number(s) to use as the column names, and the start of the data. Default behavior is to infer the column names: if no names are passed the behavior is identical to `header=0` and column names are inferred from the first line of the file, if column names are passed explicitly then the behavior is identical to `header=None`. Explicitly pass `header=0` to be able to replace existing names. The header can be a list of integers that specify row locations for a multi-index on the columns e.g. `[0,1,3]`. Intervening rows that are not specified will be skipped (e.g. 2 in this example is skipped). Note that this parameter ignores commented lines and empty lines if
skip_blank_lines=True, so header=0 denotes the first line of data rather than the first line of the file.

names : array-like, default None

List of column names to use. If file contains no header row, then you should explicitly pass header=None. Duplicates in this list will cause a UserWarning to be issued.

index_col : int or sequence or False, default None

Column to use as the row labels of the DataFrame. If a sequence is given, a MultiIndex is used. If you have a malformed file with delimiters at the end of each line, you might consider index_col=False to force pandas to _not_ use the first column as the index (row names)

usecols : list-like or callable, default None

Return a subset of the columns. If list-like, all elements must either be positional (i.e. integer indices into the document columns) or strings that correspond to column names provided either by the user in names or inferred from the document header row(s). For example, a valid list-like usecols parameter would be [0, 1, 2] or ['foo', 'bar', 'baz']. Element order is ignored, so usecols=[0, 1] is the same as [1, 0]. To instantiate a DataFrame from data with element order preserved use pd.read_csv(data, usecols=['foo', 'bar'])[['foo', 'bar']] for columns in ['foo', 'bar'] order or pd.read_csv(data, usecols=['foo', 'bar'])[['bar', 'foo']] for ['bar', 'foo'] order.

If callable, the callable function will be evaluated against the column names, returning names where the callable function evaluates to True. An example of a valid callable argument would be lambda x: x.upper() in ['AAA', 'BBB', 'DDD']. Using this parameter results in much faster parsing time and lower memory usage.

squeeze : boolean, default False

If the parsed data only contains one column then return a Series

prefix : str, default None

Prefix to add to column numbers when no header, e.g. ‘X’ for X0, X1, …

mangle_dupe_cols : boolean, default True

Duplicate columns will be specified as ‘X’, ‘X.1’, … ‘X.N’, rather than ‘X’… ‘X’. Passing in False will cause data to be overwritten if there are duplicate names in the columns.

dtype : Type name or dict of column -> type, default None

Data type for data or columns. E.g. {'a': np.float64, 'b': np.int32} Use str or object together with suitable na_values settings to preserve and not interpret dtype. If converters are specified, they will be applied INSTEAD of dtype conversion.

engine : {'c', 'python'}, optional

Parser engine to use. The C engine is faster while the python engine is currently more feature-complete.

converters : dict, default None

Dict of functions for converting values in certain columns. Keys can either be integers or column labels

true_values : list, default None
Values to consider as True

false_values : list, default None
Values to consider as False

skipinitialspace : boolean, default False
Skip spaces after delimiter.

skiprows : list-like or integer or callable, default None
Line numbers to skip (0-indexed) or number of lines to skip (int) at the start of the file.
If callable, the callable function will be evaluated against the row indices, returning True if the row should be skipped and False otherwise. An example of a valid callable argument would be lambda x: x in [0, 2].

skipfooter : int, default 0
Number of lines at bottom of file to skip (Unsupported with engine='c')

nrows : int, default None
Number of rows of file to read. Useful for reading pieces of large files

na_values : scalar, str, list-like, or dict, default None
Additional strings to recognize as NA/NaN. If dict passed, specific per-column NA values. By default the following values are interpreted as NaN: '', '#N/A', '#N/A #N/A', '<NA>', '<1.#IND>', '<1.#QNAN>', '<Na>', '1.0', 'NA', 'N/A', '

keep_default_na : bool, default True
Whether or not to include the default NaN values when parsing the data. Depending on whether na_values is passed in, the behavior is as follows:

- If keep_default_na is True, and na_values are specified, na_values is appended to the default NaN values used for parsing.
- If keep_default_na is True, and na_values are not specified, only the default NaN values are used for parsing.
- If keep_default_na is False, and na_values are specified, only the NaN values specified na_values are used for parsing.
- If keep_default_na is False, and na_values are not specified, no strings will be parsed as NaN.
Note that if na_filter is passed in as False, the keep_default_na and na_values parameters will be ignored.

na_filter : boolean, default True
Detect missing value markers (empty strings and the value of na_values). In data without any NAs, passing na_filter=False can improve the performance of reading a large file

verbose : boolean, default False
Indicate number of NA values placed in non-numeric columns

skip_blank_lines : boolean, default True
If True, skip over blank lines rather than interpreting as NaN values
**parse_dates**: boolean or list of ints or names or list of lists or dict, default False

- boolean. If True -> try parsing the index.
- list of ints or names. e.g. If [1, 2, 3] -> try parsing columns 1, 2, 3 each as a separate date column.
- list of lists. e.g. If [[1, 3]] -> combine columns 1 and 3 and parse as a single date column.
- dict, e.g. {'foo': [1, 3]} -> parse columns 1, 3 as date and call result ‘foo’

If a column or index contains an unparseable date, the entire column or index will be returned unaltered as an object data type. For non-standard datetime parsing, use `pd.to_datetime` after `pd.read_csv`

Note: A fast-path exists for iso8601-formatted dates.

**infer_datetime_format**: boolean, default False

If True and `parse_dates` is enabled, pandas will attempt to infer the format of the datetime strings in the columns, and if it can be inferred, switch to a faster method of parsing them. In some cases this can increase the parsing speed by 5-10x.

**keep_date_col**: boolean, default False

If True and `parse_dates` specifies combining multiple columns then keep the original columns.

**date_parser**: function, default None

Function to use for converting a sequence of string columns to an array of datetime instances. The default uses `dateutil.parser.parser` to do the conversion. Pandas will try to call `date_parser` in three different ways, advancing to the next if an exception occurs: 1) Pass one or more arrays (as defined by `parse_dates`) as arguments; 2) concatenate (row-wise) the string values from the columns defined by `parse_dates` into a single array and pass that; and 3) call `date_parser` once for each row using one or more strings (corresponding to the columns defined by `parse_dates`) as arguments.

**dayfirst**: boolean, default False

DD/MM format dates, international and European format

**iterator**: boolean, default False

Return TextFileReader object for iteration or getting chunks with `get_chunk()`.

**chunksize**: int, default None

Return TextFileReader object for iteration. See the IO Tools docs for more information on `iterator` and `chunksize`.

**compression**: {'infer', 'gzip', 'bz2', 'zip', 'xz', None}, default `infer`

For on-the-fly decompression of on-disk data. If `infer` and `filepath_or_buffer` is path-like, then detect compression from the following extensions: `.gz`, `.bz2`, `.zip`, or `.xz` (otherwise no decompression). If using ‘zip’, the ZIP file must contain only one data file to be read in. Set to None for no decompression.

New in version 0.18.1: support for ‘zip’ and ‘xz’ compression.

**thousands**: str, default None

Thousands separator

**decimal**: str, default ‘.’
Character to recognize as decimal point (e.g. use ',' for European data).

**float_precision** : string, default None

Specifies which converter the C engine should use for floating-point values. The options are *None* for the ordinary converter, *high* for the high-precision converter, and *round_trip* for the round-trip converter.

**lineterminator** : str (length 1), default None

Character to break file into lines. Only valid with C parser.

**quotechar** : str (length 1), optional

The character used to denote the start and end of a quoted item. Quoted items can include the delimiter and it will be ignored.

**quoting** : int or csv.QUOTE_* instance, default 0

Control field quoting behavior per csv.QUOTE_* constants. Use one of QUOTE_MINIMAL (0), QUOTE_ALL (1), QUOTE_NONNUMERIC (2) or QUOTE_NONE (3).

**doublequote** : boolean, default True

When quotechar is specified and quoting is not QUOTE_NONE, indicate whether or not to interpret two consecutive quotechar elements INSIDE a field as a single quotechar element.

**escapechar** : str (length 1), default None

One-character string used to escape delimiter when quoting is QUOTE_NONE.

**comment** : str, default None

Indicates remainder of line should not be parsed. If found at the beginning of a line, the line will be ignored altogether. This parameter must be a single character. Like empty lines (as long as skip_blank_lines=True), fully commented lines are ignored by the parameter header but not by skiprows. For example, if comment='#', parsing #empty\na,b,c\n1,2,3 with header=0 will result in ‘a,b,c’ being treated as the header.

**encoding** : str, default None

Encoding to use for UTF when reading/writing (ex. ‘utf-8’). List of Python standard encodings

**dialect** : str or csv.Dialect instance, default None

If provided, this parameter will override values (default or not) for the following parameters: delimiter, doublequote, escapechar, skipinitialspace, quotechar, and quoting. If it is necessary to override values, a ParserWarning will be issued. See csv.Dialect documentation for more details.

**tupleize_cols** : boolean, default False

Deprecated since version 0.21.0: This argument will be removed and will always convert to MultiIndex

Leave a list of tuples on columns as is (default is to convert to a MultiIndex on the columns)

**error_bad_lines** : boolean, default True
Lines with too many fields (e.g. a csv line with too many commas) will by default cause an exception to be raised, and no DataFrame will be returned. If False, then these “bad lines” will dropped from the DataFrame that is returned.

**warn_bad_lines**: boolean, default True

If error_bad_lines is False, and warn_bad_lines is True, a warning for each “bad line” will be output.

**low_memory**: boolean, default True

Internally process the file in chunks, resulting in lower memory use while parsing, but possibly mixed type inference. To ensure no mixed types either set False, or specify the type with the `dtype` parameter. Note that the entire file is read into a single DataFrame regardless, use the `chunksize` or `iterator` parameter to return the data in chunks. (Only valid with C parser)

**memory_map**: boolean, default False

If a filepath is provided for `filepath_or_buffer`, map the file object directly onto memory and access the data directly from there. Using this option can improve performance because there is no longer any I/O overhead.

Returns

result [DataFrame or TextParser]

### 34.1.2.2 pandas.read_csv

`pandas.read_csv(filepath_or_buffer, sep=’,’, delimiter=None, header=’infer’, names=None, index_col=None, usecols=None, squeeze=False, prefix=None, mangle_dupe_cols=True, dtype=None, engine=None, converters=None, true_values=None, false_values=None, keep_default_na=True, na_filter=True, verbose=False, skip_blank_lines=True, parse_dates=False, infer_datetime_format=False, keep_date_col=False, date_parser=None, dayfirst=False, iterator=False, chunksize=None, compression='infer', thousands=None, decimal=b’.’, lineterminator=None, quotechar=’”’, quoting=0, escapechar=None, comment=None, encoding=None, dialect=None, tupleize_cols=None, error_bad_lines=True, warn_bad_lines=True, skipfooter=0, doublequote=True, delim_whitespace=False, low_memory=True, memory_map=False, float_precision=None)`

Read CSV (comma-separated) file into DataFrame

Also supports optionally iterating or breaking of the file into chunks.

Additional help can be found in the online docs for IO Tools.

**Parameters**

**filepath_or_buffer** [str, pathlib.Path, py._path.local.LocalPath or any `\`]

object with a read() method (such as a file handle or StringIO)

The string could be a URL. Valid URL schemes include http, ftp, s3, and file. For file URLs, a host is expected. For instance, a local file could be `file://localhost/path/to/table.csv`

**sep**: str, default ‘,’

Delimiter to use. If sep is None, the C engine cannot automatically detect the separator, but the Python parsing engine can, meaning the latter will be used and automatically
detect the separator by Python’s builtin sniffer tool, `csv.Sniffer`. In addition, separators longer than 1 character and different from `\s+` will be interpreted as regular expressions and will also force the use of the Python parsing engine. Note that regex delimiters are prone to ignoring quoted data. Regex example: `\r\t`.

**delimiter**: str, default `None`

Alternative argument name for `sep`.

**delim_whitespace**: boolean, default `False`

Specifies whether or not whitespace (e.g. `' '` or `'\t'`) will be used as the sep. Equivalent to setting `sep='\s+'`. If this option is set to True, nothing should be passed in for the `delimiter` parameter.

New in version 0.18.1: support for the Python parser.

**header**: int or list of ints, default `'infer'`

Row number(s) to use as the column names, and the start of the data. Default behavior is to infer the column names: if no names are passed the behavior is identical to `header=0` and column names are inferred from the first line of the file, if column names are passed explicitly then the behavior is identical to `header=None`. Explicitly pass `header=0` to be able to replace existing names. The header can be a list of integers that specify row locations for a multi-index on the columns e.g. `[0,1,3]`. Intervening rows that are not specified will be skipped (e.g. 2 in this example is skipped). Note that this parameter ignores commented lines and empty lines if `skip_blank_lines=True`, so `header=0` denotes the first line of data rather than the first line of the file.

**names**: array-like, default `None`

List of column names to use. If file contains no header row, then you should explicitly pass `header=None`. Duplicates in this list will cause a `UserWarning` to be issued.

**index_col**: int or sequence or False, default `None`

Column to use as the row labels of the DataFrame. If a sequence is given, a MultiIndex is used. If you have a malformed file with delimiters at the end of each line, you might consider `index_col=False` to force pandas to _not_ use the first column as the index (row names).

**usecols**: list-like or callable, default `None`

Return a subset of the columns. If list-like, all elements must either be positional (i.e. integer indices into the document columns) or strings that correspond to column names provided either by the user in `names` or inferred from the document header row(s). For example, a valid list-like `usecols` parameter would be `[0, 1, 2]` or `['foo', 'bar', 'baz']`. Element order is ignored, so `usecols=[0, 1]` is the same as `[1, 0]`. To instantiate a DataFrame from data with element order preserved use `pd.read_csv(data, usecols=['foo', 'bar'])[['foo', 'bar']]` for columns in `['foo', 'bar']` order or `pd.read_csv(data, usecols=['foo', 'bar'])[['bar', 'foo']]` for `['bar', 'foo']` order.

If callable, the callable function will be evaluated against the column names, returning names where the callable function evaluates to True. An example of a valid callable argument would be `lambda x: x.upper() in ['AAA', 'BBB', 'DDD']`. Using this parameter results in much faster parsing time and lower memory usage.

**squeeze**: boolean, default `False`
If the parsed data only contains one column then return a Series

**prefix**: str, default None

Prefix to add to column numbers when no header, e.g. ‘X’ for X0, X1, …

**mangle_dupe_cols**: boolean, default True

Duplicate columns will be specified as ‘X’, ‘X.1’, … ‘X.N’, rather than ‘X’… ‘X’. Passing in False will cause data to be overwritten if there are duplicate names in the columns.

**dtype**: Type name or dict of column -> type, default None

Data type for data or columns. E.g. {'a': np.float64, 'b': np.int32} Use str or object together with suitable na_values settings to preserve and not interpret dtype. If converters are specified, they will be applied INSTEAD of dtype conversion.

**engine**: {'c', 'python'}, optional

Parser engine to use. The C engine is faster while the python engine is currently more feature-complete.

**converters**: dict, default None

Dict of functions for converting values in certain columns. Keys can either be integers or column labels

**true_values**: list, default None

Values to consider as True

**false_values**: list, default None

Values to consider as False

**skipinitialspace**: boolean, default False

Skip spaces after delimiter.

**skiprows**: list-like or integer or callable, default None

Line numbers to skip (0-indexed) or number of lines to skip (int) at the start of the file.

If callable, the callable function will be evaluated against the row indices, returning True if the row should be skipped and False otherwise. An example of a valid callable argument would be lambda x: x in [0, 2].

**skipfooter**: int, default 0

Number of lines at bottom of file to skip (Unsupported with engine='c')

**nrows**: int, default None

Number of rows of file to read. Useful for reading pieces of large files

**na_values**: scalar, str, list-like, or dict, default None

Additional strings to recognize as NA/NaN. If dict passed, specific per-column NA values. By default the following values are interpreted as NaN: ’’, ‘#N/A’, ‘#N/A N/A’, ‘#NA’, ‘-1.#IND’, ‘-1.#QNAN’, ‘-NaN’, ‘-nan’, ‘1.#IND’, ‘1.#QNAN’, ‘N/A’, ‘NA’, ‘NULL’, ‘NaN’, ‘n/a’, ‘nan’, ‘null’.

**keep_default_na**: bool, default True

Whether or not to include the default NaN values when parsing the data. Depending on whether na_values is passed in, the behavior is as follows:
If `keep_default_na` is True, and `na_values` are specified, `na_values` is appended to the default NaN values used for parsing.

If `keep_default_na` is True, and `na_values` are not specified, only the default NaN values are used for parsing.

If `keep_default_na` is False, and `na_values` are specified, only the NaN values specified `na_values` are used for parsing.

If `keep_default_na` is False, and `na_values` are not specified, no strings will be parsed as NaN.

Note that if `na_filter` is passed in as False, the `keep_default_na` and `na_values` parameters will be ignored.

**`na_filter`**: boolean, default True

Detect missing value markers (empty strings and the value of `na_values`). In data without any NAs, passing `na_filter=False` can improve the performance of reading a large file.

**`verbose`**: boolean, default False

Indicate number of NA values placed in non-numeric columns.

**`skip_blank_lines`**: boolean, default True

If True, skip over blank lines rather than interpreting as NaN values.

**`parse_dates`**: boolean or list of ints or names or list of lists or dict, default False

- boolean. If True -> try parsing the index.
- list of ints or names. e.g. If [1, 2, 3] -> try parsing columns 1, 2, 3 each as a separate date column.
- list of lists. e.g. If [[1, 3]] -> combine columns 1 and 3 and parse as a single date column.
- dict, e.g. {'foo': [1, 3]} -> parse columns 1, 3 as date and call result ‘foo’

If a column or index contains an unparseable date, the entire column or index will be returned unaltered as an object data type. For non-standard datetime parsing, use `pd.to_datetime` after `pd.read_csv`.

Note: A fast-path exists for iso8601-formatted dates.

**`infer_datetime_format`**: boolean, default False

If True and `parse_dates` is enabled, pandas will attempt to infer the format of the date-time strings in the columns, and if it can be inferred, switch to a faster method of parsing them. In some cases this can increase the parsing speed by 5-10x.

**`keep_date_col`**: boolean, default False

If True and `parse_dates` specifies combining multiple columns then keep the original columns.

**`date_parser`**: function, default None

Function to use for converting a sequence of string columns to an array of datetime instances. The default uses `dateutil.parser.parser` to do the conversion. Pandas will try to call `date_parser` in three different ways, advancing to the next if an exception occurs: 1) Pass one or more arrays (as defined by `parse_dates`) as arguments; 2) concatenate (row-wise) the string values from the columns defined by `parse_dates` into a
single array and pass that; and 3) call date_parser once for each row using one or more strings (corresponding to the columns defined by parse_dates) as arguments.

dayfirst : boolean, default False
   DD/MM format dates, international and European format

iterator : boolean, default False
   Return TextFileReader object for iteration or getting chunks with get_chunk().

chunksize : int, default None
   Return TextFileReader object for iteration. See the IO Tools docs for more information on iterator and chunksize.

compression : {'infer', 'gzip', 'bz2', 'zip', 'xz', None}, default ‘infer’
   For on-the-fly decompression of on-disk data. If ‘infer’ and filepath_or_buffer is path-like, then detect compression from the following extensions: '.gz', '.bz2', '.zip', or '.xz' (otherwise no decompression). If using ‘zip’, the ZIP file must contain only one data file to be read in. Set to None for no decompression.
   New in version 0.18.1: support for ‘zip’ and ‘xz’ compression.

thousands : str, default None
   Thousands separator

decimal : str, default ‘.’
   Character to recognize as decimal point (e.g. use ‘,’ for European data).

float_precision : string, default None
   Specifies which converter the C engine should use for floating-point values. The options are None for the ordinary converter, high for the high-precision converter, and round_trip for the round-trip converter.

lineterminator : str (length 1), default None
   Character to break file into lines. Only valid with C parser.

quotechar : str (length 1), optional
   The character used to denote the start and end of a quoted item. Quoted items can include the delimiter and it will be ignored.

quoting : int or csv.QUOTE_* instance, default 0
   Control field quoting behavior per csv.QUOTE_* constants. Use one of QUOTE_MINIMAL (0), QUOTE_ALL (1), QUOTE_NONNUMERIC (2) or QUOTE_NONE (3).

doublequote : boolean, default True
   When quotechar is specified and quoting is not QUOTE_NONE, indicate whether or not to interpret two consecutive quotechar elements INSIDE a field as a single quotechar element.

escapechar : str (length 1), default None
   One-character string used to escape delimiter when quoting is QUOTE_NONE.

comment : str, default None
Indicates remainder of line should not be parsed. If found at the beginning of a line, the line will be ignored altogether. This parameter must be a single character. Like empty lines (as long as `skip_blank_lines=True`), fully commented lines are ignored by the parameter `header` but not by `skiprows`. For example, if `comment='#'`, parsing
```
#empty
a,b,c
1,2,3
```
with `header=0` will result in ‘a,b,c’ being treated as the header.

**encoding**: str, default None

Encoding to use for UTF when reading/writing (ex. ‘utf-8’). [List of Python standard encodings](http://docs.python.org/3/library/codecs.html#standard-encodings)

**dialect**: str or csv.Dialect instance, default None

If provided, this parameter will override values (default or not) for the following parameters: `delimiter`, `doublequote`, `escapechar`, `skipinitialspace`, `quotechar`, and `quoting`. If it is necessary to override values, a ParserWarning will be issued. See csv.Dialect documentation for more details.

**tupleize_cols**: boolean, default False

Deprecated since version 0.21.0: This argument will be removed and will always convert to MultiIndex

Leave a list of tuples on columns as is (default is to convert to a MultiIndex on the columns)

**error_bad_lines**: boolean, default True

Lines with too many fields (e.g. a csv line with too many commas) will by default cause an exception to be raised, and no DataFrame will be returned. If False, then these “bad lines” will dropped from the DataFrame that is returned.

**warn_bad_lines**: boolean, default True

If `error_bad_lines` is False, and `warn_bad_lines` is True, a warning for each “bad line” will be output.

**low_memory**: boolean, default True

Internally process the file in chunks, resulting in lower memory use while parsing, but possibly mixed type inference. To ensure no mixed types either set False, or specify the type with the `dtype` parameter. Note that the entire file is read into a single DataFrame regardless, use the `chunksize` or `iterator` parameter to return the data in chunks. (Only valid with C parser)

**memory_map**: boolean, default False

If a filepath is provided for `filepath_or_buffer`, map the file object directly onto memory and access the data directly from there. Using this option can improve performance because there is no longer any I/O overhead.

**Returns**

result  [DataFrame or TextParser]

### 34.1.2.3 pandas.read_fwf

pandas.read_fwf (filepath_or_buffer, colspecs='infer', widths=None, **kwds)

Read a table of fixed-width formatted lines into DataFrame

Also supports optionally iterating or breaking of the file into chunks.
Additional help can be found in the online docs for IO Tools.

Parameters

- filepath_or_buffer [str, pathlib.Path, py._path.local.LocalPath or any ]

- object with a read() method (such as a file handle or StringIO)

  The string could be a URL. Valid URL schemes include http, ftp, s3, and file. For file URLs, a host is expected. For instance, a local file could be file://localhost/path/to/table.csv

- colspecs : list of pairs (int, int) or ‘infer’. optional

  A list of pairs (tuples) giving the extents of the fixed-width fields of each line as half-open intervals (i.e., [from, to[ ). String value ‘infer’ can be used to instruct the parser to try detecting the column specifications from the first 100 rows of the data which are not being skipped via skiprows (default=‘infer’).

- widths : list of ints. optional

  A list of field widths which can be used instead of ‘colspecs’ if the intervals are contiguous.

- delimiter : str, default ‘ ‘ + ‘ ‘

  Characters to consider as filler characters in the fixed-width file. Can be used to specify the filler character of the fields if it is not spaces (e.g., ‘~’).

- delim_whitespace : boolean, default False

  Specifies whether or not whitespace (e.g. ‘ ‘ or ‘\t’) will be used as the sep. Equivalent to setting sep=’\s+’. If this option is set to True, nothing should be passed in for the delimiter parameter.

  New in version 0.18.1: support for the Python parser.

- header : int or list of ints, default ‘infer’

  Row number(s) to use as the column names, and the start of the data. Default behavior is to infer the column names: if no names are passed the behavior is identical to header=0 and column names are inferred from the first line of the file, if column names are passed explicitly then the behavior is identical to header=None. Explicitly pass header=0 to be able to replace existing names. The header can be a list of integers that specify row locations for a multi-index on the columns e.g. [0,1,3]. Intervening rows that are not specified will be skipped (e.g. 2 in this example is skipped). Note that this parameter ignores commented lines and empty lines if skip_blank_lines=True, so header=0 denotes the first line of data rather than the first line of the file.

- names : array-like, default None

  List of column names to use. If file contains no header row, then you should explicitly pass header=None. Duplicates in this list will cause a UserWarning to be issued.

- index_col : int or sequence or False, default None

  Column to use as the row labels of the DataFrame. If a sequence is given, a MultiIndex is used. If you have a malformed file with delimiters at the end of each line, you might consider index_col=False to force pandas to _not_ use the first column as the index (row names)

- usecols : list-like or callable, default None
Return a subset of the columns. If list-like, all elements must either be positional (i.e. integer indices into the document columns) or strings that correspond to column names provided either by the user in names or inferred from the document header row(s). For example, a valid list-like usecols parameter would be [0, 1, 2] or ['foo', 'bar', 'baz']. Element order is ignored, so usecols=[0, 1] is the same as [1, 0]. To instantiate a DataFrame from data with element order preserved use pd.read_csv(data, usecols=['foo', 'bar'])[['foo', 'bar']] for columns in ['foo', 'bar'] order or pd.read_csv(data, usecols=['foo', 'bar'])[['bar', 'foo']] for ['bar', 'foo'] order.

If callable, the callable function will be evaluated against the column names, returning names where the callable function evaluates to True. An example of a valid callable argument would be lambda x: x.upper() in ['AAA', 'BBB', 'DDD']. Using this parameter results in much faster parsing time and lower memory usage.

squeeze : boolean, default False

If the parsed data only contains one column then return a Series

prefix : str, default None

Prefix to add to column numbers when no header, e.g. ‘X’ for X0, X1, …

mangle_dupe_cols : boolean, default True

Duplicate columns will be specified as ‘X’, ‘X.1’, … ‘X.N’, rather than ‘X’ . . . ‘X’. Passing in False will cause data to be overwritten if there are duplicate names in the columns.

dtype : Type name or dict of column -> type, default None

Data type for data or columns. E.g. {'a': np.float64, 'b': np.int32} Use str or object together with suitable na_values settings to preserve and not interpret dtypes. If converters are specified, they will be applied INSTEAD of dtype conversion.

converters : dict, default None

Dict of functions for converting values in certain columns. Keys can either be integers or column labels

true_values : list, default None

Values to consider as True

false_values : list, default None

Values to consider as False

skipinitialspace : boolean, default False

Skip spaces after delimiter.

skiprows : list-like or integer or callable, default None

Line numbers to skip (0-indexed) or number of lines to skip (int) at the start of the file.

If callable, the callable function will be evaluated against the row indices, returning True if the row should be skipped and False otherwise. An example of a valid callable argument would be lambda x: x in [0, 2].

skipfooter : int, default 0

Number of lines at bottom of file to skip (Unsupported with engine='c')

nrows : int, default None
Number of rows of file to read. Useful for reading pieces of large files

**na_values**: scalar, str, list-like, or dict, default None

Additional strings to recognize as NA/NaN. If dict passed, specific per-column NA values. By default the following values are interpreted as NaN: ‘’, ‘#N/A’, ‘#N/A N/A’, ‘#NA’, ‘-1.#IND’, ‘-1.#QNAN’, ‘-NaN’, ‘-nan’, ‘1.#IND’, ‘1.#QNAN’, ‘N/A’, ‘NA’, ‘NULL’, ‘NaN’, ‘n/a’, ‘nan’, ‘null’.

**keep_default_na**: bool, default True

Whether or not to include the default NaN values when parsing the data. Depending on whether *na_values* is passed in, the behavior is as follows:

- If *keep_default_na* is True, and *na_values* are specified, *na_values* is appended to the default NaN values used for parsing.
- If *keep_default_na* is True, and *na_values* are not specified, only the default NaN values are used for parsing.
- If *keep_default_na* is False, and *na_values* are specified, only the NaN values specified *na_values* are used for parsing.
- If *keep_default_na* is False, and *na_values* are not specified, no strings will be parsed as NaN.

Note that if *na_filter* is passed in as False, the *keep_default_na* and *na_values* parameters will be ignored.

**na_filter**: boolean, default True

Detect missing value markers (empty strings and the value of *na_values*). In data without any NAs, passing *na_filter=True* can improve the performance of reading a large file

**verbose**: boolean, default False

Indicate number of NA values placed in non-numeric columns

**skip_blank_lines**: boolean, default True

If True, skip over blank lines rather than interpreting as NaN values

**parse_dates**: boolean or list of ints or names or list of lists or dict, default False

- boolean. If True -> try parsing the index.
- list of ints or names. e.g. If [1, 2, 3] -> try parsing columns 1, 2, 3 each as a separate date column.
- list of lists. e.g. If [[1, 3]] -> combine columns 1 and 3 and parse as a single date column.
- dict, e.g. {‘foo’ : [1, 3]} -> parse columns 1, 3 as date and call result ‘foo’

If a column or index contains an unparseable date, the entire column or index will be returned unaltered as an object data type. For non-standard datetime parsing, use *pd.to_datetime* after *pd.read_csv*

Note: A fast-path exists for iso8601-formatted dates.

**infer_datetime_format**: boolean, default False

If True and *parse_dates* is enabled, pandas will attempt to infer the format of the date-time strings in the columns, and if it can be inferred, switch to a faster method of parsing them. In some cases this can increase the parsing speed by 5-10x.
keep_date_col : boolean, default False

If True and parse_dates specifies combining multiple columns then keep the original
columns.

date_parser : function, default None

Function to use for converting a sequence of string columns to an array of datetime in-
stances. The default uses dateutil.parser.parser to do the conversion. Pandas
will try to call date_parser in three different ways, advancing to the next if an exception
occurs: 1) Pass one or more arrays (as defined by parse_dates) as arguments; 2) con-
catenate (row-wise) the string values from the columns defined by parse_dates into a
single array and pass that; and 3) call date_parser once for each row using one or more
strings (corresponding to the columns defined by parse_dates) as arguments.

dayfirst : boolean, default False

DD/MM format dates, international and European format

iterator : boolean, default False

Return TextFileReader object for iteration or getting chunks with get_chunk().

chunksize : int, default None

Return TextFileReader object for iteration. See the IO Tools docs for more information
on iterator and chunksize.

compression : {'infer', 'gzip', 'bz2', 'zip', 'xz', None}, default ‘infer’

For on-the-fly decompression of on-disk data. If ‘infer’ and filepath_or_buffer is path-
like, then detect compression from the following extensions: ‘.gz’, ‘.bz2’, ‘.zip’, or ‘.xz’
(otherwise no decompression). If using ‘zip’, the ZIP file must contain only one data
file to be read in. Set to None for no decompression.

New in version 0.18.1: support for ‘zip’ and ‘xz’ compression.

thousands : str, default None

Thousands separator

decimal : str, default ‘.’

Character to recognize as decimal point (e.g. use ‘,’ for European data).

float_precision : string, default None

Specifies which converter the C engine should use for floating-point values. The op-
tions are None for the ordinary converter, high for the high-precision converter, and
round_trip for the round-trip converter.

lineterminator : str (length 1), default None

Character to break file into lines. Only valid with C parser.

quotechar : str (length 1), optional

The character used to denote the start and end of a quoted item. Quoted items can
include the delimiter and it will be ignored.

quoting : int or csv.QUOTE_* instance, default 0

Control field quoting behavior per csv.QUOTE_* constants. Use one of
QUOTE_MINIMAL (0), QUOTE_ALL (1), QUOTE_NONNUMERIC (2) or
QUOTE_NONE (3).
**doublequote**: boolean, default `True`

When quotechar is specified and quoting is not `QUOTE_NONE`, indicate whether or not to interpret two consecutive quotechar elements INSIDE a field as a single quotechar element.

**escapechar**: str (length 1), default None

One-character string used to escape delimiter when quoting is `QUOTE_NONE`.

**comment**: str, default None

Indicates remainder of line should not be parsed. If found at the beginning of a line, the line will be ignored altogether. This parameter must be a single character. Like empty lines (as long as `skip_blank_lines=True`), fully commented lines are ignored by the parameter `header` but not by `skiprows`. For example, if `comment='#'`, parsing 
```
#empty
a,b,c
1,2,3
```
with `header=0` will result in ‘a,b,c’ being treated as the header.

**encoding**: str, default None

Encoding to use for UTF when reading/writing (ex. ‘utf-8’). See Python standard encodings

**dialect**: str or csv.Dialect instance, default None

If provided, this parameter will override values (default or not) for the following parameters: `delimiter`, `doublequote`, `escapechar`, `skipinitialspace`, `quotechar`, and `quoting`. If it is necessary to override values, a ParserWarning will be issued. See csv.Dialect documentation for more details.

**tupleize_cols**: boolean, default False

Deprecated since version 0.21.0: This argument will be removed and will always convert to MultiIndex

Leave a list of tuples on columns as is (default is to convert to a MultiIndex on the columns)

**error_bad_lines**: boolean, default True

Lines with too many fields (e.g. a csv line with too many commas) will by default cause an exception to be raised, and no DataFrame will be returned. If False, then these “bad lines” will dropped from the DataFrame that is returned.

**warn_bad_lines**: boolean, default True

If `error_bad_lines` is False, and `warn_bad_lines` is True, a warning for each “bad line” will be output.

**low_memory**: boolean, default True

Internally process the file in chunks, resulting in lower memory use while parsing, but possibly mixed type inference. To ensure no mixed types either set False, or specify the type with the `dtype` parameter. Note that the entire file is read into a single DataFrame regardless, use the `chunksize` or `iterator` parameter to return the data in chunks. (Only valid with C parser)

**memory_map**: boolean, default False

If a filepath is provided for `filepath_or_buffer`, map the file object directly onto memory and access the data directly from there. Using this option can improve performance because there is no longer any I/O overhead.
34.1.2.4 pandas.read_msgpack

```python
pandas.read_msgpack(path_or_buf, encoding='utf-8', iterator=False, **kwargs)
```

Load msgpack pandas object from the specified file path

**THIS IS AN EXPERIMENTAL LIBRARY** and the storage format may not be stable until a future release.

**Parameters**

- `path_or_buf` [string File path, BytesIO like or string]
- `encoding` : Encoding for decoding msgpack str type
- `iterator` : boolean, if True, return an iterator to the unpacker
  (default is False)

**Returns**

- `obj` [type of object stored in file]

34.1.3 Clipboard

```python
read_clipboard([sep])
```

Read text from clipboard and pass to read_table.

34.1.3.1 pandas.read_clipboard

```python
pandas.read_clipboard(sep='\s+', **kwargs)
```

Read text from clipboard and pass to read_table. See read_table for the full argument list

**Parameters**

- `sep` : str, default ‘s+’.
  A string or regex delimiter. The default of ‘s+’ denotes one or more whitespace characters.

**Returns**

- `parsed` [DataFrame]

34.1.4 Excel

```python
read_excel(io[, sheet_name, header, names, ...])
```

Read an Excel table into a pandas DataFrame

```python
ExcelFile.parse([sheet_name, header, names, ...])
```

Parse specified sheet(s) into a DataFrame

34.1. Input/Output
34.1.4.1 pandas.read_excel

```python
pandas.read_excel(io, sheet_name=0, header=0, names=None, index_col=None, usecols=None, squeeze=False, dtype=None, engine=None, converters=None, true_values=None, false_values=None, skiprows=None, nrows=None, na_values=None, parse_dates=False, date_parser=None, thousands=None, comment=None, skipfooter=0, convert_float=True, **kwds)
```

Read an Excel table into a pandas DataFrame

**Parameters**

- `io`: string, path object (pathlib.Path or py._path.local.LocalPath), file-like object, pandas ExcelFile, or xlrd workbook. The string could be a URL. Valid URL schemes include http, ftp, s3, and file. For file URLs, a host is expected. For instance, a local file could be file://localhost/path/to/workbook.xlsx

- `sheet_name`: string, int, mixed list of strings/integers, or None, default 0
  - Strings are used for sheet names, Integers are used in zero-indexed sheet positions.
  - Lists of strings/integers are used to request multiple sheets.
  - Specify None to get all sheets.
  - str/int -> DataFrame is returned. list|None -> Dict of DataFrames is returned, with keys representing sheets.
  - Available Cases
  - Defaults to 0 -> 1st sheet as a DataFrame
  - 1 -> 2nd sheet as a DataFrame
  - "Sheet1" -> 1st sheet as a DataFrame
  - [0,1,"Sheet5"] -> 1st, 2nd & 5th sheet as a dictionary of DataFrames
  - None -> All sheets as a dictionary of DataFrames

- `sheetname`: string, int, mixed list of strings/integers, or None, default 0
  - Deprecated since version 0.21.0: Use `sheet_name` instead

- `header`: int, list of ints, default 0
  - Row (0-indexed) to use for the column labels of the parsed DataFrame. If a list of integers is passed those row positions will be combined into a MultiIndex. Use None if there is no header.

- `names`: array-like, default None
  - List of column names to use. If file contains no header row, then you should explicitly pass `header=None`

- `index_col`: int, list of ints, default None
  - Column (0-indexed) to use as the row labels of the DataFrame. Pass None if there is no such column. If a list is passed, those columns will be combined into a MultiIndex. If a subset of data is selected with `usecols`, `index_col` is based on the subset.

- `parse_cols`: int or list, default None
  - Deprecated since version 0.21.0: Pass in `usecols` instead.

- `usecols`: int or list, default None
  - If None then parse all columns,
• If int then indicates last column to be parsed
• If list of ints then indicates list of column numbers to be parsed
• If string then indicates comma separated list of Excel column letters and column ranges (e.g. “A:E” or “A,C,E:F”). Ranges are inclusive of both sides.

squeeze : boolean, default False

If the parsed data only contains one column then return a Series

dtype : Type name or dict of column -> type, default None

Data type for data or columns. E.g. {'a': np.float64, 'b': np.int32} Use object to preserve data as stored in Excel and not interpret dtype. If converters are specified, they will be applied INSTEAD of dtype conversion.

New in version 0.20.0.

engine: string, default None

If io is not a buffer or path, this must be set to identify io. Acceptable values are None or xlrd

converters : dict, default None

Dict of functions for converting values in certain columns. Keys can either be integers or column labels, values are functions that take one input argument, the Excel cell content, and return the transformed content.

true_values : list, default None

Values to consider as True

New in version 0.19.0.

false_values : list, default None

Values to consider as False

New in version 0.19.0.

skiprows : list-like

Rows to skip at the beginning (0-indexed)

nrows : int, default None

Number of rows to parse

New in version 0.23.0.

na_values : scalar, str, list-like, or dict, default None

Additional strings to recognize as NA/NaN. If dict passed, specific per-column NA values. By default the following values are interpreted as NaN: ‘’, ‘#N/A’, ‘#N/A N/A’, ‘#NA’, ‘-1.#IND’, ‘-1.#QNAN’, ‘-NaN’, ‘-nan’, ‘1.#IND’, ‘1.#QNAN’, ‘N/A’, ‘NA’, ‘NULL’, ‘NaN’, ‘n/a’, ‘nan’, ‘null’.

keep_default_na : bool, default True

If na_values are specified and keep_default_na is False the default NaN values are overridden, otherwise they're appended to.

verbose : boolean, default False

Indicate number of NA values placed in non-numeric columns
thousands : str, default None

Thousands separator for parsing string columns to numeric. Note that this parameter
is only necessary for columns stored as TEXT in Excel, any numeric columns will
automatically be parsed, regardless of display format.

comment : str, default None

Comments out remainder of line. Pass a character or characters to this argument to
indicate comments in the input file. Any data between the comment string and the end
of the current line is ignored.

skip_footer : int, default 0

Deprecated since version 0.23.0: Pass in skipfooter instead.

skipfooter : int, default 0

Rows at the end to skip (0-indexed)

convert_float : boolean, default True

convert integral floats to int (i.e., 1.0 -> 1). If False, all numeric data will be read in as
floats: Excel stores all numbers as floats internally

Returns parsed : DataFrame or Dict of DataFrames

DataFrame from the passed in Excel file. See notes in sheet_name argument for more
information on when a Dict of Dataframes is returned.

Examples

An example DataFrame written to a local file

```python
>>> df_out = pd.DataFrame([('string1', 1),
...                        ('string2', 2),
...                        ('string3', 3)],
...                        columns=['Name', 'Value'])
>>> df_out
   Name  Value
0  string1   1
1  string2   2
2  string3   3
>>> df_out.to_excel('tmp.xlsx')
```

The file can be read using the file name as string or an open file object:

```python
>>> pd.read_excel('tmp.xlsx')
     Name  Value
0  string1   1
1  string2   2
2  string3   3
```

```python
>>> pd.read_excel(open('tmp.xlsx','rb'))
     Name  Value
0  string1   1
1  string2   2
2  string3   3
```

Index and header can be specified via the index_col and header arguments
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
>>> pd.read_excel('tmp.xlsx', index_col=None, header=None)
   0  1  2
0 NaN Name Value
1 0.0 string1 1
2 1.0 string2 2
3 2.0 string3 3
```

Column types are inferred but can be explicitly specified

```python
>>> pd.read_excel('tmp.xlsx', dtype={'Name':str, 'Value':float})
   Name   Value
0  NaN     1.0
1  NaN     2.0
2  string3  3.0
```

True, False, and NA values, and thousands separators have defaults, but can be explicitly specified, too. Supply the values you would like as strings or lists of strings!

```python
>>> pd.read_excel('tmp.xlsx', na_values=['string1', 'string2'])
   Name   Value
0  NaN     1
1  NaN     2
2  string3  3
```

Comment lines in the excel input file can be skipped using the `comment` kwarg

```python
>>> df = pd.DataFrame({'a': ['1', '#2'], 'b': [2, 3]})
>>> df.to_excel('tmp.xlsx', index=False)
>>> pd.read_excel('tmp.xlsx', comment='#')
   a   b
0  1  2
1 #2 3
```

34.1.4.2 pandas.ExcelFile.parse

ExcelFile.parse(sheet_name=0, header=0, names=None, index_col=None, usecols=None, squeeze=False, converters=None, true_values=None, false_values=None, skiprows=None, nrows=None, na_values=None, parse_dates=False, date_parser=None, thousands=None, comment=None, skipfooter=0, convert_float=True, **kwds)

Parse specified sheet(s) into a DataFrame

Equivalent to read_excel(ExcelFile, ...) See the read_excel docstring for more info on accepted parameters

34.1.5 JSON

```python
read_json([path_or_buf, orient, typ, dtype, ...])  Convert a JSON string to pandas object
```
34.1.5.1 pandas.read_json

pandas.read_json(path_or_buf=None, orient=None, typ='frame', dtype=True, convert_axes=True, convert_dates=True, keep_default_dates=False, numpy=False, precise_float=False, date_unit=None, encoding=None, lines=False, chunksize=None, compression='infer')

Convert a JSON string to pandas object

Parameters

path_or_buf : a valid JSON string or file-like, default: None

The string could be a URL. Valid URL schemes include http, ftp, s3, and file. For file URLs, a host is expected. For instance, a local file could be file://localhost/path/to/table.json

orient : string,

Indication of expected JSON string format. Compatible JSON strings can be produced by to_json() with a corresponding orient value. The set of possible orients is:

- 'split': dict like {index -> [index], columns -> [columns], data -> [values]}
- 'records': list like [{column -> value}, ... , {column -> value}]
- 'index': dict like {index -> {column -> value}}
- 'columns': dict like {column -> {index -> value}}
- 'values': just the values array

The allowed and default values depend on the value of the typ parameter.

- when typ == 'series',
  - allowed orients are {'split','records','index'}
  - default is 'index'
  - The Series index must be unique for orient 'index'.

- when typ == 'frame',
  - allowed orients are {'split','records','index', 'columns', 'values', 'table'}
  - default is 'columns'
  - The DataFrame index must be unique for orients 'index' and 'columns'.
  - The DataFrame columns must be unique for orients 'index','columns', and 'records'.

New in version 0.23.0: ‘table’ as an allowed value for the orient argument

typ [type of object to recover (series or frame), default ‘frame’]

dtype : boolean or dict, default True

If True, infer dtypes, if a dict of column to dtype, then use those, if False, then don’t infer dtypes at all, applies only to the data.

convert_axes : boolean, default True

Try to convert the axes to the proper dtypes.
**convert_dates**: boolean, default True

List of columns to parse for dates; If True, then try to parse datelike columns default is True; a column label is datelike if

- it ends with '_at',
- it ends with '_time',
- it begins with 'timestamp',
- it is 'modified', or
- it is 'date'

**keep_default_dates**: boolean, default True

If parsing dates, then parse the default datelike columns

**numpy**: boolean, default False

Direct decoding to numpy arrays. Supports numeric data only, but non-numeric column and index labels are supported. Note also that the JSON ordering MUST be the same for each term if numpy=True.

**precise_float**: boolean, default False

Set to enable usage of higher precision (strtod) function when decoding string to double values. Default (False) is to use fast but less precise builtin functionality

**date_unit**: string, default None

The timestamp unit to detect if converting dates. The default behaviour is to try and detect the correct precision, but if this is not desired then pass one of 's', 'ms', 'us' or 'ns' to force parsing only seconds, milliseconds, microseconds or nanoseconds respectively.

**lines**: boolean, default False

Read the file as a json object per line.

New in version 0.19.0.

**encoding**: str, default is 'utf-8'

The encoding to use to decode py3 bytes.

New in version 0.19.0.

**chunksize**: integer, default None

Return JsonReader object for iteration. See the line-delimited json docs for more information on chunksize. This can only be passed if lines=True. If this is None, the file will be read into memory all at once.

New in version 0.21.0.

**compression**: {'infer', 'gzip', 'bz2', 'zip', 'xz', None}, default 'infer'

For on-the-fly decompression of on-disk data. If 'infer', then use gzip, bz2, zip or xz if path_or_buf is a string ending in '.gz', '.bz2', '.zip', or 'xz', respectively, and no decompression otherwise. If using 'zip', the ZIP file must contain only one data file to be read in. Set to None for no decompression.

New in version 0.21.0.

**Returns**

**result** [Series or DataFrame, depending on the value of typ.]
pandas: powerful Python data analysis toolkit, Release 0.23.2

See also:
DataFrame.to_json
Notes
Specific to orient='table', if a DataFrame with a literal Index name of index gets written with
to_json(), the subsequent read operation will incorrectly set the Index name to None. This is because
index is also used by DataFrame.to_json() to denote a missing Index name, and the subsequent
read_json() operation cannot distinguish between the two. The same limitation is encountered with a
MultiIndex and any names beginning with 'level_'.
Examples
>>> df = pd.DataFrame([['a', 'b'], ['c', 'd']],
...
index=['row 1', 'row 2'],
...
columns=['col 1', 'col 2'])

Encoding/decoding a Dataframe using 'split' formatted JSON:
>>> df.to_json(orient='split')
'{"columns":["col 1","col 2"],
"index":["row 1","row 2"],
"data":[["a","b"],["c","d"]]}'
>>> pd.read_json(_, orient='split')
col 1 col 2
row 1
a
b
row 2
c
d

Encoding/decoding a Dataframe using 'index' formatted JSON:
>>> df.to_json(orient='index')
'{"row 1":{"col 1":"a","col 2":"b"},"row 2":{"col 1":"c","col 2":"d"}}'
>>> pd.read_json(_, orient='index')
col 1 col 2
row 1
a
b
row 2
c
d

Encoding/decoding a Dataframe using 'records' formatted JSON. Note that index labels are not preserved
with this encoding.
>>> df.to_json(orient='records')
'[{"col 1":"a","col 2":"b"},{"col 1":"c","col 2":"d"}]'
>>> pd.read_json(_, orient='records')
col 1 col 2
0
a
b
1
c
d

Encoding with Table Schema
>>> df.to_json(orient='table')
'{"schema": {"fields": [{"name": "index", "type": "string"},
{"name": "col 1", "type": "string"},
{"name": "col 2", "type": "string"}],
(continues on next page)

1362

Chapter 34. API Reference


pandas: powerful Python data analysis toolkit, Release 0.23.2

(continued from previous page)

"primaryKey": "index",
"pandas_version": "0.20.0"},
"data": [{"index": "row 1", "col 1": "a", "col 2": "b"},
{"index": "row 2", "col 1": "c", "col 2": "d"}]}'

json_normalize(data[, record_path, meta, . . . ])
build_table_schema(data[, index, . . . ])

“Normalize” semi-structured JSON data into a flat table
Create a Table schema from data.

34.1.5.2 pandas.io.json.json_normalize
pandas.io.json.json_normalize(data, record_path=None, meta=None, meta_prefix=None,
record_prefix=None, errors=’raise’, sep=’.’)
“Normalize” semi-structured JSON data into a flat table
Parameters data : dict or list of dicts
Unserialized JSON objects
record_path : string or list of strings, default None
Path in each object to list of records. If not passed, data will be assumed to be an array
of records
meta : list of paths (string or list of strings), default None
Fields to use as metadata for each record in resulting table
record_prefix : string, default None
If True, prefix records with dotted (?) path, e.g. foo.bar.field if path to records is [‘foo’,
‘bar’]
meta_prefix [string, default None]
errors : {‘raise’, ‘ignore’}, default ‘raise’
• ‘ignore’ : will ignore KeyError if keys listed in meta are not always present
• ‘raise’ : will raise KeyError if keys listed in meta are not always present
New in version 0.20.0.
sep : string, default ‘.’
Nested records will generate names separated by sep, e.g., for sep=’.’, { ‘foo’ : { ‘bar’ :
0 } } -> foo.bar
New in version 0.20.0.
Returns
frame [DataFrame]
Examples

34.1. Input/Output

1363


>>> from pandas.io.json import json_normalize
>>> data = [{'id': 1, 'name': {'first': 'Coleen', 'last': 'Volk'}},
... {'name': {'given': 'Mose', 'family': 'Regner'}},
... {'id': 2, 'name': 'Faye Raker'}]
>>> json_normalize(data)
    id   name  name.family  name.first  name.given  name.last
0  1.0     NaN          NaN          NaN          Coleen     Volk
1  NaN     NaN          Regner       NaN          Mose        NaN
2  2.0     Faye Raker  NaN          NaN          NaN          NaN

>>> data = [{'state': 'Florida',
... 'shortname': 'FL',
... 'info': {'governor': 'Rick Scott'}},
... {'state': 'Ohio',
... 'shortname': 'OH',
... 'info': {'governor': 'John Kasich'}}]
>>> result = json_normalize(data, 'counties', ['state', 'shortname', 'info.governor'])
>>> result
   name  population  info.governor  state  shortname
0  Dade       12345          Rick Scott  Florida     FL
1  Broward    40000          Rick Scott  Florida     FL
2  Palm Beach 60000          Rick Scott  Florida     FL
3  Summit     1234           John Kasich  Ohio       OH
4  Cuyahoga   1337           John Kasich  Ohio       OH

>>> data = {'A': [1, 2]}
>>> json_normalize(data, 'A', record_prefix='Prefix.')
Prefix.0
0  1
1  2

34.1.5.3 pandas.io.json.build_table_schema

pandas.io.json.build_table_schema(data, index=True, primary_key=None, version=True)

Create a Table schema from data.

Parameters

data  [Series, DataFrame]

index: bool, default True

Whether to include data.index in the schema.

primary_key: bool or None, default True

column names to designate as the primary key. The default None will set 'primaryKey'
to the index level or levels if the index is unique.
version : bool, default True

Whether to include a field `pandas_version` with the version of pandas that generated the schema.

Returns

    schema [dict]

Notes

See `_as_json_table_type` for conversion types. Timedeltas as converted to ISO8601 duration format with 9 decimal places after the seconds field for nanosecond precision.

Categoricals are converted to the `any` dtype, and use the `enum` field constraint to list the allowed values. The `ordered` attribute is included in an `ordered` field.

Examples

```python
>>> df = pd.DataFrame(
...     {'A': [1, 2, 3],
...      'B': ['a', 'b', 'c'],
...      'C': pd.date_range('2016-01-01', freq='d', periods=3),
...     }, index=pd.Index(range(3), name='idx'))
>>> build_table_schema(df)
{'fields': [{'name': 'idx', 'type': 'integer'},
            {'name': 'A', 'type': 'integer'},
            {'name': 'B', 'type': 'string'},
            {'name': 'C', 'type': 'datetime'}],
     'pandas_version': '0.20.0',
     'primaryKey': ['idx']}
```

34.1.6 HTML

`read_html(io[, match, flavor, header, ...])` Read HTML tables into a list of DataFrame objects.

34.1.6.1 pandas.read_html

```python
pandas.read_html(io, match='.+', flavor=None, header=None, index_col=None, skiprows=None, attrs=None, parse_dates=False, tupleize_cols=None, thousands='.', encoding=None, decimal='.', converters=None, na_values=None, keep_default_na=True, displayed_only=True)
```

Read HTML tables into a list of DataFrame objects.

Parameters

    **io** : str or file-like

    A URL, a file-like object, or a raw string containing HTML. Note that lxml only accepts the http, ftp and file url protocols. If you have a URL that starts with 'https' you might try removing the 's'.

    **match** : str or compiled regular expression, optional

    The set of tables containing regular expression text matching this regex or string will be returned. Unless
the HTML is extremely simple you will probably need to pass a non-empty string here. Defaults to `.+` (match any non-empty string). The default value will return all tables contained on a page. This value is converted to a regular expression so that there is consistent behavior between Beautiful Soup and lxml.

**flavor** : str or None, container of strings

The parsing engine to use. ‘bs4’ and ‘html5lib’ are synonymous with each other, they are both there for backwards compatibility. The default of None tries to use lxml to parse and if that fails it falls back on bs4 + html5lib.

**header** : int or list-like or None, optional

The row (or list of rows for a MultiIndex) to use to make the columns headers.

**index_col** : int or list-like or None, optional

The column (or list of columns) to use to create the index.

**skiprows** : int or list-like or slice or None, optional

0-based. Number of rows to skip after parsing the column integer. If a sequence of integers or a slice is given, will skip the rows indexed by that sequence. Note that a single element sequence means ‘skip the nth row’ whereas an integer means ‘skip n rows’.

**attrs** : dict or None, optional

This is a dictionary of attributes that you can pass to use to identify the table in the HTML. These are not checked for validity before being passed to lxml or Beautiful Soup. However, these attributes must be valid HTML table attributes to work correctly. For example,

```
attrs = {'id': 'table'}
```

is a valid attribute dictionary because the ‘id’ HTML tag attribute is a valid HTML attribute for any HTML tag as per this document.

```
attrs = {'asdf': 'table'}
```

is not a valid attribute dictionary because ‘asdf’ is not a valid HTML attribute even if it is a valid XML attribute. Valid HTML 4.01 table attributes can be found here. A working draft of the HTML 5 spec can be found here. It contains the latest information on table attributes for the modern web.

**parse_dates** : bool, optional

See read_csv() for more details.

**tupleize_cols** : bool, optional

If False try to parse multiple header rows into a MultiIndex, otherwise return raw tuples. Defaults to False.

Deprecated since version 0.21.0: This argument will be removed and will always convert to MultiIndex

**thousands** : str, optional

Separator to use to parse thousands. Defaults to ‘, ‘.

**encoding** : str or None, optional
The encoding used to decode the web page. Defaults to None. ‘None’ preserves the previous encoding behavior, which depends on the underlying parser library (e.g., the parser library will try to use the encoding provided by the document).

**decimal**: str, default ‘.’

Character to recognize as decimal point (e.g. use ‘,’ for European data).

New in version 0.19.0.

**converters**: dict, default None

Dict of functions for converting values in certain columns. Keys can either be integers or column labels, values are functions that take one input argument, the cell (not column) content, and return the transformed content.

New in version 0.19.0.

**na_values**: iterable, default None

Custom NA values

New in version 0.19.0.

**keep_default_na**: bool, default True

If na_values are specified and keep_default_na is False the default NaN values are overridden, otherwise they’re appended to

New in version 0.19.0.

**display_only**: bool, default True

Whether elements with “display: none” should be parsed

New in version 0.23.0.

**Returns**

- **dfs**: [list of DataFrames]

**See also**

* pandas.read_csv

**Notes**

Before using this function you should read the *gotchas about the HTML parsing libraries.*

Expect to do some cleanup after you call this function. For example, you might need to manually assign column names if the column names are converted to NaN when you pass the *header=0* argument. We try to assume as little as possible about the structure of the table and push the idiosyncrasies of the HTML contained in the table to the user.

This function searches for `<table>` elements and only for `<tr>` and `<th>` rows and `<td>` elements within each `<tr>` or `<th>` element in the table. `<td>` stands for “table data”.

Similar to *read_csv()* the header argument is applied after skiprows is applied.

This function will *always* return a list of *DataFrame* or it will fail, e.g., it will *not* return an empty list.
### Examples

See the [read_html documentation in the IO section of the docs](https://pandas.pydata.org/pandas-docs/stable/reference/io.html) for some examples of reading in HTML tables.

#### 34.1.7 HDFStore: PyTables (HDF5)

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>read_hdf()</code></td>
<td>Read from the store, close it if we opened it.</td>
</tr>
<tr>
<td><code>HDFStore.put()</code></td>
<td>Store object in HDFStore</td>
</tr>
<tr>
<td><code>HDFStore.append()</code></td>
<td>Append to Table in file.</td>
</tr>
<tr>
<td><code>HDFStore.get()</code></td>
<td>Retrieve pandas object stored in file</td>
</tr>
<tr>
<td><code>HDFStore.select()</code></td>
<td>Retrieve pandas object stored in file, optionally based on where criteria</td>
</tr>
<tr>
<td><code>HDFStore.info()</code></td>
<td>Print detailed information on the store</td>
</tr>
<tr>
<td><code>HDFStore.keys()</code></td>
<td>Return a (potentially unordered) list of the keys corresponding to the objects stored in the HDFStore.</td>
</tr>
</tbody>
</table>

#### 34.1.7.1 pandas.read_hdf

```python
def pandas.read_hdf(path_or_buf, key=None, mode='r', **kwargs):
    Read from the store, close it if we opened it.
```

Retrieve pandas object stored in file, optionally based on where criteria

**Parameters**

- **path_or_buf**: string, buffer or path object
  - Path to the file to open, or an open `pandas.HDFStore` object. Supports any object implementing the `__fspath__` protocol. This includes `pathlib.Path` and `py._path.local.LocalPath` objects.
  - New in version 0.19.0: support for `pathlib`, `py.path`.
  - New in version 0.21.0: support for `__fspath__` protocol.
- **key**: object, optional
  - The group identifier in the store. Can be omitted if the HDF file contains a single pandas object.
- **mode**: ['r', 'r+', 'a'], optional
  - Mode to use when opening the file. Ignored if `path_or_buf` is a `pandas.HDFStore`. Default is 'r'.
- **where**: list, optional
  - A list of Term (or convertible) objects.
- **start**: int, optional
  - Row number to start selection.
- **stop**: int, optional
  - Row number to stop selection.
- **columns**: list, optional
  - A list of columns names to return.
- **iterator**: bool, optional
Return an iterator object.

**chunksize** : int, optional

Number of rows to include in an iteration when using an iterator.

**errors** : str, default ‘strict’

Specifies how encoding and decoding errors are to be handled. See the errors argument for open() for a full list of options.

**kwargs**

Additional keyword arguments passed to HDFStore.

**Returns**

**item** : object

The selected object. Return type depends on the object stored.

**See also:**

**pandas.DataFrame.to_hdf** write a HDF file from a DataFrame

**pandas.HDFStore** low-level access to HDF files

**Examples**

```python
>>> df = pd.DataFrame([[1, 1.0, 'a']], columns=['x', 'y', 'z'])
>>> df.to_hdf('./store.h5', 'data')
>>> reread = pd.read_hdf('./store.h5')
```

### 34.1.7.2 pandas.HDFStore.put

**HDFStore.put**(key, value, format=None, append=False, **kwargs)

Store object in HDFStore

**Parameters**

- **key** : object
- **value** : [{Series, DataFrame, Panel}]
- **format** : ‘fixed(f)|table(t)’, default is ‘fixed’
  - fixed(f) [Fixed format] Fast writing/reading. Not-appendable, nor searchable
  - table(t) [Table format] Write as a PyTables Table structure which may perform worse but allow more flexible operations like searching / selecting subsets of the data
- **append** : boolean, default False
  
  This will force Table format, append the input data to the existing.
- **data_columns** : list of columns to create as data columns, or True to use all columns. See here # noqa
- **encoding** : [default None, provide an encoding for strings]
- **dropna** : boolean, default False, do not write an ALL nan row to the store settable by the option ‘io.hdf.dropna_table’
34.1.7.3 pandas.HDFStore.append

HDFStore.append(key, value, format=None, append=True, columns=None, dropna=None, **kwargs)
Append to Table in file. Node must already exist and be Table format.

Parameters

key [object]
value [{Series, DataFrame, Panel}]
format: ‘table’ is the default
table(t) [table format] Write as a PyTables Table structure which may perform worse but allow more flexible operations like searching / selecting subsets of the data
append : boolean, default True, append the input data to the existing
data_columns : list of columns, or True, default None
List of columns to create as indexed data columns for on-disk queries, or True to use all columns. By default only the axes of the object are indexed. See here.

min_itemsize [dict of columns that specify minimum string sizes]
nan_rep [string to use as string nan representation]
chunksize [size to chunk the writing]
expectedrows [expected TOTAL row size of this table]
encoding [default None, provide an encoding for strings]
dropna : boolean, default False, do not write an ALL nan row to the store settable by the option ‘io.hdf.dropna_table’

Notes

Does not check if data being appended overlaps with existing data in the table, so be careful

34.1.7.4 pandas.HDFStore.get

HDFStore.get(key)
Retrieve pandas object stored in file

Parameters

key [object]

Returns

obj [type of object stored in file]
34.1.7.5 pandas.HDFStore.select

HDFStore.select(key, where=None, start=None, stop=None, columns=None, iterator=False, chunksize=None, auto_close=False, **kwargs)
Retrieve pandas object stored in file, optionally based on where criteria

Parameters

- key [object]
- where [list of Term (or convertible) objects, optional]
- start [integer (defaults to None), row number to start selection]
- stop [integer (defaults to None), row number to stop selection]
- columns : a list of columns that if not None, will limit the return
- columns
- iterator [boolean, return an iterator, default False]
- chunksize [nrows to include in iteration, return an iterator]
- auto_close : boolean, should automatically close the store when
  finished, default is False

Returns

The selected object

34.1.7.6 pandas.HDFStore.info

HDFStore.info()
print detailed information on the store
New in version 0.21.0.

34.1.7.7 pandas.HDFStore.keys

HDFStore.keys()
Return a (potentially unordered) list of the keys corresponding to the objects stored in the HDFStore. These are
ABSOLUTE path-names (e.g. have the leading '/')

34.1.8 Feather

read_feather(path[, nthreads])
Load a feather-format object from the file path

34.1.8.1 pandas.read_feather

pandas.read_feather(path, nthreads=1)
Load a feather-format object from the file path

Parameters

- path [string file path, or file-like object]
Pandas: Powerful Python Data Analysis Toolkit, Release 0.23.2

**nthreads**: int, default 1

Number of CPU threads to use when reading to pandas.DataFrame

Returns

type of object stored in file

### 34.1.9 Parquet

#### read_parquet(path[, engine, columns])

Load a parquet object from the file path, returning a DataFrame.

#### pandas.read_parquet

**pandas.read_parquet** *(path, engine='auto', columns=None, **kwargs)*

Load a parquet object from the file path, returning a DataFrame.

**Parameters**

- **path** : string
  - File path

- **columns** : list, default=None
  - If not None, only these columns will be read from the file.

- **engine** : {'auto', 'pyarrow', 'fastparquet'}, default 'auto'
  - Parquet library to use. If 'auto', then the option io.parquet.engine is used. The default behavior is to try 'pyarrow', falling back to 'fastparquet' if 'pyarrow' is unavailable.

**kwargs** are passed to the engine

**Returns**

DataFrame

### 34.1.10 SAS

#### read_sas(filepath_or_buffer[, format, ...])

Read SAS files stored as either XPORT or SAS7BDAT format files.

#### pandas.read_sas

**pandas.read_sas** *(filepath_or_buffer, format=None, index=None, encoding=None, chunksize=None, iterator=False)*

Read SAS files stored as either XPORT or SAS7BDAT format files.

**Parameters**

- **filepath_or_buffer** : string or file-like object
  - Path to the SAS file.

- **format** : string {'xport', 'sas7bdat'} or None
  - If None, file format is inferred. If 'xport' or 'sas7bdat', uses the corresponding format.

- **index** : identifier of index column, defaults to None
Identifier of column that should be used as index of the DataFrame.

**encoding**: string, default is None

Encoding for text data. If None, text data are stored as raw bytes.

**chunksize**: int

Read file *chunksize* lines at a time, returns iterator.

**iterator**: bool, defaults to False

If True, returns an iterator for reading the file incrementally.

**Returns**

DataFrame if iterator=False and chunksize=None, else SAS7BDATReader or XportReader

### 34.1.11 SQL

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>read_sql_table</code></td>
<td>Read SQL database table into a DataFrame.</td>
</tr>
<tr>
<td><code>read_sql_query</code></td>
<td>Read SQL query into a DataFrame.</td>
</tr>
<tr>
<td><code>read_sql</code></td>
<td>Read SQL query or database table into a DataFrame.</td>
</tr>
</tbody>
</table>

### 34.1.12 Google BigQuery

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>read_gbq</code></td>
<td>Load data from Google BigQuery.</td>
</tr>
</tbody>
</table>

#### 34.1.12.1 pandas.read_gbq

```python
pandas.read_gbq(query[, project_id=None, index_col=None, col_order=None, reauth=False, verbose=None, private_key=None, dialect='legacy', **kwargs])
```

Load data from Google BigQuery.

This function requires the pandas-gbq package.

Authentication to the Google BigQuery service is via OAuth 2.0.

- If “private_key” is not provided:
  By default “application default credentials” are used.
  If default application credentials are not found or are restrictive, user account credentials are used. In this case, you will be asked to grant permissions for product name ‘pandas GBQ’.

- If “private_key” is provided:
  Service account credentials will be used to authenticate.

**Parameters**

- **query**: str
  SQL-Like Query to return data values.
- **project_id**: str
  Google BigQuery Account project ID.
- **index_col**: str, optional
Name of result column to use for index in results DataFrame.

**col_order** : list(str), optional
List of BigQuery column names in the desired order for results DataFrame.

**reauth** : boolean, default False
Force Google BigQuery to reauthenticate the user. This is useful if multiple accounts are used.

**private_key** : str, optional
Service account private key in JSON format. Can be file path or string contents. This is useful for remote server authentication (e.g., Jupyter/IPython notebook on remote host).

**dialect** : str, default ‘legacy’
SQL syntax dialect to use. Value can be one of:

- ‘legacy’ Use BigQuery’s legacy SQL dialect. For more information see BigQuery Legacy SQL Reference.
- ‘standard’ Use BigQuery’s standard SQL, which is compliant with the SQL 2011 standard. For more information see BigQuery Standard SQL Reference.

**verbose** : boolean, deprecated
Deprecated in Pandas-GBQ 0.4.0. Use the logging module to adjust verbosity instead.

**kwargs** : dict
Arbitrary keyword arguments. configuration (dict): query config parameters for job processing. For example:

```
configuration = {'query': {'useQueryCache': False}}
```
For more information see BigQuery SQL Reference

**Returns** df: DataFrame
DataFrame representing results of query.

See also:

- **pandas_gbq.read_gbq** This function in the pandas-gbq library.
- **pandas.DataFrame.to_gbq** Write a DataFrame to Google BigQuery.

### 34.1.13 STATA

**read_stata**(filepath_or_buffer[, ...])
Read Stata file into DataFrame.

### 34.1.13.1 pandas.read_stata

**pandas.read_stata**(filepath_or_buffer, convert_dates=True, convert_categoricals=True, encoding=None, index_col=None, convert_missing=False, preserve_dtypes=True, columns=None, order_categoricals=True, chunksize=None, iterator=False)
Read Stata file into DataFrame.

**Parameters**

- **filepath_or_buffer** : string or file-like object
  Path to .dta file or object implementing a binary read() functions.
**convert_dates** : boolean, defaults to True
   Convert date variables to DataFrame time values.

**convert_categoricals** : boolean, defaults to True
   Read value labels and convert columns to Categorical/Factor variables.

**encoding** : string, None or encoding
   Encoding used to parse the files. None defaults to latin-1.

**index_col** : string, optional, default: None
   Column to set as index.

**convert_missing** : boolean, defaults to False
   Flag indicating whether to convert missing values to their Stata representations. If False, missing values are replaced with nan. If True, columns containing missing values are returned with object data types and missing values are represented by StataMissingValue objects.

**preserve_dtypes** : boolean, defaults to True
   Preserve Stata datatypes. If False, numeric data are upcast to pandas default types for foreign data (float64 or int64).

**columns** : list or None
   Columns to retain. Columns will be returned in the given order. None returns all columns.

**order_categoricals** : boolean, defaults to True
   Flag indicating whether converted categorical data are ordered.

**chunksize** : int, default None
   Return StataReader object for iterations, returns chunks with given number of lines.

**iterator** : boolean, default False
   Return StataReader object.

**Returns**
   DataFrame or StataReader

See also:

**pandas.io.stata.StataReader**  low-level reader for Stata data files

**pandas.DataFrame.to_stata**  export Stata data files

**Examples**

Read a Stata dta file:

```python
>>> import pandas as pd
>>> df = pd.read_stata('filename.dta')
```

Read a Stata dta file in 10,000 line chunks:
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
>>> itr = pd.read_stata('filename.dta', chunksize=10000)
>>> for chunk in itr:
...     do_something(chunk)
```

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>StataReader.data(**kwargs)</td>
<td>(DEPRECATED) Reads observations from Stata file, converting them into a dataframe</td>
</tr>
<tr>
<td>StataReader.data_label()</td>
<td>Returns data label of Stata file</td>
</tr>
<tr>
<td>StataReader.value_labels()</td>
<td>Returns a dict, associating each variable name a dict, associating each value its corresponding label</td>
</tr>
<tr>
<td>StataReader.variable_labels()</td>
<td>Returns variable labels as a dict, associating each variable name with corresponding label</td>
</tr>
<tr>
<td>StataWriter.write_file()</td>
<td></td>
</tr>
</tbody>
</table>

### 34.1.13.2 pandas.io.stata.StataReader.data

```python
StataReader.data(**kwargs)

Reads observations from Stata file, converting them into a dataframe

Deprecated since version 0.16.0: This is a legacy method. Use `read` in new code.

**Parameters**

- `convert_dates`: boolean, defaults to True
  - Convert date variables to DataFrame time values.
- `convert_categoricals`: boolean, defaults to True
  - Read value labels and convert columns to Categorical/Factor variables.
- `index_col`: string, optional, default: None
  - Column to set as index.
- `convert_missing`: boolean, defaults to False
  - Flag indicating whether to convert missing values to their Stata representations. If False, missing values are replaced with nan. If True, columns containing missing values are returned with object data types and missing values are represented by StataMissingValue objects.
- `preserve_dtypes`: boolean, defaults to True
  - Preserve Stata datatypes. If False, numeric data are upcast to pandas default types for foreign data (float64 or int64).
- `columns`: list or None
  - Columns to retain. Columns will be returned in the given order. None returns all columns.
- `order_categoricals`: boolean, defaults to True
  - Flag indicating whether converted categorical data are ordered.

**Returns**

- `DataFrame`
```
34.1.13.3 pandas.io.stata.StataReader.data_label

`StataReader.data_label()`
Returns data label of Stata file

34.1.13.4 pandas.io.stata.StataReader.value_labels

`StataReader.value_labels()`
Returns a dict, associating each variable name a dict, associating each value its corresponding label

34.1.13.5 pandas.io.stata.StataReader.variable_labels

`StataReader.variable_labels()`
Returns variable labels as a dict, associating each variable name with corresponding label

34.1.13.6 pandas.io.stata.StataWriter.write_file

`StataWriter.write_file()`

34.2 General functions

34.2.1 Data manipulations

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>melt(frame[, id_vars, value_vars, var_name, ...])</code></td>
<td>“Unpivots” a DataFrame from wide format to long format, optionally leaving identifier variables set.</td>
</tr>
<tr>
<td><code>pivot(index, columns, values)</code></td>
<td>Produce ‘pivot’ table based on 3 columns of this DataFrame.</td>
</tr>
<tr>
<td><code>pivot_table(data[, values, index, columns, ...])</code></td>
<td>Create a spreadsheet-style pivot table as a DataFrame.</td>
</tr>
<tr>
<td><code>crosstab(index, columns[, values, rownames, ...])</code></td>
<td>Compute a simple cross-tabulation of two (or more) factors.</td>
</tr>
<tr>
<td><code>cut(x, bins[, right, labels, retbins, ...])</code></td>
<td>Bin values into discrete intervals.</td>
</tr>
<tr>
<td><code>qcut(x, q[, labels, retbins, precision, ...])</code></td>
<td>Quantile-based discretization function.</td>
</tr>
<tr>
<td><code>merge(left, right[, how, on, left_on, ...])</code></td>
<td>Merge DataFrame objects by performing a database-style join operation by columns or indexes.</td>
</tr>
<tr>
<td><code>merge_ordered(left, right[, on, left_on, ...])</code></td>
<td>Perform merge with optional filling/interpolation designed for ordered data like time series data.</td>
</tr>
<tr>
<td><code>merge_asof(left, right[, on, left_on, ...])</code></td>
<td>Perform an asof merge.</td>
</tr>
<tr>
<td><code>concat(objs[, axis, join, join_axes, ...])</code></td>
<td>Concatenate pandas objects along a particular axis with optional set logic along the other axes.</td>
</tr>
<tr>
<td><code>get_dummies(data[, prefix, prefix_sep, ...])</code></td>
<td>Convert categorical variable into dummy/indicator variables.</td>
</tr>
<tr>
<td><code>factorize(values[, sort, order, ...])</code></td>
<td>Encode the object as an enumerated type or categorical variable.</td>
</tr>
<tr>
<td><code>unique(values)</code></td>
<td>Hash table-based unique.</td>
</tr>
<tr>
<td><code>wide_to_long(df, stubnames, i, j[, sep, suffix])</code></td>
<td>Wide panel to long format.</td>
</tr>
</tbody>
</table>
34.2.1.1 pandas.melt

pandas.melt(frame, id_vars=None, value_vars=None, var_name=None, value_name='value', col_level=None)

“Unpivots” a DataFrame from wide format to long format, optionally leaving identifier variables set.

This function is useful to massage a DataFrame into a format where one or more columns are identifier variables (id_vars), while all other columns, considered measured variables (value_vars), are “unpivoted” to the row axis, leaving just two non-identifier columns, ‘variable’ and ‘value’.

Parameters

frame [DataFrame]

id_vars : tuple, list, or ndarray, optional

Column(s) to use as identifier variables.

value_vars : tuple, list, or ndarray, optional

Column(s) to unpivot. If not specified, uses all columns that are not set as id_vars.

var_name : scalar

Name to use for the ‘variable’ column. If None it uses frame.columns.name or ‘variable’.

value_name : scalar, default ‘value’

Name to use for the ‘value’ column.

col_level : int or string, optional

If columns are a MultiIndex then use this level to melt.

See also:

DataFrame.melt, pivot_table, DataFrame.pivot

Examples

```python
>>> import pandas as pd
>>> df = pd.DataFrame({'A': {0: 'a', 1: 'b', 2: 'c'},
... 'B': {0: 1, 1: 3, 2: 5},
... 'C': {0: 2, 1: 4, 2: 6}})
>>> df
   A  B  C
0  a  1  2
1  b  3  4
2  c  5  6

>>> pd.melt(df, id_vars=['A'], value_vars=['B'])
   A variable  value
0  a B B 1
1  b B B 3
2  c B B 5

>>> pd.melt(df, id_vars=['A'], value_vars=['B', 'C'])
   A variable  value
0  a B B 1
(continues on next page)
```
The names of ‘variable’ and ‘value’ columns can be customized:

```python
>>> pd.melt(df, id_vars=['A'], value_vars=['B'],
           var_name='myVarname', value_name='myValname',
       )
   A      myVarname  myValname
   0  a            B          1
   1  b            B          3
   2  c            B          5
```

If you have multi-index columns:

```python
>>> df.columns = [list('ABC'), list('DEF')]
>>> df
   A  B  C
   0  a  1  2
   1  b  3  4
   2  c  5  6
```

```python
>>> pd.melt(df, col_level=0, id_vars=['A'], value_vars=['B'])
   A  variable  value
   0  a          B  1
   1  b          B  3
   2  c          B  5
```

```python
>>> pd.melt(df, id_vars=[('A', 'D')], value_vars=[('B', 'E')])
   (A, D)  variable_0  variable_1  value
   0  a          B          E          1
   1  b          B          E          3
   2  c          B          E          5
```

### 34.2.1.2 pandas.pivot

`pandas.pivot(index, columns, values)`

Produce ‘pivot’ table based on 3 columns of this DataFrame. Uses unique values from index / columns and fills with values.

**Parameters**

- **index**: ndarray
  
  Labels to use to make new frame’s index

- **columns**: ndarray
  
  Labels to use to make new frame’s columns

- **values**: ndarray
  
  Values to use for populating new frame’s values

**Returns**

- **DataFrame**
See also:

`DataFrame.pivot_table` generalization of pivot that can handle duplicate values for one index/column pair

Notes

Obviously, all 3 of the input arguments must have the same length

34.2.1.3 pandas.pivot_table

Pandas is a powerful Python data analysis toolkit, Release 0.23.2

```
pandas.pivot_table(data, values=None, index=None, columns=None, aggfunc='mean',
                   fill_value=None, margins=False, dropna=True, margins_name='All')
```

Create a spreadsheet-style pivot table as a DataFrame. The levels in the pivot table will be stored in MultiIndex objects (hierarchical indexes) on the index and columns of the result DataFrame

Parameters

- **data** [DataFrame]
- **values** [column to aggregate, optional]
- **index** : column, Grouper, array, or list of the previous
  - If an array is passed, it must be the same length as the data. The list can contain any of the other types (except list). Keys to group by on the pivot table index. If an array is passed, it is being used as the same manner as column values.
- **columns** : column, Grouper, array, or list of the previous
  - If an array is passed, it must be the same length as the data. The list can contain any of the other types (except list). Keys to group by on the pivot table column. If an array is passed, it is being used as the same manner as column values.
- **aggfunc** : function, list of functions, dict, default numpy.mean
  - If list of functions passed, the resulting pivot table will have hierarchical columns whose top level are the function names (inferred from the function objects themselves) If dict is passed, the key is column to aggregate and value is function or list of functions
- **fill_value** : scalar, default None
  - Value to replace missing values with
- **dropna** : boolean, default True
  - Do not include columns whose entries are all NaN
- **margins** : boolean, default False
  - Add all row / columns (e.g. for subtotal / grand totals)
- **margins_name** : string, default ‘All’
  - Name of the row / column that will contain the totals when margins is True.

Returns

- **table** [DataFrame]

See also:
**DataFrame.pivot** pivot without aggregation that can handle non-numeric data

**Examples**

```python
>>> df = pd.DataFrame({
    "A": ["foo", "foo", "foo", "foo", "foo", "bar", "bar", "bar", "bar"],
    "B": ["one", "one", "one", "two", "two", "one", "one", "two", "two"],
    "C": ["small", "large", "large", "small", "small", "large", "small", "large"],
    "D": [1, 2, 2, 3, 3, 4, 5, 6, 7]
})
>>> df
   A     B   C  D
0  foo   one  small  1
1  foo   one  large  2
2  foo   one  large  2
3  foo   two  small  3
4  foo   two  small  3
5  bar   one  large  4
6  bar   one  small  5
7  bar   two  small  6
8  bar   two  large  7

>>> table = pivot_table(df, values='D', index=['A', 'B'], columns=['C'], aggfunc=np.sum)
>>> table
   C     large  small
A  B   
bar one  4.0   5.0
    two  7.0   6.0
foo one  4.0   1.0
    two  NaN   6.0

>>> table = pivot_table(df, values='D', index=['A', 'B'], columns=['C'], aggfunc=np.sum)
>>> table
   C     large  small
A  B   
bar one  4.0   5.0
    two  7.0   6.0
foo one  4.0   1.0
    two  NaN   6.0

>>> table = pivot_table(df, values=['D', 'E'], index=['A', 'C'], aggfunc={'D': np.mean, 'E': [min, max, np.mean]})
>>> table
    D  E
   mean  max median  min
A  C
bar large  5.500000 16  14.5  13
    small  5.500000 15  14.5  14
foo large  2.000000 10  9.5   9
    small  2.333333 12  11.0  8
```
34.2.1.4 pandas.crosstab

pandas.crosstab(index, columns, values=None, rownames=None, colnames=None, aggfunc=None, margins=False, margins_name='All', dropna=True, normalize=False)

Compute a simple cross-tabulation of two (or more) factors. By default computes a frequency table of the factors unless an array of values and an aggregation function are passed

**Parameters**

- **index**: array-like, Series, or list of arrays/Series
  - Values to group by in the rows
- **columns**: array-like, Series, or list of arrays/Series
  - Values to group by in the columns
- **values**: array-like, optional
  - Array of values to aggregate according to the factors. Requires `aggfunc` be specified.
- **aggfunc**: function, optional
  - If specified, requires `values` be specified as well
- **rownames**: sequence, default None
  - If passed, must match number of row arrays passed
- **colnames**: sequence, default None
  - If passed, must match number of column arrays passed
- **margins**: boolean, default False
  - Add row/column margins (subtotals)
- **margins_name**: string, default ‘All’
  - Name of the row / column that will contain the totals when margins is True.
  - New in version 0.21.0.
- **dropna**: boolean, default True
  - Do not include columns whose entries are all NaN
- **normalize**: boolean, ['all', 'index', 'columns'], or {0,1}, default False
  - Normalize by dividing all values by the sum of values.
  - • If passed ‘all’ or True, will normalize over all values.
  - • If passed ‘index’ will normalize over each row.
  - • If passed ‘columns’ will normalize over each column.
  - • If margins is True, will also normalize margin values.
  - New in version 0.18.1.

**Returns**

- **crosstab** [DataFrame]
Notes

Any Series passed will have their name attributes used unless row or column names for the cross-tabulation are specified.

Any input passed containing Categorical data will have all of its categories included in the cross-tabulation, even if the actual data does not contain any instances of a particular category.

In the event that there aren’t overlapping indexes an empty DataFrame will be returned.

Examples

```python
>>> a = np.array(['foo', 'foo', 'foo', 'foo', 'bar', 'bar',
                'bar', 'bar', 'foo', 'foo'], dtype=object)
>>> b = np.array(['one', 'one', 'one', 'two', 'one', 'one',
                'two', 'two', 'one', 'one'], dtype=object)
>>> c = np.array(['dull', 'dull', 'shiny', 'dull', 'dull', 'shiny',
                'shiny', 'shiny', 'shiny', 'shiny'], dtype=object)
>>> pd.crosstab(a, [b, c], rownames=['a'], colnames=['b', 'c'])
...  b  one  two
  c  dull  shiny  dull  shiny
  a  bar    1    2    1    0
       foo    2    2    1    2
```

```python
>>> foo = pd.Categorical(['a', 'b'], categories=['a', 'b', 'c'])
>>> bar = pd.Categorical(['d', 'e'], categories=['d', 'e', 'f'])
>>> crosstab(foo, bar)  # 'c' and 'f' are not represented in the data,
...                      # but they still will be counted in the output
...  col_0 d e f
  row_0
    a    1  0  0
    b    0  1  0
    c    0  0  0
```

34.2.1.5 pandas.cut

```
pandas.cut(x, bins, right=True, labels=None, retbins=False, precision=3, include_lowest=False, duplicates='raise')
```

Bin values into discrete intervals.

Use `cut` when you need to segment and sort data values into bins. This function is also useful for going from a continuous variable to a categorical variable. For example, `cut` could convert ages to groups of age ranges. Supports binning into an equal number of bins, or a pre-specified array of bins.

**Parameters**

- **x**: array-like
  - The input array to be binned. Must be 1-dimensional.
- **bins**: int, sequence of scalars, or pandas.IntervalIndex
  - The criteria to bin by.
• int : Defines the number of equal-width bins in the range of x. The range of x is extended by .1% on each side to include the minimum and maximum values of x.

• sequence of scalars : Defines the bin edges allowing for non-uniform width. No extension of the range of x is done.

• IntervalIndex : Defines the exact bins to be used.

right : bool, default True

Indicates whether bins includes the rightmost edge or not. If right == True (the default), then the bins [1, 2, 3, 4] indicate (1,2], (2,3], (3,4]. This argument is ignored when bins is an IntervalIndex.

labels : array or bool, optional

Specifies the labels for the returned bins. Must be the same length as the resulting bins. If False, returns only integer indicators of the bins. This affects the type of the output container (see below). This argument is ignored when bins is an IntervalIndex.

rebins : bool, default False

Whether to return the bins or not. Usefull when bins is provided as a scalar.

precision : int, default 3

The precision at which to store and display the bins labels.

include_lowest : bool, default False

Whether the first interval should be left-inclusive or not.

duplicates : {default ‘raise’, ‘drop’}, optional

If bin edges are not unique, raise ValueError or drop non-uniques.

New in version 0.23.0.

Returns out : pandas.Categorical, Series, or ndarray

An array-like object representing the respective bin for each value of x. The type depends on the value of labels.

• True (default) : returns a Series for Series x or a pandas.Categorical for all other inputs. The values stored within are Interval dtype.

• sequence of scalars : returns a Series for Series x or a pandas.Categorical for all other inputs. The values stored within are whatever the type in the sequence is.

• False : returns an ndarray of integers.

bins : numpy.ndarray or IntervalIndex.

The computed or specified bins. Only returned when rebins=True. For scalar or sequence bins, this is an ndarray with the computed bins. If set duplicates=drop, bins will drop non-unique bin. For an IntervalIndex bins, this is equal to bins.

See also:

gcut Discretize variable into equal-sized buckets based on rank or based on sample quantiles.

pandas.Categorical Array type for storing data that come from a fixed set of values.

Series One-dimensional array with axis labels (including time series).

pandas.IntervalIndex Immutable Index implementing an ordered, sliceable set.
Notes

Any NA values will be NA in the result. Out of bounds values will be NA in the resulting Series or pandas.Categorical object.

Examples

Discretize into three equal-sized bins.

```python
>>> pd.cut(np.array([1, 7, 5, 4, 6, 3]), 3)
...  
[(0.994, 3.0], (5.0, 7.0], (3.0, 5.0], (3.0, 5.0], (5.0, 7.0], ...
Categories (3, interval[float64]): [(0.994, 3.0] < (3.0, 5.0] ...

>>> pd.cut(np.array([1, 7, 5, 4, 6, 3]), 3, retbins=True)
...
[(0.994, 3.0], (5.0, 7.0], (3.0, 5.0], (3.0, 5.0], (5.0, 7.0], ...
Categories (3, interval[float64]): [(0.994, 3.0] < (3.0, 5.0] ... 
array([0.994, 3. , 5. , 7. , 7. ])
```

Discovers the same bins, but assign them specific labels. Notice that the returned Categorical’s categories are **labels** and is ordered.

```python
>>> pd.cut(np.array([1, 7, 5, 4, 6, 3]), 3, labels=['bad', 'medium', 'good'])
[bad, good, medium, medium, good, bad]
Categories (3, object): [bad < medium < good]
labels=False implies you just want the bins back.

```python
>>> pd.cut([0, 1, 1, 2], bins=4, labels=False)
array([0, 1, 1, 3])
```

Passing a Series as an input returns a Series with categorical dtype:

```python
>>> s = pd.Series(np.array([2, 4, 6, 8, 10]),
...               index=['a', 'b', 'c', 'd', 'e'])
>>> pd.cut(s, 3)
...
  a  (1.992, 4.667]
b  (1.992, 4.667]
c  (4.667, 7.333]
d  (7.333, 10.0]
e  (7.333, 10.0]
dtype: category
Categories (3, interval[float64]): [(1.992, 4.667] < (4.667, ...
```

Passing a Series as an input returns a Series with mapping value. It is used to map numerically to intervals based on bins.

```python
>>> s = pd.Series(np.array([2, 4, 6, 8, 10]),
...               index=['a', 'b', 'c', 'd', 'e'])
>>> pd.cut(s, [0, 2, 4, 6, 8, 10], labels=False, retbins=True, right=False)
...
(a  0.0
```
Use `drop` optional when bins is not unique

```python
>>> pd.cut(s, [0, 2, 4, 6, 10, 10], labels=False, retbins=True,
...       right=False, duplicates='drop')
... 
... (a 0.0
b 1.0
c 2.0
d 3.0
e 3.0
dtype: float64, array([0, 2, 4, 6, 8]))
```

Passing an IntervalIndex for `bins` results in those categories exactly. Notice that values not covered by the IntervalIndex are set to NaN. 0 is to the left of the first bin (which is closed on the right), and 1.5 falls between two bins.

```python
>>> bins = pd.IntervalIndex.from_tuples([(0, 1), (2, 3), (4, 5)])
>>> pd.cut([0, 0.5, 1.5, 2.5, 4.5], bins)
[NaN, (0, 1], NaN, (2, 3], (4, 5]
Categories (3, interval[int64]): [(0, 1] < (2, 3] < (4, 5]
```

### 34.2.1.6 pandas.qcut

`pandas.qcut(x, q, labels=None, retbins=False, precision=3, duplicates='raise')`

Quantile-based discretization function. Discretize variable into equal-sized buckets based on rank or based on sample quantiles. For example 1000 values for 10 quantiles would produce a Categorical object indicating quantile membership for each data point.

**Parameters**

- **x** [1d ndarray or Series]
- **q** : integer or array of quantiles
  Number of quantiles. 10 for deciles, 4 for quartiles, etc. Alternately array of quantiles, e.g. [0, .25, .5, .75, 1.] for quartiles
- **labels** : array or boolean, default None
  Used as labels for the resulting bins. Must be of the same length as the resulting bins. If False, return only integer indicators of the bins.
- **retbins** : bool, optional
  Whether to return the (bins, labels) or not. Can be useful if bins is given as a scalar.
- **precision** : int, optional
  The precision at which to store and display the bins labels
- **duplicates** : {default ‘raise’, ‘drop’}, optional
If bin edges are not unique, raise ValueError or drop non-uniques.

New in version 0.20.0.

**Returns out**: Categorical or Series or array of integers if labels is False

The return type (Categorical or Series) depends on the input: a Series of type category if input is a Series else Categorical. Bins are represented as categories when categorical data is returned.

**bins**: ndarray of floats

Returned only if `retbins` is True.

**Notes**

Out of bounds values will be NA in the resulting Categorical object

**Examples**

```python
good, medium, bad

Categories (3, object): [good < medium < bad]
```

```python
array([0, 0, 1, 2, 3])
```

### 34.2.1.7 pandas.merge

**pandas.merge**

Merge DataFrame objects by performing a database-style join operation by columns or indexes.

If joining columns on columns, the DataFrame indexes will be ignored. Otherwise if joining indexes on indexes or indexes on a column or columns, the index will be passed on.

**Parameters**

- **left** [DataFrame]
- **right** [DataFrame]
- **how** : {'left', 'right', 'outer', 'inner'}, default 'inner'
  - left: use only keys from left frame, similar to a SQL left outer join; preserve key order
  - right: use only keys from right frame, similar to a SQL right outer join; preserve key order
  - outer: use union of keys from both frames, similar to a SQL full outer join; sort keys lexicographically
- **inner**: use intersection of keys from both frames, similar to a SQL inner join; preserve the order of the left keys

**on**: label or list

Column or index level names to join on. These must be found in both DataFrames. If `on` is `None` and not merging on indexes then this defaults to the intersection of the columns in both DataFrames.

**left_on**: label or list, or array-like

Column or index level names to join on in the left DataFrame. Can also be an array or list of arrays of the length of the left DataFrame. These arrays are treated as if they are columns.

**right_on**: label or list, or array-like

Column or index level names to join on in the right DataFrame. Can also be an array or list of arrays of the length of the right DataFrame. These arrays are treated as if they are columns.

**left_index**: boolean, default `False`

Use the index from the left DataFrame as the join key(s). If it is a MultiIndex, the number of keys in the other DataFrame (either the index or a number of columns) must match the number of levels.

**right_index**: boolean, default `False`

Use the index from the right DataFrame as the join key. Same caveats as `left_index`.

**sort**: boolean, default `False`

Sort the join keys lexicographically in the result DataFrame. If `False`, the order of the join keys depends on the join type (how keyword).

**suffixes**: 2-length sequence (tuple, list, . . .)

Suffix to apply to overlapping column names in the left and right side, respectively.

**copy**: boolean, default `True`

If `False`, do not copy data unnecessarily.

**indicator**: boolean or string, default `False`

If `True`, adds a column to output DataFrame called “_merge” with information on the source of each row. If string, column with information on source of each row will be added to output DataFrame, and column will be named value of string. Information column is Categorical-type and takes on a value of “left_only” for observations whose merge key only appears in ‘left’ DataFrame, “right_only” for observations whose merge key only appears in ‘right’ DataFrame, and “both” if the observation’s merge key is found in both.

**validate**: string, default `None`

If specified, checks if merge is of specified type.

- “one_to_one” or “1:1”: check if merge keys are unique in both left and right datasets.
- “one_to_many” or “1:m”: check if merge keys are unique in left dataset.
- “many_to_one” or “m:1”: check if merge keys are unique in right dataset.
- “many_to_many” or “m:m”: allowed, but does not result in checks.
New in version 0.21.0.

**Returns** `merged` : DataFrame

The output type will the be same as ‘left’, if it is a subclass of DataFrame.

**See also:**

`merge_ordered`, `merge_asof`, `DataFrame.join`

**Notes**

Support for specifying index levels as the `on`, `left_on`, and `right_on` parameters was added in version 0.23.0

**Examples**

```python
>>> A
           lkey value
    0   foo    1
    1   bar    2
    2   baz    3
    3   foo    4

>>> B
           rkey value
    0   foo    5
    1   bar    6
    2   qux    7

>>> A.merge(B, left_on='lkey', right_on='rkey', how='outer')
           lkey value_x  rkey value_y
    0   foo      1   foo      5
    1   foo      4   foo      5
    2   bar      2   bar      6
    3   bar      2   bar      8
    4   baz      3   NaN      NaN
    5   NaN      NaN   qux      7
```

34.2.1.8 pandas.merge_ordered

**pandas.merge_ordered** *(left, right, on=None, left_on=None, right_on=None, left_by=None, right_by=None, fill_method=None, suffixes=('_x', '_y'), how='outer')*

Perform merge with optional filling/interpolation designed for ordered data like time series data. Optionally perform group-wise merge (see examples)

**Parameters**

- **left** [DataFrame]
- **right** [DataFrame]
- **on** : label or list
  - Field names to join on. Must be found in both DataFrames.
- **left_on** : label or list, or array-like
  - Field names to join on in left DataFrame. Can be a vector or list of vectors of the length of the DataFrame to use a particular vector as the join key instead of columns
- **right_on** : label or list, or array-like
  - Field names to join on in right DataFrame or vector/list of vectors per left_on docs
- **left_by** : column name or list of column names
Group left DataFrame by group columns and merge piece by piece with right DataFrame

**right_by**: column name or list of column names

Group right DataFrame by group columns and merge piece by piece with left DataFrame

**fill_method**: {'ffill', None}, default None

Interpolation method for data

**suffixes**: 2-length sequence (tuple, list, ...)

Suffix to apply to overlapping column names in the left and right side, respectively

**how**: {'left', 'right', 'outer', 'inner'}, default 'outer'

- left: use only keys from left frame (SQL: left outer join)
- right: use only keys from right frame (SQL: right outer join)
- outer: use union of keys from both frames (SQL: full outer join)
- inner: use intersection of keys from both frames (SQL: inner join)

New in version 0.19.0.

**Returns merged**: DataFrame

The output type will be the same as 'left', if it is a subclass of DataFrame.

**See also:**

merge, merge_asof

**Examples**

```python
>>> A
 key lvalue group
0 a 1 a
1 c 2 a
2 e 3 a
3 a 1 b
4 c 2 b
5 e 3 b

>>> B
 key rvalue
0 a 1
1 c 2
2 e 3
3 a 1
4 c 2
5 e 3

>>> merge_ordered(A, B, fill_method='ffill', left_by='group')
group key lvalue rvalue
0 a a 1 NaN
1 a b 1 1.0
2 a c 2 2.0
3 a d 2 3.0
4 a e 3 3.0
5 b a 1 NaN
6 b b 1 1.0
7 b c 2 2.0
8 b d 2 3.0
9 b e 3 3.0
```
### 34.2.1.9 pandas.merge_asof

**pandas.merge_asof**(left, right, on=None, left_on=None, right_on=None, left_index=False, right_index=False, by=None, left_by=None, right_by=None, suffixes=('_x', '_y'), tolerance=None, allow_exact_matches=True, direction='backward')

Perform an asof merge. This is similar to a left-join except that we match on nearest key rather than equal keys.

Both DataFrames must be sorted by the key.

For each row in the left DataFrame:

- A “backward” search selects the last row in the right DataFrame whose ‘on’ key is less than or equal to the left’s key.
- A “forward” search selects the first row in the right DataFrame whose ‘on’ key is greater than or equal to the left’s key.
- A “nearest” search selects the row in the right DataFrame whose ‘on’ key is closest in absolute distance to the left’s key.

The default is “backward” and is compatible in versions below 0.20.0. The direction parameter was added in version 0.20.0 and introduces “forward” and “nearest”.

Optionally match on equivalent keys with ‘by’ before searching with ‘on’.

New in version 0.19.0.

**Parameters**

- **left** [DataFrame]
- **right** [DataFrame]
- **on** : label
  - Field name to join on. Must be found in both DataFrames. The data MUST be ordered. Furthermore this must be a numeric column, such as datetimelike, integer, or float. On or left_on/right_on must be given.
- **left_on** : label
  - Field name to join on in left DataFrame.
- **right_on** : label
  - Field name to join on in right DataFrame.
- **left_index** : boolean
  - Use the index of the left DataFrame as the join key.
  - New in version 0.19.2.
- **right_index** : boolean
  - Use the index of the right DataFrame as the join key.
  - New in version 0.19.2.
- **by** : column name or list of column names
  - Match on these columns before performing merge operation.
- **left_by** : column name
  - Field names to match on in the left DataFrame.
  - New in version 0.19.2.
right_by : column name
Field names to match on in the right DataFrame.
New in version 0.19.2.
suffixes : 2-length sequence (tuple, list, ...)
Suffix to apply to overlapping column names in the left and right side, respectively.
tolerance : integer or Timedelta, optional, default None
Select asof tolerance within this range; must be compatible with the merge index.
allow_exact_matches : boolean, default True
• If True, allow matching with the same ‘on’ value (i.e. less-than-or-equal-to / greater-than-
or-equal-to)
• If False, don’t match the same ‘on’ value (i.e., strict less-than / strictly greater-than)
direction : ‘backward’ (default), ‘forward’, or ‘nearest’
Whether to search for prior, subsequent, or closest matches.
New in version 0.20.0.

Returns
merged [DataFrame]

See also:
merge, merge_ordered

Examples

```python
>>> left = pd.DataFrame({'a': [1, 5, 10], 'left_val': ['a', 'b', 'c']})
>>> left
   a  left_val
0  1      a
1  5      b
2 10     c

>>> right = pd.DataFrame({'a': [1, 2, 3, 6, 7],
                        'right_val': [1, 2, 3, 6, 7]})
>>> right
   a  right_val
0  1       1
1  2       2
2  3       3
3  6       6
4  7       7

>>> pd.merge_asof(left, right, on='a')
   a  left_val  right_val
0  1      a       1
1  5      b       3
2 10     c       7
```
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
>>> pd.merge_asof(left, right, on='a', allow_exact_matches=False)
   a  left_val  right_val
0  1         a          NaN
1  5         b          3.0
2 10        c          7.0

>>> pd.merge_asof(left, right, on='a', direction='forward')
   a  left_val  right_val
0  1         a          1.0
1  5         b          6.0
2 10        c          NaN

>>> pd.merge_asof(left, right, on='a', direction='nearest')
   a  left_val  right_val
0  1         a           1
1  5         b           6
2 10        c          NaN

We can use indexed DataFrames as well.

```python
>>> left = pd.DataFrame({'left_val': ['a', 'b', 'c'], index=[1, 5, 10])
>>> left
   left_val
1      a
5      b
10     c

```python
>>> right = pd.DataFrame({'right_val': [1, 2, 3, 6, 7], ...
   index=[1, 2, 3, 6, 7])
>>> right
   right_val
1         1
2         2
3         3
6         6
7         7

```python
>>> pd.merge_asof(left, right, left_index=True, right_index=True)
   left_val  right_val
1         a         1
5         b         3
10        c         7

Here is a real-world times-series example

```python
>>> quotes
          time  ticker  bid  ask
0  2016-05-25  13:30:00.023  GOOG  720.50  720.93
1  2016-05-25  13:30:00.023  MSFT  51.95  51.96
2  2016-05-25  13:30:00.030  MSFT  51.97  51.98
3  2016-05-25  13:30:00.041  MSFT  51.99  52.00
4  2016-05-25  13:30:00.048  GOOG  720.50  720.93
5  2016-05-25  13:30:00.049  AAPL  97.99  98.01
6  2016-05-25  13:30:00.072  GOOG  720.50  720.88
7  2016-05-25  13:30:00.075  MSFT  52.01  52.03
```

34.2. General functions
By default we are taking the asof of the quotes

```python
>>> pd.merge_asof(trades, quotes,
... on='time',
... by='ticker')
```

<table>
<thead>
<tr>
<th>time</th>
<th>ticker</th>
<th>price</th>
<th>quantity</th>
<th>bid</th>
<th>ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 2016-05-25</td>
<td>MSFT</td>
<td>51.95</td>
<td>75</td>
<td>51.95</td>
<td>51.96</td>
</tr>
<tr>
<td>1 2016-05-25</td>
<td>MSFT</td>
<td>51.95</td>
<td>155</td>
<td>51.97</td>
<td>51.98</td>
</tr>
<tr>
<td>2 2016-05-25</td>
<td>GOOG</td>
<td>720.77</td>
<td>100</td>
<td>720.50</td>
<td>720.93</td>
</tr>
<tr>
<td>3 2016-05-25</td>
<td>GOOG</td>
<td>720.92</td>
<td>100</td>
<td>720.50</td>
<td>720.93</td>
</tr>
<tr>
<td>4 2016-05-25</td>
<td>AAPL</td>
<td>98.00</td>
<td>100</td>
<td>NaN</td>
<td>NaN</td>
</tr>
</tbody>
</table>

We only asof within 2ms between the quote time and the trade time

```python
>>> pd.merge_asof(trades, quotes,
... on='time',
... by='ticker',
... tolerance=pd.Timedelta('2ms'))
```

<table>
<thead>
<tr>
<th>time</th>
<th>ticker</th>
<th>price</th>
<th>quantity</th>
<th>bid</th>
<th>ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 2016-05-25</td>
<td>MSFT</td>
<td>51.95</td>
<td>75</td>
<td>51.95</td>
<td>51.96</td>
</tr>
<tr>
<td>1 2016-05-25</td>
<td>MSFT</td>
<td>51.95</td>
<td>155</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>2 2016-05-25</td>
<td>GOOG</td>
<td>720.77</td>
<td>100</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>3 2016-05-25</td>
<td>GOOG</td>
<td>720.92</td>
<td>100</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>4 2016-05-25</td>
<td>AAPL</td>
<td>98.00</td>
<td>100</td>
<td>NaN</td>
<td>NaN</td>
</tr>
</tbody>
</table>

We only asof within 10ms between the quote time and the trade time and we exclude exact matches on time. However prior data will propagate forward

```python
>>> pd.merge_asof(trades, quotes,
... on='time',
... by='ticker',
... tolerance=pd.Timedelta('10ms'),
... allow_exact_matches=False)
```

<table>
<thead>
<tr>
<th>time</th>
<th>ticker</th>
<th>price</th>
<th>quantity</th>
<th>bid</th>
<th>ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 2016-05-25</td>
<td>MSFT</td>
<td>51.95</td>
<td>75</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>1 2016-05-25</td>
<td>MSFT</td>
<td>51.95</td>
<td>155</td>
<td>51.97</td>
<td>51.98</td>
</tr>
<tr>
<td>2 2016-05-25</td>
<td>GOOG</td>
<td>720.77</td>
<td>100</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>3 2016-05-25</td>
<td>GOOG</td>
<td>720.92</td>
<td>100</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>4 2016-05-25</td>
<td>AAPL</td>
<td>98.00</td>
<td>100</td>
<td>NaN</td>
<td>NaN</td>
</tr>
</tbody>
</table>

### 34.2.1.10 pandas.concat

```python
pandas.concat(objs, axis=0, join='outer', join_axes=None, ignore_index=False, keys=None, levels=None, names=None, verify_integrity=False, sort=None, copy=True)
```

Concatenate pandas objects along a particular axis with optional set logic along the other axes.

Can also add a layer of hierarchical indexing on the concatenation axis, which may be useful if the labels are the same (or overlapping) on the passed axis number.
Parameters **objs**: a sequence or mapping of Series, DataFrame, or Panel objects

If a dict is passed, the sorted keys will be used as the *keys* argument, unless it is passed, in which case the values will be selected (see below). Any None objects will be dropped silently unless they are all None in which case a ValueError will be raised

**axis**: `{0/'index', 1/'columns'}`, default 0

The axis to concatenate along

**join**: `{‘inner’, ‘outer’}`, default ‘outer’

How to handle indexes on other axis(es)

**join_axes**: list of Index objects

Specific indexes to use for the other n - 1 axes instead of performing inner/outer set logic

**ignore_index**: boolean, default False

If True, do not use the index values along the concatenation axis. The resulting axis will be labeled 0, . . ., n - 1. This is useful if you are concatenating objects where the concatenation axis does not have meaningful indexing information. Note the index values on the other axes are still respected in the join.

**keys**: sequence, default None

If multiple levels passed, should contain tuples. Construct hierarchical index using the passed keys as the outermost level

**levels**: list of sequences, default None

Specific levels (unique values) to use for constructing a MultiIndex. Otherwise they will be inferred from the keys

**names**: list, default None

Names for the levels in the resulting hierarchical index

**verify_integrity**: boolean, default False

Check whether the new concatenated axis contains duplicates. This can be very expensive relative to the actual data concatenation

**sort**: boolean, default None

Sort non-concatenation axis if it is not already aligned when *join* is ‘outer’. The current default of sorting is deprecated and will change to not-sorting in a future version of pandas.

Explicitly pass **sort=True** to silence the warning and sort. Explicitly pass **sort=False** to silence the warning and not sort.

This has no effect when *join=‘inner’*, which already preserves the order of the non-concatenation axis.

New in version 0.23.0.

**copy**: boolean, default True

If False, do not copy data unnecessarily

Returns **concatenated**: object, type of objs
When concatenating all `Series` along the index (axis=0), a `Series` is returned.
When `objs` contains at least one `DataFrame`, a `DataFrame` is returned. When concatenating along the columns (axis=1), a `DataFrame` is returned.

See also:

`Series.append`, `DataFrame.append`, `DataFrame.join`, `DataFrame.merge`

Notes

The keys, levels, and names arguments are all optional.

A walkthrough of how this method fits in with other tools for combining pandas objects can be found [here](#).

Examples

Combine two `Series`.

```python
g1 = pd.Series(['a', 'b'])
g2 = pd.Series(['c', 'd'])
g3 = pd.concat([g1, g2])
0   a
1   b
0   c
1   d
dtype: object
```

Clear the existing index and reset it in the result by setting the `ignore_index` option to `True`.

```python
g1 = pd.concat([g1, g2], ignore_index=True)
0   a
1   b
2   c
3   d
dtype: object
```

Add a hierarchical index at the outermost level of the data with the `keys` option.

```python
g1 = pd.concat([g1, g2], keys=['s1', 's2'])
s1 0   a
   1   b
s2 0   c
   1   d
dtype: object
```

Label the index keys you create with the `names` option.

```python
g1 = pd.concat([g1, g2], keys=['s1', 's2'],
... names=['Series name', 'Row ID'])
```

Combine two `DataFrame` objects with identical columns.
```python
>>> df1 = pd.DataFrame([['a', 1], ['b', 2]],
                       columns=['letter', 'number'])
>>> df1
   letter number
0    a      1
1    b      2

>>> df2 = pd.DataFrame([['c', 3], ['d', 4]],
                       columns=['letter', 'number'])
>>> df2
   letter number
0    c      3
1    d      4

>>> pd.concat([df1, df2])
   letter number
0    a      1
1    b      2
0    c      3
1    d      4

Combine DataFrame objects with overlapping columns and return everything. Columns outside the intersection will be filled with NaN values.

>>> df3 = pd.DataFrame([['c', 3, 'cat'], ['d', 4, 'dog']],
                       columns=['letter', 'number', 'animal'])
>>> df3
   letter number animal
0    c      3  cat
1    d      4  dog

>>> pd.concat([df1, df3])
   animal letter number
0      NaN    a      1
1      NaN    b      2
0      cat    c      3
1      dog    d      4

Combine DataFrame objects with overlapping columns and return only those that are shared by passing inner to the join keyword argument.

>>> pd.concat([df1, df3], join="inner")
   letter number
0    a      1
1    b      2
0    c      3
1    d      4

Combine DataFrame objects horizontally along the x axis by passing in axis=1.

>>> df4 = pd.DataFrame([['bird', 'polly'], ['monkey', 'george']],
                       columns=['animal', 'name'])
>>> df4
   animal name
0    bird  polly
1    monkey  george

>>> pd.concat([df1, df4], axis=1)
   letter number animal  name
0    a      1   bird    polly
1    b      2  monkey   george

Prevent the result from including duplicate index values with the verify_integrity option.
```
```python
>>> df5 = pd.DataFrame([1], index=['a'])
>>> df5
 0
a 1
>>> df6 = pd.DataFrame([2], index=['a'])
>>> df6
 0
a 2
>>> pd.concat([df5, df6], verify_integrity=True)
Traceback (most recent call last):
...  
ValueError: Indexes have overlapping values: ['a']
```

### 34.2.1.11 pandas.get_dummies

The `pandas.get_dummies` function converts categorical variables into dummy/indicator variables.

**Parameters**

- **data** [array-like, Series, or DataFrame]
- **prefix** : string, list of strings, or dict of strings, default None
  
  String to append DataFrame column names. Pass a list with length equal to the number of columns when calling get_dummies on a DataFrame. Alternatively, `prefix` can be a dictionary mapping column names to prefixes.

- **prefix_sep** : string, default `_`
  
  If appending prefix, separator/delimiter to use. Or pass a list or dictionary as with `prefix`.

- **dummy_na** : bool, default False
  
  Add a column to indicate NaNs, if False NaNs are ignored.

- **columns** : list-like, default None
  
  Column names in the DataFrame to be encoded. If `columns` is None then all the columns with `object` or `category` dtype will be converted.

- **sparse** : bool, default False
  
  Whether the dummy columns should be sparse or not. Returns SparseDataFrame if `data` is a Series or if all columns are included. Otherwise returns a DataFrame with some SparseBlocks.

- **drop_first** : bool, default False
  
  Whether to get k-1 dummies out of k categorical levels by removing the first level.

  New in version 0.18.0.

- **dtype** : dtype, default np.uint8
  
  Data type for new columns. Only a single dtype is allowed.

  New in version 0.23.0.

**Returns**

- **dummies** [DataFrame or SparseDataFrame]
See also:

*Series.str.get_dummies*

**Examples**

```python
>>> import pandas as pd
>>> s = pd.Series(list('abca'))
```

```python
>>> pd.get_dummies(s)
     a  b  c
0  1  0  0
1  0  1  0
2  0  0  1
3  1  0  0
```

```python
>>> s1 = ['a', 'b', np.nan]
```

```python
>>> pd.get_dummies(s1)
     a  b
0  1  0
1  0  1
2  0  0
```

```python
>>> pd.get_dummies(s1, dummy_na=True)
     a  b  NaN
0  1  0  0
1  0  1  0
2  0  0  1
```

```python
df = pd.DataFrame({'A': ['a', 'b', 'a'], 'B': ['b', 'a', 'c'], ...
                   'C': [1, 2, 3]})
```

```python
>>> pd.get_dummies(df, prefix=['col1', 'col2'])
   C  col1_a  col1_b  col2_a  col2_b  col2_c
0  1       1       0       0       1       0
1  2       0       1       1       0       0
2  3       1       0       0       0       1
```

```python
>>> pd.get_dummies(pd.Series(list('abcaa')))
     a  b  c
0  1  0  0
1  0  1  0
2  0  0  1
3  1  0  0
4  1  0  0
```

```python
>>> pd.get_dummies(pd.Series(list('abcaa')), drop_first=True)
      b  c
0  0  0
1  1  0
2  0  1
3  0  0
4  0  0
```
```python
>>> pd.get_dummies(pd.Series(list('abc')), dtype=float)
   a  b  c
0  1  0  0
1  0  1  0
2  0  0  1
```

### 34.2.1.12 pandas.factorize

The `factorize` method encodes the object as an enumerated type or categorical variable. This method is useful for obtaining a numeric representation of an array when all that matters is identifying distinct values. `factorize` is available as both a top-level function `pandas.factorize()`, and as a method `Series.factorize()` and `Index.factorize()`.

**Parameters**

- `values` : sequence
  A 1-D sequence. Sequences that aren’t pandas objects are coerced to ndarrays before factorization.
- `sort` : bool, default `False`
  Sort `uniques` and shuffle `labels` to maintain the relationship.
- `order` : default `None`
  Deprecation since version 0.23.0: This parameter has no effect and is deprecated.
- `na_sentinel` : int, default `-1`
  Value to mark “not found”.
- `size_hint` : int, optional
  Hint to the hashtable sizer.

**Returns**

- `labels` : ndarray
  An integer ndarray that’s an indexer into `uniques`. `uniques.take(labels)` will have the same values as `values`.
- `uniques` : ndarray, Index, or Categorical
  The unique valid values. When `values` is Categorical, `uniques` is a Categorical. When `values` is some other pandas object, an Index is returned. Otherwise, a 1-D ndarray is returned.

**Note:** Even if there’s a missing value in `values`, `uniques` will not contain an entry for it.

**See also:**

- `pandas.cut` Discretize continuous-valued array.
- `pandas.unique` Find the unique value in an array.
Examples

These examples all show factorize as a top-level method like `pd.factorize(values)`. The results are identical for methods like `Series.factorize()`.

```python
>>> labels, uniques = pd.factorize(['b', 'b', 'a', 'c', 'b'])
>>> labels
array([0, 0, 1, 2, 0])
>>> uniques
array(['b', 'a', 'c'], dtype=object)
```

With `sort=True`, the `uniques` will be sorted, and `labels` will be shuffled so that the relationship is maintained.

```python
>>> labels, uniques = pd.factorize(['b', 'b', 'a', 'c', 'b'], sort=True)
>>> labels
array([1, 1, 0, 2, 1])
>>> uniques
array(['a', 'b', 'c'], dtype=object)
```

Missing values are indicated in `labels` with `na_sentinel` (-1 by default). Note that missing values are never included in `uniques`.

```python
>>> labels, uniques = pd.factorize(['b', None, 'a', 'c', 'b'])
>>> labels
array([ 0, -1, 1, 2, 0])
>>> uniques
array(['b', 'a', 'c'], dtype=object)
```

Thus far, we’ve only factorized lists (which are internally coerced to NumPy arrays). When factorizing pandas objects, the type of `uniques` will differ. For Categoricals, a `Categorical` is returned.

```python
>>> cat = pd.Categorical(['a', 'a', 'c'], categories=['a', 'b', 'c'])
>>> labels, uniques = pd.factorize(cat)
>>> labels
array([0, 0, 1])
>>> uniques
Categories (3, object): [a, b, c]
```

Notice that 'b' is in `uniques.categories`, despite not being present in `cat.values`.

For all other pandas objects, an Index of the appropriate type is returned.

```python
>>> cat = pd.Series(['a', 'a', 'c'])
>>> labels, uniques = pd.factorize(cat)
>>> labels
array([0, 0, 1])
>>> uniques
Index(['a', 'c'], dtype='object')
```

---

34.2.1.13 pandas.unique

`pandas.unique(values)`

Hash table-based unique. Uniques are returned in order of appearance. This does NOT sort.

Significantly faster than `numpy.unique`. Includes NA values.
Parameters

values [1d array-like]

Returns unique values.

- If the input is an Index, the return is an Index
- If the input is a Categorical dtype, the return is a Categorical
- If the input is a Series/ndarray, the return will be an ndarray

See also:
pandas.Index.unique, pandas.Series.unique

Examples

```python
>>> pd.unique(pd.Series([2, 1, 3, 3]))
array([2, 1, 3])
```

```python
>>> pd.unique(pd.Series([2] + [1] * 5))
array([2, 1])
```

```python
>>> pd.unique(pd.Series([pd.Timestamp('20160101'), ... pd.Timestamp('20160101')]))
array(['2016-01-01T00:00:00.000000000'], dtype='datetime64[ns]')
```

```python
>>> pd.unique(pd.Series([pd.Timestamp('20160101', tz='US/Eastern'), ... pd.Timestamp('20160101', tz='US/Eastern')]))
array([Timestamp('2016-01-01 00:00:00-0500', tz='US/Eastern')], dtype=object)
```

```python
>>> pd.unique(pd.Index([pd.Timestamp('20160101', tz='US/Eastern'), ... pd.Timestamp('20160101', tz='US/Eastern')]))
DatetimeIndex(['2016-01-01 00:00:00-05:00'], ...
               dtype='datetime64[ns, US/Eastern]', freq=None)
```

```python
>>> pd.unique(list('baabc'))
array(['b', 'a', 'c'], dtype=object)
```

An unordered Categorical will return categories in the order of appearance.

```python
>>> pd.unique(Series(pd.Categorical(list('baabc'))))
Categories (3, object): [b, a, c]
```

```python
>>> pd.unique(Series(pd.Categorical(list('baabc'), ... categories=list('abc'))))
Categories (3, object): [b, a, c]
```

An ordered Categorical preserves the category ordering.

```python
>>> pd.unique(Series(pd.Categorical(list('baabc'), ... categories=list('abc'))),
            categories=list('abc'))
```
An array of tuples

```
>>> pd.unique([(‘a’, ‘b’), (‘b’, ‘a’), (‘a’, ‘c’), (‘b’, ‘a’)])
array([(‘a’, ‘b’), (‘b’, ‘a’), (‘a’, ‘c’)], dtype=object)
```

### 34.2.1.14 pandas.wide_to_long

**pandas.wide_to_long** *(df, stubnames, i, j, sep=”, suffix=’\d+’)*

Wide panel to long format. Less flexible but more user-friendly than melt.

With stubnames [‘A’, ‘B’], this function expects to find one or more group of columns with format A-suffix1, A-suffix2,... B-suffix1, B-suffix2,... You specify what you want to call this suffix in the resulting long format with *j* (for example *j*='*year*')

Each row of these wide variables are assumed to be uniquely identified by *i* (can be a single column name or a list of column names)

All remaining variables in the data frame are left intact.

**Parameters**

- **df**: DataFrame
  The wide-format DataFrame
- **stubnames**: str or list-like
  The stub name(s). The wide format variables are assumed to start with the stub names.
- **i**: str or list-like
  Column(s) to use as id variable(s)
- **j**: str
  The name of the subobservation variable. What you wish to name your suffix in the long format.
- **sep**: str, default “”
  A character indicating the separation of the variable names in the wide format, to be stripped from the names in the long format. For example, if your column names are A-suffix1, A-suffix2, you can strip the hyphen by specifying *sep*='.’
  
  New in version 0.20.0.
- **suffix**: str, default ‘\d+’
  A regular expression capturing the wanted suffixes. ‘\d+’ captures numeric suffixes. Suffixes with no numbers could be specified with the negated character class ‘\D+’. You can also further disambiguate suffixes, for example, if your wide variables are of the form Aone, Btwo,..., and you have an unrelated column Arating, you can ignore the last one by specifying *suffix*=('!one|two')
  
  New in version 0.20.0.

**Returns**

DataFrame
A DataFrame that contains each stub name as a variable, with new index (i, j)

Notes

All extra variables are left untouched. This simply uses pandas.melt under the hood, but is hard-coded to “do the right thing” in a typical case.

Examples

```python
>>> import pandas as pd
>>> import numpy as np
>>> np.random.seed(123)
>>> df = pd.DataFrame({
...     "A1970": {0: "a", 1: "b", 2: "c"},
...     "A1980": {0: "d", 1: "e", 2: "f"},
...     "B1970": {0: 2.5, 1: 1.2, 2: .7},
...     "B1980": {0: 3.2, 1: 1.3, 2: .1},
...     "X": dict(zip(range(3), np.random.randn(3)))
... })
>>> df["id"] = df.index
>>> df
0 a d 2.5 3.2 -1.085631 0
1 b e 1.2 1.3 0.997345 1
2 c f 0.7 0.1 0.282978 2
>>>
>>> pd.wide_to_long(df, ["A", "B"], i="id", j="year")
X A B
id year
0 1970 -1.085631 a 2.5
1 1970 0.997345 b 1.2
2 1970 0.282978 c 0.7
0 1980 -1.085631 d 3.2
1 1980 0.997345 e 1.3
2 1980 0.282978 f 0.1
```

With multiple id columns

```python
>>> df = pd.DataFrame({
...     'famid': [1, 1, 1, 2, 2, 2, 3, 3, 3],
...     'birth': [1, 2, 3, 1, 2, 3, 1, 2, 3],
...     'ht1': [2.8, 2.9, 2.2, 1.8, 1.9, 2.2, 2.3, 2.1],
...     'ht2': [1.4, 3.8, 2.9, 3.2, 2.8, 2.4, 3.3, 3.4, 2.9]
... })
>>> df
birth famid ht1 ht2
0 1 1 2.8 3.4
1 2 1 2.9 3.8
2 3 1 2.2 2.9
3 1 2 2.0 3.2
4 2 2 1.8 2.8
5 3 2 1.9 2.4
6 1 3 2.2 3.3
7 2 3 2.3 3.4
8 3 3 2.1 2.9
>>> l = pd.wide_to_long(df, stubnames='ht', i='famid', j='birth')
```

(continues on next page)
Going from long back to wide just takes some creative use of *unstack*

```python
>>> w = l.unstack()
>>> w.columns = w.columns.map('{}[0][1]'.format)
>>> w.reset_index()
```

<table>
<thead>
<tr>
<th>famid</th>
<th>birth</th>
<th>ht1</th>
<th>ht2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2.8</td>
<td>3.4</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>2.9</td>
<td>3.4</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2.0</td>
<td>3.2</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1.8</td>
<td>2.8</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1.9</td>
<td>2.8</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>2.2</td>
<td>2.4</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>1.8</td>
<td>2.3</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>2.3</td>
<td>3.3</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>2.3</td>
<td>3.4</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>3.1</td>
<td>2.9</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>2.3</td>
<td>3.1</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>2.3</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Less wieldy column names are also handled

```python
>>> np.random.seed(0)
>>> df = pd.DataFrame({'A(quarterly)-2010': np.random.rand(3),
                     ... 'A(quarterly)-2011': np.random.rand(3),
                     ... 'B(quarterly)-2010': np.random.rand(3),
                     ... 'B(quarterly)-2011': np.random.rand(3),
                     ... 'X' : np.random.randint(3, size=3))
>>> df['id'] = df.index
>>> df
```

<table>
<thead>
<tr>
<th>A(quarterly)-2010</th>
<th>A(quarterly)-2011</th>
<th>B(quarterly)-2010</th>
<th>B(quarterly)-2011</th>
<th>X</th>
<th>id</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.548814</td>
<td>0.544883</td>
<td>0.437587</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>0.715189</td>
<td>0.423655</td>
<td>0.891773</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>0.602763</td>
<td>0.645894</td>
<td>0.963663</td>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>
If we have many columns, we could also use a regex to find our stubnames and pass that list on to `wide_to_long`

```python
>>> stubnames = sorted(set([match[0] for match in df.columns.str.findall(r'\[A-B]\((.*)\)').values if match != []])
... )
>>> list(stubnames)
['A(quarterly)', 'B(quarterly)']
```

All of the above examples have integers as suffixes. It is possible to have non-integers as suffixes.

```python
>>> df = pd.DataFrame({
...     'famid': [1, 1, 1, 2, 2, 2, 3, 3, 3],
...     'birth': [1, 2, 3, 1, 2, 3, 1, 2, 3],
...     'ht_one': [2.8, 2.9, 2.2, 2.0, 1.8, 1.9, 2.2, 2.3, 2.1],
...     'ht_two': [3.4, 3.8, 2.9, 3.2, 2.8, 2.4, 3.3, 3.4, 2.9]
... })
>>> df
  birth  famid  ht_one  ht_two
0  1.0  1.0  2.80  3.40
1  2.0  1.0  2.90  3.80
2  3.0  1.0  2.20  2.90
3  1.0  2.0  2.00  3.20
4  2.0  2.0  1.80  2.80
5  3.0  2.0  1.90  2.40
6  1.0  3.0  2.20  3.30
7  2.0  3.0  2.30  3.40
8  3.0  3.0  2.10  2.90
```

```python
>>> l = pd.wide_to_long(df, stubnames='ht', i=['famid', 'birth'], j='age', sep='_', suffix='\w')
>>> l
  famid  birth  age
1  1.0  2.80   one
2  2.0  2.90   one
3  3.0  2.20   one
```

(continues on next page)
34.2.2 Top-level missing data

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pandas.isna</td>
<td>Detect missing values for an array-like object.</td>
</tr>
<tr>
<td>isnull</td>
<td>Detect missing values for an array-like object.</td>
</tr>
<tr>
<td>notna</td>
<td>Detect non-missing values for an array-like object.</td>
</tr>
<tr>
<td>notnull</td>
<td>Detect non-missing values for an array-like object.</td>
</tr>
</tbody>
</table>

34.2.2.1 pandas.isna

### pandas.isna(obj)

Detect missing values for an array-like object.

This function takes a scalar or array-like object and indicates whether values are missing (NaN in numeric arrays, None or NaN in object arrays, NaT in datetimelike).

**Parameters**

- **obj**: scalar or array-like

  Object to check for null or missing values.

**Returns**

- **bool or array-like of bool**

  For scalar input, returns a scalar boolean. For array input, returns an array of boolean indicating whether each corresponding element is missing.

**See also:**

- **notna**: boolean inverse of pandas.isna.
- **Series.isna**: Detect missing values in a Series.
- **DataFrame.isna**: Detect missing values in a DataFrame.
- **Index.isna**: Detect missing values in an Index.

**Examples**

Scalar arguments (including strings) result in a scalar boolean.

```python
>>> pd.isna('dog')
False
```

```python
>>> pd.isna(np.nan)
True
```

Ndarrays result in an ndarray of booleans.
```python
>>> array = np.array([[1, np.nan, 3], [4, 5, np.nan]])
>>> array
array([[ 1., nan, 3.],
        [ 4., 5., nan]])
>>> pd.isna(array)
array([[False, True, False],
        [False, False, True]])
```

For indexes, an `ndarray` of booleans is returned.

```python
>>> index = pd.DatetimeIndex(['2017-07-05', '2017-07-06', None, ... '2017-07-08'])
>>> index
DatetimeIndex(['2017-07-05', '2017-07-06', 'NaT', '2017-07-08'],
              dtype='datetime64[ns]', freq=None)
>>> pd.isna(index)
array([False, False, True, False])
```

For Series and DataFrame, the same type is returned, containing booleans.

```python
>>> df = pd.DataFrame([['ant', 'bee', 'cat'], ['dog', None, 'fly']])
>>> df
   0   1   2
0  ant bee cat
1  dog  None fly
>>> pd.isna(df)
   0   1   2
0 False False False
1 False  True False
```

```python
>>> pd.isna(df[1])
   0  1  2
0 False False False
1    True
Name: 1, dtype: bool
```

### 34.2.2.2 pandas.isnull

#### pandas.isnull(obj)

Detect missing values for an array-like object.

This function takes a scalar or array-like object and indicates whether values are missing (NaN in numeric arrays, None or NaN in object arrays, NaT in datetimelike).

**Parameters**

- **obj** : scalar or array-like

**Returns**

- **bool** or **array-like of bool**

  For scalar input, returns a scalar boolean. For array input, returns an array of boolean indicating whether each corresponding element is missing.

**See also:**

- `notna` boolean inverse of pandas.isna.
- `Series.isna` Detect missing values in a Series.
- `DataFrame.isna` Detect missing values in a DataFrame.
**Index.isna** Detect missing values in an Index.

### Examples

Scalar arguments (including strings) result in a scalar boolean.

```python
>>> pd.isna('dog')
False
```

```python
>>> pd.isna(np.nan)
True
```

Ndarrays result in an ndarray of booleans.

```python
>>> array = np.array([[1, np.nan, 3], [4, 5, np.nan]])
>>> array
array([[ 1., nan, 3.],
       [ 4., 5., nan]])
>>> pd.isna(array)
array([[False, True, False],
       [False, False, True]])
```

For indexes, an ndarray of booleans is returned.

```python
>>> index = pd.DatetimeIndex(['2017-07-05', '2017-07-06', 'NaT', '2017-07-08'])
>>> index
DatetimeIndex(['2017-07-05', '2017-07-06', 'NaT', '2017-07-08'],
              dtype='datetime64[ns]', freq=None)
>>> pd.isna(index)
array([False, False, True, False])
```

For Series and DataFrame, the same type is returned, containing booleans.

```python
>>> df = pd.DataFrame([['ant', 'bee', 'cat'], ['dog', None, 'fly']])
>>> df
  0  1  2
0  ant bee cat
1  dog None fly
>>> pd.isna(df)
0  1  2
0  False False False
1  False  True False
```

```python
>>> pd.isna(df[1])
0  False
1  True
Name: 1, dtype: bool
```

#### 34.2.2.3 pandas.notna

**pandas.notna**(obj)

Detect non-missing values for an array-like object.
This function takes a scalar or array-like object and indicates whether values are valid (not missing, which is NaN in numeric arrays, None or NaN in object arrays, NaT in datetimelike).

**Parameters**

- `obj` : array-like or object value
  
  Object to check for not null or non-missing values.

**Returns**

- `bool` or array-like of `bool`
  
  For scalar input, returns a scalar boolean. For array input, returns an array of boolean indicating whether each corresponding element is valid.

See also:

- `isna` boolean inverse of pandas.notna.
- `Series.notna` Detect valid values in a Series.
- `DataFrame.notna` Detect valid values in a DataFrame.
- `Index.notna` Detect valid values in an Index.

**Examples**

Scalar arguments (including strings) result in a scalar boolean.

```python
>>> pd.notna('dog')
True
```

```python
>>> pd.notna(np.nan)
False
```

Ndarrays result in an ndarray of booleans.

```python
>>> array = np.array([[1, np.nan, 3], [4, 5, np.nan]])
>>> pd.notna(array)
array([[ True, False, True],
       [ True, True, False]])
```

For indexes, an ndarray of booleans is returned.

```python
>>> index = pd.DatetimeIndex(['2017-07-05', '2017-07-06', None, ...
                            '2017-07-08'])
>>> pd.notna(index)
array([ True, True, False, True])
```

For Series and DataFrame, the same type is returned, containing booleans.

```python
>>> df = pd.DataFrame([['ant', 'bee', 'cat'], ['dog', None, 'fly']])
>>> df
   0  1  2
0  ant bee cat
1  dog    NaN   fly
```
pandas: powerful Python data analysis toolkit, Release 0.23.2

1 dog None fly

```python
>>> pd.notna(df)
0  1  2
0  True True True
1  True False True
```

```python
>>> pd.notna(df[1])
0  True
1  False
Name: 1, dtype: bool
```

### 34.2.2.4 pandas.notnull

**pandas.notnull**(obj)

Detect non-missing values for an array-like object.

This function takes a scalar or array-like object and indicates whether values are valid (not missing, which is NaN in numeric arrays, None or NaN in object arrays, NaT in datetimelike).

**Parameters**

- `obj`: array-like or object value

  Object to check for not null or non-missing values.

**Returns**

- **bool or array-like of bool**

  For scalar input, returns a scalar boolean. For array input, returns an array of boolean indicating whether each corresponding element is valid.

**See also:**

- `isna` boolean inverse of pandas.notna.
- `Series.notna` Detect valid values in a Series.
- `DataFrame.notna` Detect valid values in a DataFrame.
- `Index.notna` Detect valid values in an Index.

**Examples**

Scalar arguments (including strings) result in a scalar boolean.

```python
>>> pd.notna('dog')
True
```

```python
>>> pd.notna(np.nan)
False
```

Ndarrays result in an ndarray of booleans.

```python
>>> array = np.array([[1, np.nan, 3], [4, 5, np.nan]])
>>> array
array([[ 1., nan, 3.],
       [ 4., 5., nan]])
```

```python
>>> pd.notna(array)
```

(continues on next page)
array([[ True, False, True],
       [ True, True, False]])

For indexes, an ndarray of booleans is returned.

```python
>>> index = pd.DatetimeIndex(['2017-07-05', '2017-07-06', None,
                            '2017-07-08'])
>>> index
DatetimeIndex(['2017-07-05', '2017-07-06', 'NaT', '2017-07-08'],
               dtype='datetime64[ns]', freq=None)
>>> pd.notna(index)
array([ True, True, False, True])
```

For Series and DataFrame, the same type is returned, containing booleans.

```python
>>> df = pd.DataFrame([['ant', 'bee', 'cat'], ['dog', None, 'fly']])
>>> df
  0 1 2
0 ant bee cat
1 dog None fly
>>> pd.notna(df)
   0  1  2
0 True True True
1 True False True
```

```python
>>> pd.notna(df[1])
0   True
1   False
Name: 1, dtype: bool
```

### 34.2.3 Top-level conversions

**to_numeric**(arg[, errors, downcast]) Convert argument to a numeric type.

#### 34.2.3.1 pandas.to_numeric

pandas.to_numeric(arg, errors='raise', downcast=None) Convert argument to a numeric type.

**Parameters**

- **arg** [list, tuple, 1-d array, or Series]
- **errors** : {‘ignore’, ‘raise’, ‘coerce’}, default ‘raise’
  - If ‘raise’, then invalid parsing will raise an exception
  - If ‘coerce’, then invalid parsing will be set as NaN
  - If ‘ignore’, then invalid parsing will return the input
- **downcast** : {‘integer’, ‘signed’, ‘unsigned’, ‘float’}, default None
  If not None, and if the data has been successfully cast to a numerical dtype (or if the data was numeric to begin with), downcast that resulting data to the smallest numerical dtype possible according to the following rules:
• ‘integer’ or ‘signed’: smallest signed int dtype (min.: np.int8)
• 'unsigned': smallest unsigned int dtype (min.: np.uint8)
• ‘float’: smallest float dtype (min.: np.float32)

As this behaviour is separate from the core conversion to numeric values, any errors raised during the downcasting will be surfaced regardless of the value of the 'errors' input.

In addition, downcasting will only occur if the size of the resulting data’s dtype is strictly larger than the dtype it is to be cast to, so if none of the dtypes checked satisfy that specification, no downcasting will be performed on the data.

New in version 0.19.0.

Returns ret : numeric if parsing succeeded.

Return type depends on input. Series if Series, otherwise ndarray

See also:

pandas.DataFrame.astype Cast argument to a specified dtype.
pandas.to_datetime Convert argument to datetime.
pandas.to_timedelta Convert argument to timedelta.
numpy.ndarray.astype Cast a numpy array to a specified type.

Examples

Take separate series and convert to numeric, coercing when told to

```python
>>> import pandas as pd
>>> s = pd.Series(['1.0', '2', -3])
>>> pd.to_numeric(s)
0   1.0  
1   2.0  
2  -3.0  
dtype: float64
>>> pd.to_numeric(s, downcast='float')
0   1.0  
1   2.0  
2  -3.0  
dtype: float32
>>> pd.to_numeric(s, downcast='signed')
0    1    
1    2    
2   -3    
dtype: int8
>>> s = pd.Series(['apple', '1.0', '2', -3])
>>> pd.to_numeric(s, errors='ignore')
0  apple
1   1.0
2    2
3   -3
dtype: object
>>> pd.to_numeric(s, errors='coerce')
0       NaN
```

(continues on next page)
1.0 2.0 -3.0
dtype: float64

34.2.4 Top-level dealing with datetimelike

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>to_datetime</code></td>
<td>Convert argument to datetime.</td>
</tr>
<tr>
<td><code>to_timedelta</code></td>
<td>Convert argument to timedelta.</td>
</tr>
<tr>
<td><code>date_range</code></td>
<td>Return a fixed frequency DatetimeIndex.</td>
</tr>
<tr>
<td><code>bdate_range</code></td>
<td>Return a fixed frequency DatetimeIndex, with business day as the default frequency</td>
</tr>
<tr>
<td><code>period_range</code></td>
<td>Return a fixed frequency PeriodIndex, with day (calendar) as the default frequency</td>
</tr>
<tr>
<td><code>timedelta_range</code></td>
<td>Return a fixed frequency TimedeltaIndex, with day as the default frequency</td>
</tr>
<tr>
<td><code>infer_freq</code></td>
<td>Infer the most likely frequency given the input index.</td>
</tr>
</tbody>
</table>

34.2.4.1 pandas.to_datetime

`pandas.to_datetime(arg, errors='raise', dayfirst=False, yearfirst=False, utc=None, box=True, format=None, exact=True, unit=None, infer_datetime_format=False, origin='unix', cache=False)`

Convert argument to datetime.

**Parameters**
- **arg**: integer, float, string, datetime, list, tuple, 1-d array, Series
  - New in version 0.18.1: or DataFrame/dict-like
- **errors**: {'ignore', 'raise', 'coerce'}, default ‘raise’
  - If ‘raise’, then invalid parsing will raise an exception
  - If ‘coerce’, then invalid parsing will be set as NaT
  - If ‘ignore’, then invalid parsing will return the input
- **dayfirst**: boolean, default False
  - Specify a date parse order if `arg` is str or its list-likes. If True, parses dates with the day first, eg 10/11/12 is parsed as 2012-11-10. Warning: dayfirst=True is not strict, but will prefer to parse with day first (this is a known bug, based on dateutil behavior).
- **yearfirst**: boolean, default False
  - Specify a date parse order if `arg` is str or its list-likes.
  - If True parses dates with the year first, eg 10/11/12 is parsed as 2010-11-12.
  - If both dayfirst and yearfirst are True, yearfirst is preceded (same as dateutil).
  - Warning: yearfirst=True is not strict, but will prefer to parse with year first (this is a known bug, based on dateutil behavior).
- **utc**: boolean, default None
  - New in version 0.16.1.
Return UTC DatetimeIndex if True (converting any tz-aware datetime.datatetime objects as well).

**box** : boolean, default True
- If True returns a DatetimeIndex
- If False returns ndarray of values.

**format** : string, default None
    strftime to parse time, eg “%d/%m/%Y”, note that “%f” will parse all the way up to nanoseconds.

**exact** : boolean, True by default
- If True, require an exact format match.
- If False, allow the format to match anywhere in the target string.

**unit** : string, default ‘ns’
    unit of the arg (D,s,ms,us,ns) denote the unit, which is an integer or float number. This will be based off the origin. Example, with unit=’ms’ and origin=’unix’ (the default), this would calculate the number of milliseconds to the unix epoch start.

**infer_datetime_format** : boolean, default False
    If True and no format is given, attempt to infer the format of the datetime strings, and if it can be inferred, switch to a faster method of parsing them. In some cases this can increase the parsing speed by ~5-10x.

**origin** : scalar, default is ‘unix’
    Define the reference date. The numeric values would be parsed as number of units (defined by unit) since this reference date.
    - If ‘unix’ (or POSIX) time; origin is set to 1970-01-01.
    - If ‘julian’, unit must be ‘D’, and origin is set to beginning of Julian Calendar. Julian day number 0 is assigned to the day starting at noon on January 1, 4713 BC.
    - If Timestamp convertible, origin is set to Timestamp identified by origin.
    New in version 0.20.0.

**cache** : boolean, default False
    If True, use a cache of unique, converted dates to apply the datetime conversion. May produce significant speed-up when parsing duplicate date strings, especially ones with timezone offsets.
    New in version 0.23.0.

Returns **ret** : datetime if parsing succeeded.

Return type depends on input:
- list-like: DatetimeIndex
- Series: Series of datetime64 dtype
- scalar: Timestamp

In case when it is not possible to return designated types (e.g. when any element of input is before Timestamp.min or after Timestamp.max) return will have datetime.datetime type (or corresponding array/Series).
See also:

- `pandas.DataFrame.astype`: Cast argument to a specified dtype.
- `pandas.to_timedelta`: Convert argument to timedelta.

**Examples**

Assembling a datetime from multiple columns of a DataFrame. The keys can be common abbreviations like
`['year', 'month', 'day', 'minute', 'second', 'ms', 'us', 'ns']` or plurals of the same.

```python
>>> df = pd.DataFrame({'year': [2015, 2016],
                     'month': [2, 3],
                     'day': [4, 5]})
```

```python
>>> pd.to_datetime(df)
0 2015-02-04
1 2016-03-05
```

dtype: datetime64[ns]

If a date does not meet the *timestamp limitations*, passing `errors='ignore'` will return the original input instead of raising any exception.

Passing `errors='coerce'` will force an out-of-bounds date to NaT, in addition to forcing non-dates (or non-parseable dates) to NaT.

```python
>>> pd.to_datetime('13000101', format='%Y%m%d', errors='ignore')
datetime.datetime(1300, 1, 1, 0, 0)
```

```python
>>> pd.to_datetime('13000101', format='%Y%m%d', errors='coerce')
NaT
```

Passing `infer_datetime_format=True` can often-times speedup a parsing if it's not an ISO8601 format exactly, but in a regular format.

```python
```

```python
>>> s.head()
0 3/11/2000
1 3/12/2000
2 3/13/2000
3 3/11/2000
4 3/12/2000
```

dtype: object

```python
>>> %timeit pd.to_datetime(s,infer_datetime_format=True)
100 loops, best of 3: 10.4 ms per loop
```

```python
>>> %timeit pd.to_datetime(s,infer_datetime_format=False)
1 loop, best of 3: 471 ms per loop
```

Using a unix epoch time

```python
>>> pd.to_datetime(1490195805, unit='s')
Timestamp('2017-03-22 15:16:45')
```

```python
>>> pd.to_datetime(1490195805433502912, unit='ns')
Timestamp('2017-03-22 15:16:45.433502912')
```
Warning: For float arg, precision rounding might happen. To prevent unexpected behavior use a fixed-width exact type.

Using a non-unix epoch origin

```python
>>> pd.to_datetime([1, 2, 3], unit='D',
                  origin=pd.Timestamp('1960-01-01'))
0 1960-01-02
1 1960-01-03
2 1960-01-04
```

34.2.4.2 pandas.to_timedelta

**pandas.to_timedelta** *(arg, unit='ns', box=True, errors='raise')*

Convert argument to timedelta

Parameters

- **arg** [string, timedelta, list, tuple, 1-d array, or Series]
- **unit**: unit of the arg (D, h, m, s, ms, us, ns) denote the unit, which is an integer/float number
- **box**: boolean, default True
  - If True returns a Timedelta/TimedeltaIndex of the results
  - If False returns a np.timedelta64 or ndarray of values of dtype timedelta64[ns]
- **errors** : {'ignore', 'raise', 'coerce'}, default 'raise'
  - If 'raise', then invalid parsing will raise an exception
  - If 'coerce', then invalid parsing will be set as NaT
  - If 'ignore', then invalid parsing will return the input

Returns

- **ret** [timedelta64/arrays of timedelta64 if parsing succeeded]

See also:

- **pandas.DataFrame.astype** Cast argument to a specified dtype.
- **pandas.to_datetime** Convert argument to datetime.

Examples

Parsing a single string to a Timedelta:

```python
>>> pd.to_timedelta('1 days 06:05:01.00003')
Timedelta('1 days 06:05:01.000030')
>>> pd.to_timedelta('15.5us')
Timedelta('0 days 00:00:00.000015')
```

Parsing a list or array of strings:
```python
>>> pd.to_timedelta(['1 days 06:05:01.00003', '15.5us', 'nan'])
TimedeltaIndex(['1 days 06:05:01.000030', '0 days 00:00:00.000015', NaT],
              dtype='timedelta64[ns]', freq=None)
```

Converting numbers by specifying the `unit` keyword argument:

```python
>>> pd.to_timedelta(np.arange(5), unit='s')
TimedeltaIndex(['00:00:00', '00:00:01', '00:00:02',
                '00:00:03', '00:00:04'],
               dtype='timedelta64[ns]', freq=None)
>>> pd.to_timedelta(np.arange(5), unit='d')
TimedeltaIndex(['0 days', '1 days', '2 days', '3 days', '4 days'],
               dtype='timedelta64[ns]', freq=None)
```

### 34.2.4.3 pandas.date_range

pandas.`date_range` 

Return a fixed frequency DatetimeIndex.

**Parameters**

- **start**: str or datetime-like, optional
  - Left bound for generating dates.

- **end**: str or datetime-like, optional
  - Right bound for generating dates.

- **periods**: integer, optional
  - Number of periods to generate.

- **freq**: str or DateOffset, default ‘D’ (calendar daily)
  - Frequency strings can have multiples, e.g. ‘5H’. See [here](#) for a list of frequency aliases.

- **tz**: str or tzinfo, optional
  - Time zone name for returning localized DatetimeIndex, for example ‘Asia/Hong_Kong’. By default, the resulting DatetimeIndex is timezone-naive.

- **normalize**: bool, default False
  - Normalize start/end dates to midnight before generating date range.

- **name**: str, default None
  - Name of the resulting DatetimeIndex.

- **closed**: {None, ‘left’, ‘right’}, optional
  - Make the interval closed with respect to the given frequency to the ‘left’, ‘right’, or both sides (None, the default).

**Returns**

- **rng**: [DatetimeIndex]

See also:
pandas.DatetimeIndex An immutable container for datetimes.
pandas.timedelta_range Return a fixed frequency TimedeltaIndex.
pandas.period_range Return a fixed frequency PeriodIndex.
pandas.interval_range Return a fixed frequency IntervalIndex.

Notes

Of the four parameters start, end, periods, and freq, exactly three must be specified. If freq is omitted, the resulting DatetimeIndex will have periods linearly spaced elements between start and end (closed on both sides).

To learn more about the frequency strings, please see this link.

Examples

Specifying the values

The next four examples generate the same DatetimeIndex, but vary the combination of start, end and periods.

Specify start and end, with the default daily frequency.

```python
>>> pd.date_range(start='1/1/2018', end='1/08/2018')
               dtype='datetime64[ns]', freq='D')
```

Specify start and periods, the number of periods (days).

```python
>>> pd.date_range(start='1/1/2018', periods=8)
               dtype='datetime64[ns]', freq='D')
```

Specify end and periods, the number of periods (days).

```python
>>> pd.date_range(end='1/1/2018', periods=8)
DatetimeIndex(['2017-12-25', '2017-12-26', '2017-12-27', '2017-12-28',
               '2017-12-29', '2017-12-30', '2017-12-31', '2018-01-01'],
               dtype='datetime64[ns]', freq='D')
```

Specify start, end, and periods; the frequency is generated automatically (linearly spaced).

```python
>>> pd.date_range(start='2018-04-24', end='2018-04-27', periods=3)
DatetimeIndex(['2018-04-24 00:00:00', '2018-04-25 12:00:00',
               '2018-04-27 00:00:00'], freq=None)
```

Other Parameters

Changed the freq (frequency) to 'M' (month end frequency).

```python
>>> pd.date_range(start='1/1/2018', periods=5, freq='M')
               '2018-05-31'],
               dtype='datetime64[ns]', freq='M')
```
Multiples are allowed

```python
>>> pd.date_range(start='1/1/2018', periods=5, freq='3M')
               '2019-01-31'],
             dtype='datetime64[ns]', freq='3M')
```

`freq` can also be specified as an Offset object.

```python
>>> pd.date_range(start='1/1/2018', periods=5, freq=pd.offsets.MonthEnd(3))
               '2019-01-31'],
             dtype='datetime64[ns]', freq='3M')
```

Specify `tz` to set the timezone.

```python
>>> pd.date_range(start='1/1/2018', periods=5, tz='Asia/Tokyo')
DatetimeIndex(['2018-01-01 00:00:00+09:00', '2018-01-02 00:00:00+09:00',
               '2018-01-03 00:00:00+09:00', '2018-01-04 00:00:00+09:00',
               '2018-01-05 00:00:00+09:00'],
             dtype='datetime64[ns, Asia/Tokyo]', freq='D')
```

`closed` controls whether to include `start` and `end` that are on the boundary. The default includes boundary points on either end.

```python
>>> pd.date_range(start='2017-01-01', end='2017-01-04', closed=None)
DatetimeIndex(['2017-01-01', '2017-01-02', '2017-01-03', '2017-01-04'],
             dtype='datetime64[ns]', freq='D')
```

Use `closed='left'` to exclude `end` if it falls on the boundary.

```python
>>> pd.date_range(start='2017-01-01', end='2017-01-04', closed='left')
DatetimeIndex(['2017-01-01', '2017-01-02', '2017-01-03'],
             dtype='datetime64[ns]', freq='D')
```

Use `closed='right'` to exclude `start` if it falls on the boundary.

```python
>>> pd.date_range(start='2017-01-01', end='2017-01-04', closed='right')
DatetimeIndex(['2017-01-02', '2017-01-03', '2017-01-04'],
             dtype='datetime64[ns]', freq='D')
```

### 34.2.4.4 pandas.bdate_range

**pandas.bdate_range** (*start=None, end=None, periods=None, freq='B', tz=None, normalize=True, name=None, weekmask=None, holidays=None, closed=None, **kwargs*)

Return a fixed frequency DatetimeIndex, with business day as the default frequency

**Parameters**

- **start**: string or datetime-like, default None
  - Left bound for generating dates

- **end**: string or datetime-like, default None
  - Right bound for generating dates

- **periods**: integer, default None
  - Number of periods to generate

- **freq**: string or DateOffset, default ‘B’ (business daily)
Frequency strings can have multiples, e.g. ‘5H’

tz : string or None
    Time zone name for returning localized DatetimeIndex, for example Asia/Beijing

normalize : bool, default False
    Normalize start/end dates to midnight before generating date range

name : string, default None
    Name of the resulting DatetimeIndex

weekmask : string or None, default None
    Weekmask of valid business days, passed to numpy.busdaycalendar, only used when custom frequency strings are passed. The default value None is equivalent to ‘Mon Tue Wed Thu Fri’
    New in version 0.21.0.

holidays : list-like or None, default None
    Dates to exclude from the set of valid business days, passed to numpy.busdaycalendar, only used when custom frequency strings are passed
    New in version 0.21.0.

closed : string, default None
    Make the interval closed with respect to the given frequency to the ‘left’, ‘right’, or both sides (None)

Returns
rng [DatetimeIndex]

Notes

Of the four parameters: start, end, periods, and freq, exactly three must be specified. Specifying freq is a requirement for bdate_range. Use date_range if specifying freq is not desired.

To learn more about the frequency strings, please see this link.

34.2.4.5 pandas.period_range

pandas.period_range (start=None, end=None, periods=None, freq='D', name=None)
    Return a fixed frequency PeriodIndex, with day (calendar) as the default frequency

Parameters start : string or period-like, default None
    Left bound for generating periods

date : string or period-like, default None
    Right bound for generating periods

periods : integer, default None
    Number of periods to generate

freq : string or DateOffset, default ‘D’ (calendar daily)
    Frequency alias

34.2. General functions
**name** : string, default None

Name of the resulting PeriodIndex

**Returns**

*prng* [PeriodIndex]

**Notes**

Of the three parameters: start, end, and periods, exactly two must be specified.

To learn more about the frequency strings, please see this link.

**Examples**

```python
>>> pd.period_range(start='2017-01-01', end='2018-01-01', freq='M')
PeriodIndex(['2017-01', '2017-02', '2017-03', '2017-04', '2017-05',
             '2017-06', '2017-06', '2017-07', '2017-08', '2017-09',
             '2017-10', '2017-11', '2017-12', '2018-01'],
            dtype='period[M]', freq='M')
```

If start or end are Period objects, they will be used as anchor endpoints for a PeriodIndex with frequency matching that of the period_range constructor.

```python
>>> pd.period_range(start=pd.Period('2017Q1', freq='Q'),
                  end=pd.Period('2017Q2', freq='Q'), freq='M')
PeriodIndex(['2017-03', '2017-04', '2017-05', '2017-06'],
            dtype='period[M]', freq='M')
```

### 34.2.4.6 pandas.timedelta_range

**pandas.timedelta_range**(start=None, end=None, periods=None, freq=None, name=None, closed=None)

Return a fixed frequency TimedeltaIndex, with day as the default frequency

**Parameters**

- **start**: string or timedelta-like, default None
  
  Left bound for generating timedeltas
  
- **end**: string or timedelta-like, default None
  
  Right bound for generating timedeltas
  
- **periods**: integer, default None
  
  Number of periods to generate
  
- **freq**: string or DateOffset, default ‘D’ (calendar daily)
  
  Frequency strings can have multiples, e.g. ‘5H’
  
- **name**: string, default None
  
  Name of the resulting TimedeltaIndex
  
- **closed**: string, default None
  
  Make the interval closed with respect to the given frequency to the ‘left’, ‘right’, or both sides (None)
Returns

rng [TimedeltaIndex]

Notes

Of the four parameters start, end, periods, and freq, exactly three must be specified. If freq is omitted, the resulting TimedeltaIndex will have periods linearly spaced elements between start and end (closed on both sides).

To learn more about the frequency strings, please see this link.

Examples

```python
>>> pd.timedelta_range(start='1 day', periods=4)
TimedeltaIndex(['1 days', '2 days', '3 days', '4 days'],
               dtype='timedelta64[ns]', freq='D')
```

The closed parameter specifies which endpoint is included. The default behavior is to include both endpoints.

```python
>>> pd.timedelta_range(start='1 day', periods=4, closed='right')
TimedeltaIndex(['2 days', '3 days', '4 days'],
               dtype='timedelta64[ns]', freq='D')
```

The freq parameter specifies the frequency of the TimedeltaIndex. Only fixed frequencies can be passed, non-fixed frequencies such as 'M' (month end) will raise.

```python
>>> pd.timedelta_range(start='1 day', end='2 days', freq='6H')
TimedeltaIndex(['1 days 00:00:00', '1 days 06:00:00', '1 days 12:00:00',
                '1 days 18:00:00', '2 days 00:00:00'],
               dtype='timedelta64[ns]', freq='6H')
```

Specify start, end, and periods; the frequency is generated automatically (linearly spaced).

```python
>>> pd.timedelta_range(start='1 day', end='5 days', periods=4)
TimedeltaIndex(['1 days 00:00:00', '2 days 08:00:00', '3 days 16:00:00',
                '5 days 00:00:00'],
               dtype='timedelta64[ns]', freq=None)
```

34.2.4.7 pandas.infer_freq

pandas.infer_freq(index, warn=True)

Infer the most likely frequency given the input index. If the frequency is uncertain, a warning will be printed.

Parameters

index : DatetimeIndex or TimedeltaIndex
    if passed a Series will use the values of the series (NOT THE INDEX)

warn [boolean, default True]

Returns

freq : string or None
    None if no discernible frequency TypeError if the index is not datetime-like ValueError if there are less than three values.
34.2.5 Top-level dealing with intervals

\[ \text{interval\_range}([\text{start, end, periods, freq, ... }]) \quad \text{Return a fixed frequency IntervalIndex} \]

34.2.5.1 pandas.interval_range

```python
def pandas.interval_range(start=None, end=None, periods=None, freq=None, name=None, closed='right')
    Return a fixed frequency IntervalIndex
```

**Parameters**  
- **start**: numeric or datetime-like, default None  
  - Left bound for generating intervals
- **end**: numeric or datetime-like, default None  
  - Right bound for generating intervals
- **periods**: integer, default None  
  - Number of periods to generate
- **freq**: numeric, string, or DateOffset, default None  
  - The length of each interval. Must be consistent with the type of start and end, e.g. 2 for numeric, or ‘5H’ for datetime-like. Default is 1 for numeric and ‘D’ (calendar daily) for datetime-like.
- **name**: string, default None  
  - Name of the resulting IntervalIndex
- **closed**: {'left', 'right', 'both', 'neither'}, default 'right'  
  - Whether the intervals are closed on the left-side, right-side, both or neither.

**Returns**  
- **rng** [IntervalIndex]

**See also**  
- `IntervalIndex` an Index of intervals that are all closed on the same side.

**Notes**

Of the four parameters `start`, `end`, `periods`, and `freq`, exactly three must be specified. If `freq` is omitted, the resulting `IntervalIndex` will have `periods` linearly spaced elements between `start` and `end`, inclusively.

To learn more about datetime-like frequency strings, please see this link.

**Examples**

Numeric `start` and `end` is supported.

```python
>>> pd.interval_range(start=0, end=5)
IntervalIndex([(0, 1], (1, 2], (2, 3], (3, 4], (4, 5]
    closed='right', dtype='interval[int64]')
```
Additionally, datetime-like input is also supported.

```python
>>> pd.interval_range(start=pd.Timestamp('2017-01-01'),
                    end=pd.Timestamp('2017-01-04'))
IntervalIndex([(2017-01-01, 2017-01-02], (2017-01-02, 2017-01-03],
               (2017-01-03, 2017-01-04]
               closed='right', dtype='interval[datetime64[ns]]')
```

The `freq` parameter specifies the frequency between the left and right endpoints of the individual intervals within the `IntervalIndex`. For numeric `start` and `end`, the frequency must also be numeric.

```python
>>> pd.interval_range(start=0, periods=4, freq=1.5)
IntervalIndex([(0.0, 1.5], (1.5, 3.0], (3.0, 4.5], (4.5, 6.0]
               closed='right', dtype='interval[float64]')
```

Similarly, for datetime-like `start` and `end`, the frequency must be convertible to a DateOffset.

```python
>>> pd.interval_range(start=pd.Timestamp('2017-01-01'),
                    periods=3, freq='MS')
IntervalIndex([(2017-01-01, 2017-02-01], (2017-02-01, 2017-03-01],
               (2017-03-01, 2017-04-01]
               closed='right', dtype='interval[datetime64[ns]]')
```

Specify `start`, `end`, and `periods`; the frequency is generated automatically (linearly spaced).

```python
>>> pd.interval_range(start=0, end=6, periods=4)
IntervalIndex([(0.0, 1.5], (1.5, 3.0], (3.0, 4.5], (4.5, 6.0]
               closed='right',
               dtype='interval[float64]')
```

The `closed` parameter specifies which endpoints of the individual intervals within the `IntervalIndex` are closed.

```python
>>> pd.interval_range(end=5, periods=4, closed='both')
IntervalIndex([[1, 2], [2, 3], [3, 4], [4, 5]
               closed='both',
               dtype='interval[int64]')
```

### 34.2.6 Top-level evaluation

`eval(expr[, parser, engine, truediv, …])`
Evaluate a Python expression as a string using various backends.

#### 34.2.6.1 pandas.eval

`pandas.eval` (expr, parser='pandas', engine=None, truediv=True, local_dict=None, global_dict=None, resolvers=(), level=0, target=None, inplace=False)
Evaluate a Python expression as a string using various backends.

The following arithmetic operations are supported: `+`, `-`, `*`, `/`, `**`, `%`, `//` (python engine only) along with the following boolean operations: `|` (or), `&` (and), and `~` (not). Additionally, the 'pandas’ parser allows the use of `and`, `or`, and `not` with the same semantics as the corresponding bitwise operators. `Series` and `DataFrame` objects are supported and behave as they would with plain ol’ Python evaluation.

**Parameters**
- **expr** : str or unicode
  The expression to evaluate. This string cannot contain any Python statements, only
Python expressions.

**parser** : string, default ‘pandas’, {'pandas', 'python'}

The parser to use to construct the syntax tree from the expression. The default of 'pandas' parses code slightly different than standard Python. Alternatively, you can parse an expression using the 'python' parser to retain strict Python semantics. See the *enhancing performance* documentation for more details.

**engine** : string or None, default ‘numexpr’, {'python', 'numexpr'}

The engine used to evaluate the expression. Supported engines are

- None : tries to use numexpr, falls back to python
- 'numexpr' : *This default engine evaluates pandas objects using* numexpr *for large speed ups in complex expressions with large frames.*
- 'python' : *Performs operations as if you had eval’d in top level python. This engine is generally not that useful.*

More backends may be available in the future.

**truediv** : bool, optional

Whether to use true division, like in Python >= 3

**local_dict** : dict or None, optional

A dictionary of local variables, taken from locals() by default.

**global_dict** : dict or None, optional

A dictionary of global variables, taken from globals() by default.

**resolvers** : list of dict-like or None, optional

A list of objects implementing the `__getitem__` special method that you can use to inject an additional collection of namespaces to use for variable lookup. For example, this is used in the `query()` method to inject the `DataFrame.index` and `DataFrame.columns` variables that refer to their respective `DataFrame` instance attributes.

**level** : int, optional

The number of prior stack frames to traverse and add to the current scope. Most users will not need to change this parameter.

**target** : object, optional, default None

This is the target object for assignment. It is used when there is variable assignment in the expression. If so, then `target` must support item assignment with string keys, and if a copy is being returned, it must also support `.copy()`.

**inplace** : bool, default False

If `target` is provided, and the expression mutates `target`, whether to modify `target` inplace. Otherwise, return a copy of `target` with the mutation.

**Returns**

ndarray, numeric scalar, DataFrame, Series

**Raises** ValueError

There are many instances where such an error can be raised:
• target=None, but the expression is multiline.

• The expression is multiline, but not all them have item assignment. An example of such an arrangement is this:

\[ a = b + 1 \]
\[ a + 2 \]

Here, there are expressions on different lines, making it multiline, but the last line has no variable assigned to the output of \( a + 2 \).

• inplace=True, but the expression is missing item assignment.

• Item assignment is provided, but the target does not support string item assignment.

• Item assignment is provided and inplace=False, but the target does not support the .copy() method

See also:

pandas.DataFrame.query, pandas.DataFrame.eval

Notes

The dtype of any objects involved in an arithmetic % operation are recursively cast to float64.

See the enhancing performance documentation for more details.

34.2.7 Testing

test([extra_args])

34.2.7.1 pandas.test

pandas.test(extra_args=None)

34.3 Series

34.3.1 Constructor

Series([data, index, dtype, name, copy, ...]) One-dimensional ndarray with axis labels (including time series).

34.3.1.1 pandas.Series

class pandas.Series(data=None, index=None, dtype=None, name=None, copy=False, fast-path=False)

One-dimensional ndarray with axis labels (including time series).

Labels need not be unique but must be a hashable type. The object supports both integer- and label-based indexing and provides a host of methods for performing operations involving the index. Statistical methods from ndarray have been overridden to automatically exclude missing data (currently represented as NaN).

Operations between Series (+, -, /, *) align values based on their associated index values– they need not be the
same length. The result index will be the sorted union of the two indexes.

**Parameters**

- **data**: array-like, dict, or scalar value
  
  Contains data stored in Series

  Changed in version 0.23.0: If data is a dict, argument order is maintained for Python 3.6 and later.

- **index**: array-like or Index (1d)
  
  Values must be hashable and have the same length as `data`. Non-unique index values are allowed. Will default to RangelIndex (0, 1, 2, . . . , n) if not provided. If both a dict and index sequence are used, the index will override the keys found in the dict.

- **dtype**: numpy.dtype or None
  
  If None, dtype will be inferred

  If None, dtype will be inferred

- **copy**: boolean, default False
  
  Copy input data

**Attributes**

- `T` return the transpose, which is by definition self

- `asobject` Return object Series which contains boxed values.

- `at` Access a single value for a row/column label pair.

- `axes` Return a list of the row axis labels

- `base` return the base object if the memory of the underlying data is shared

- `blocks` *(DEPRECATED)* Internal property, property synonym for as_blocks()

- `data` return the data pointer of the underlying data

- `dtypes` return the dtype object of the underlying data

- `flags` return the dtype object of the underlying data

- `ftype` return if the data is sparse|dense

- `f types` return if the data is sparse|dense

- `hasnans` return if I have any nans; enables various perf speedups

- `iat` Access a single value for a row/column pair by integer position.

- `iloc` Purely integer-location based indexing for selection by position.

- `index` The index (axis labels) of the Series.

- `is_monotonic` Return boolean if values in the object are monotonic_increasing

- `is_monotonic_decreasing` Return boolean if values in the object are monotonic_decreasing

- `is_monotonic_increasing` Return boolean if values in the object are monotonic_increasing

- `is_unique` Return boolean if values in the object are unique

- `itemsize` return the size of the dtype of the item of the underlying data

Continued on next page
<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>ix</code></td>
<td>A primarily label-location based indexer, with integer position fallback.</td>
</tr>
<tr>
<td><code>loc</code></td>
<td>Access a group of rows and columns by label(s) or a boolean array.</td>
</tr>
<tr>
<td><code>nbytes</code></td>
<td>return the number of bytes in the underlying data</td>
</tr>
<tr>
<td><code>ndim</code></td>
<td>return the number of dimensions of the underlying data, by definition 1</td>
</tr>
<tr>
<td><code>shape</code></td>
<td>return a tuple of the shape of the underlying data</td>
</tr>
<tr>
<td><code>size</code></td>
<td>return the number of elements in the underlying data</td>
</tr>
<tr>
<td><code>strides</code></td>
<td>return the strides of the underlying data</td>
</tr>
<tr>
<td><code>values</code></td>
<td>Return Series as ndarray or ndarray-like depending on the dtype</td>
</tr>
</tbody>
</table>

**pandas.Series.T**

Series.T

return the transpose, which is by definition self

**pandas.Series.asobject**

Series.asobject

Return object Series which contains boxed values.

Deprecated since version 0.23.0: Use `astype(object)` instead.

this is an internal non-public method

**pandas.Series.at**

Series.at

Access a single value for a row/column label pair.

Similar to `loc`, in that both provide label-based lookups. Use `at` if you only need to get or set a single value in a DataFrame or Series.

Raises **KeyError**

When label does not exist in DataFrame

See also:

DataFrame.iat Access a single value for a row/column pair by integer position

DataFrame.loc Access a group of rows and columns by label(s)

Series.at Access a single value using a label

**Examples**

```python
>>> df = pd.DataFrame([[[0, 2, 3], [0, 4, 1], [10, 20, 30]],
                       ...
                       index=[4, 5, 6], columns=['A', 'B', 'C'])
>>> df
```

(continues on next page)
A | B | C
--|---|---
4 | 0 | 2 | 3
5 | 0 | 4 | 1
6 | 10| 20| 30

Get value at specified row/column pair

```python
>>> df.at[4, 'B']
2
```

Set value at specified row/column pair

```python
>>> df.at[4, 'B'] = 10
>>> df.at[4, 'B']
10
```

Get value within a Series

```python
>>> df.loc[5].at['B']
4
```

**pandas.Series.axes**

`Series.axes`

Return a list of the row axis labels

**pandas.Series.base**

`Series.base`

return the base object if the memory of the underlying data is shared

**pandas.Series.blocks**

`Series.blocks`

Internal property, property synonym for as_blocks()

Deprecated since version 0.21.0.

**pandas.Series.data**

`Series.data`

return the data pointer of the underlying data

**pandas.Series.dtype**

`Series.dtype`

return the dtype object of the underlying data
pandas.Series.dtypes

Series.dtypes
return the dtype object of the underlying data

pandas.Series.flags

Series.flags

pandas.Series.ftype

Series.ftype
return if the data is sparseldense

pandas.Series.ftypes

Series.ftypes
return if the data is sparseldense

pandas.Series.hasnans

Series.hasnans
return if I have any nans; enables various perf speedups

pandas.Series.iat

Series.iat
Access a single value for a row/column pair by integer position.
Similar to iloc, in that both provide integer-based lookups. Use iat if you only need to get or set a single value in a DataFrame or Series.

Raises IndexError
When integer position is out of bounds

See also:

DataFrame.at Access a single value for a row/column label pair
DataFrame.loc Access a group of rows and columns by label(s)
DataFrame.iloc Access a group of rows and columns by integer position(s)

Examples
```
>>> df = pd.DataFrame([[0, 2, 3], [0, 4, 1], [10, 20, 30]],
                   columns=['A', 'B', 'C'])
>>> df
  A  B  C
0  0  2  3
1  0  4  1
2 10 20 30
```

Get value at specified row/column pair

```
>>> df.iat[1, 2]
1
```

Set value at specified row/column pair

```
>>> df.iat[1, 2] = 10
>>> df.iat[1, 2]
10
```

Get value within a series

```
>>> df.loc[0].iat[1]
2
```

### pandas.Series.iloc

#### Series.iloc

Purely integer-location based indexing for selection by position.

`.iloc[]` is primarily integer position based (from 0 to length-1 of the axis), but may also be used with a boolean array.

Allowed inputs are:

- An integer, e.g. 5.
- A list or array of integers, e.g. [4, 3, 0].
- A slice object with ints, e.g. 1:7.
- A boolean array.
- A callable function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above)

`.iloc[]` will raise `IndexError` if a requested indexer is out-of-bounds, except `slice` indexers which allow out-of-bounds indexing (this conforms with python/numpy `slice` semantics).

See more at *Selection by Position*

### pandas.Series.index

#### Series.index

The index (axis labels) of the Series.
pandas.Series.is_monotonic

Series.is_monotonic
Return boolean if values in the object are monotonic_increasing
New in version 0.19.0.
Returns
is_monotonic [boolean]

pandas.Series.is_monotonic_decreasing

Series.is_monotonic_decreasing
Return boolean if values in the object are monotonic_decreasing
New in version 0.19.0.
Returns
is_monotonic_decreasing [boolean]

pandas.Series.is_monotonic_increasing

Series.is_monotonic_increasing
Return boolean if values in the object are monotonic_increasing
New in version 0.19.0.
Returns
is_monotonic [boolean]

pandas.Series.is_unique

Series.is_unique
Return boolean if values in the object are unique

Returns
is_unique [boolean]

pandas.Series.itemsize

Series.itemsize
return the size of the dtype of the item of the underlying data

pandas.Series.ix

Series.ix
A primarily label-location based indexer, with integer position fallback.
Warning: Starting in 0.20.0, the .ix indexer is deprecated, in favor of the more strict .iloc and .loc indexers.
.ix[] supports mixed integer and label based access. It is primarily label based, but will fall back to integer positional access unless the corresponding axis is of integer type.

.ix is the most general indexer and will support any of the inputs in .loc and .iloc. .ix also supports floating point label schemes. .ix is exceptionally useful when dealing with mixed positional and label based hierarchical indexes.

However, when an axis is integer based, ONLY label based access and not positional access is supported. Thus, in such cases, it’s usually better to be explicit and use .iloc or .loc.

See more at Advanced Indexing.

**pandas.Series.loc**

Series.loc

Access a group of rows and columns by label(s) or a boolean array.

.loc[] is primarily label based, but may also be used with a boolean array.

Allowed inputs are:

- A single label, e.g. 5 or 'a', (note that 5 is interpreted as a label of the index, and never as an integer position along the index).
- A list or array of labels, e.g. ['a', 'b', 'c'].
- A slice object with labels, e.g. 'a': 'f'.
- A boolean array of the same length as the axis being sliced, e.g. [True, False, True].
- A callable function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above)

**Warning:** Note that contrary to usual python slices, both the start and the stop are included

See more at Selection by Label

**Raises KeyError:**

when any items are not found

See also:

Dataframe.at Access a single value for a row/column label pair

Dataframe.iloc Access group of rows and columns by integer position(s)

Dataframe.xs Returns a cross-section (row(s) or column(s)) from the Series/DataFrame.

Series.loc Access group of values using labels

**Examples**

**Getting values**
>>> df = pd.DataFrame([[1, 2], [4, 5], [7, 8]],
...                   index=['cobra', 'viper', 'sidewinder'],
...                   columns=['max_speed', 'shield'])
>>> df
       max_speed  shield
   cobra          1      2
   viper          4      5
   sidewinder     7      8

Single label. Note this returns the row as a Series.

>>> df.loc['viper']
max_speed  4
shield     5
Name: viper, dtype: int64

List of labels. Note using [[]] returns a DataFrame.

>>> df.loc[['viper', 'sidewinder']]
       max_speed  shield
   viper          4      5
   sidewinder     7      8

Single label for row and column

>>> df.loc['cobra', 'shield']
2

Slice with labels for row and single label for column. As mentioned above, note that both the start and stop of the slice are included.

>>> df.loc['cobra':'viper', 'max_speed']
cobra  1
viper  4
Name: max_speed, dtype: int64

Boolean list with the same length as the row axis

>>> df.loc[[False, False, True]]
       max_speed  shield
   sidewinder          7      8

Conditional that returns a boolean Series

>>> df.loc[df['shield'] > 6]
       max_speed  shield
   sidewinder          7      8

Conditional that returns a boolean Series with column labels specified

>>> df.loc[df['shield'] > 6, ['max_speed']]
       max_speed
   sidewinder          7

Callable that returns a boolean Series
Setting values

Set value for all items matching the list of labels

```python
>>> df.loc[["viper", "sidewinder"], ["shield"]] = 50
```

```yaml
cobra   max_speed shield
  cobra  1 2
  viper  4 50
  sidewinder  7 50
```

Set value for an entire row

```python
>>> df.loc["cobra"] = 10
```

```yaml
cobra   max_speed shield
  cobra  10 10
  viper  4 50
  sidewinder  7 50
```

Set value for an entire column

```python
>>> df.loc[ :, "max_speed"] = 30
```

```yaml
cobra   max_speed shield
  cobra  30 10
  viper  30 50
  sidewinder  30 50
```

Set value for rows matching callable condition

```python
>>> df.loc[df["shield"] > 35] = 0
```

```yaml
cobra   max_speed shield
  cobra  30 10
  viper  0 0
  sidewinder  0 0
```

Getting values on a DataFrame with an index that has integer labels

Another example using integers for the index

```python
>>> df = pd.DataFrame([[1, 2], [4, 5], [7, 8]],
                    index=[7, 8, 9], columns=["max_speed", "shield"])
```

```yaml
cobra   max_speed shield
7       1 2
8       4 5
9       7 8
```

Slice with integer labels for rows. As mentioned above, note that both the start and stop of the slice are included.
Getting values with a MultiIndex

A number of examples using a DataFrame with a MultiIndex

```python
>>> tuples = [
... ('cobra', 'mark i'), ('cobra', 'mark ii'),
... ('sidewinder', 'mark i'), ('sidewinder', 'mark ii'),
... ('viper', 'mark ii'), ('viper', 'mark iii')
... ]
>>> index = pd.MultiIndex.from_tuples(tuples)
>>> values = [[12, 2], [0, 4], [10, 20],
...            [1, 4], [7, 1], [16, 36]]
>>> df = pd.DataFrame(values, columns=['max_speed', 'shield'], index=index)
>>> df
      max_speed  shield
    cobra      mark i   12   2
        mark ii   0   4
    sidewinder      mark i  10  20
        mark ii   1   4
    viper      mark ii   7   1
        mark iii  16  36

Single label. Note this returns a DataFrame with a single index.

```python
>>> df.loc['cobra']
      max_speed  shield
    mark i     12   2
    mark ii     0   4
```

Single index tuple. Note this returns a Series.

```python
>>> df.loc[('cobra', 'mark ii')]
    max_speed    0
Name: (cobra, mark ii), dtype: int64
```

Single label for row and column. Similar to passing in a tuple, this returns a Series.

```python
>>> df.loc['cobra', 'mark i']
    max_speed    12
    shield       2
Name: (cobra, mark i), dtype: int64
```

Single tuple. Note using [[]] returns a DataFrame.

```python
>>> df.loc[['cobra', 'mark ii']]
    max_speed  shield
  cobra mark ii    0    4
```

Single tuple for the index with a single label for the column
Slice from index tuple to single label

```python
>>> df.loc[('cobra', 'mark i'), 'shield']
2
```

Slice from index tuple to index tuple

```python
>>> df.loc[('cobra', 'mark i'):'viper']
  max_speed shield
    cobra mark i   12   2
        mark ii  0    4
    sidewinder mark i  10  20
         mark ii  1    4
        viper mark ii  7    1
            mark iii 16  36
```

**pandas.Series.nbytes**

Series.nbytes
return the number of bytes in the underlying data

**pandas.Series.ndim**

Series.ndim
return the number of dimensions of the underlying data, by definition 1

**pandas.Series.shape**

Series.shape
return a tuple of the shape of the underlying data

**pandas.Series.size**

Series.size
return the number of elements in the underlying data

**pandas.Series.strides**

Series.strides
return the strides of the underlying data
Series.values

Return Series as ndarray or ndarray-like depending on the dtype

Returns

arr [numpy.ndarray or ndarray-like]

Examples

```python
>>> pd.Series([1, 2, 3]).values
array([1, 2, 3])

>>> pd.Series(list('aabc')).values
array(['a', 'a', 'b', 'c'], dtype=object)

>>> pd.Series(list('aabc')).astype('category').values
[a, a, b, c]
Categories (3, object): [a, b, c]
```

Timezone aware datetime data is converted to UTC:

```python
>>> pd.Series(pd.date_range('20130101', periods=3, tz='US/Eastern')).values
array(['2013-01-01T05:00:00.000000000',
       '2013-01-02T05:00:00.000000000',
       '2013-01-03T05:00:00.000000000'],
       dtype='datetime64[ns]')
```

Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>abs()</td>
<td>Return a Series/DataFrame with absolute numeric value of each element.</td>
</tr>
<tr>
<td>add(other[, level, fill_value, axis])</td>
<td>Addition of series and other, element-wise (binary operator add).</td>
</tr>
<tr>
<td>add_prefix(prefix)</td>
<td>Prefix labels with string prefix.</td>
</tr>
<tr>
<td>add_suffix(suffix)</td>
<td>Suffix labels with string suffix.</td>
</tr>
<tr>
<td>agg(func[, axis])</td>
<td>Aggregate using one or more operations over the specified axis.</td>
</tr>
<tr>
<td>aggregate(func[, axis])</td>
<td>Aggregate using one or more operations over the specified axis.</td>
</tr>
<tr>
<td>align(other[, join, axis, level, copy, ...])</td>
<td>Align two objects on their axes with the specified join method for each axis Index.</td>
</tr>
</tbody>
</table>
Table 25 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>all()</code></td>
<td>(axis, bool_only, skipna, level) Return whether all elements are True, potentially over an axis.</td>
</tr>
<tr>
<td><code>any()</code></td>
<td>(axis, bool_only, skipna, level) Return whether any element is True over requested axis.</td>
</tr>
<tr>
<td><code>append()</code></td>
<td>(to_append[, ignore_index, ...]) Concatenate two or more Series.</td>
</tr>
<tr>
<td><code>apply()</code></td>
<td>(func[, convert_dtype, args]) Invoke function on values of Series.</td>
</tr>
<tr>
<td><code>argmax()</code></td>
<td>(axis, skipna) (DEPRECATED) ..</td>
</tr>
<tr>
<td><code>argmin()</code></td>
<td>(axis, skipna) (DEPRECATED) ..</td>
</tr>
<tr>
<td><code>argsort()</code></td>
<td>(axis, kind, order) Overrides ndarray.argsort.</td>
</tr>
<tr>
<td><code>as_blocks()</code></td>
<td>(axis, kind, order) (DEPRECATED) Convert the frame to a dict of dtype -&gt; Constructor Types that each has a homogeneous dtype.</td>
</tr>
<tr>
<td><code>as_matrix()</code></td>
<td>(columns) (DEPRECATED) Convert the frame to its Numpy-array representation.</td>
</tr>
<tr>
<td><code>asfreq()</code></td>
<td>(freq[, method, how, normalize, ...]) Convert TimeSeries to specified frequency.</td>
</tr>
<tr>
<td><code>asof()</code></td>
<td>(where[, subset]) The last row without any NaN is taken (or the last row without NaN considering only the subset of columns in the case of a DataFrame)</td>
</tr>
<tr>
<td><code>astype()</code></td>
<td>(dtype[, copy, errors]) Cast a pandas object to a specified dtype dtype.</td>
</tr>
<tr>
<td><code>at_time()</code></td>
<td>(time[, asof]) Select values at particular time of day (e.g. 9:00-9:30 AM).</td>
</tr>
<tr>
<td><code>autocorr()</code></td>
<td>(lag) Lag-N autocorrelation</td>
</tr>
<tr>
<td><code>between()</code></td>
<td>(left, right[, inclusive]) Return boolean Series equivalent to left &lt;= series &lt;= right.</td>
</tr>
<tr>
<td><code>between_time()</code></td>
<td>(start_time, end_time[, ...]) Select values between particular times of the day (e.g., 9:00-9:30 AM).</td>
</tr>
<tr>
<td><code>bfill()</code></td>
<td>(axis, inplace, limit, downcast) Synonym for DataFrame.fillna(method='bfill')</td>
</tr>
<tr>
<td><code>bool()</code></td>
<td>Return the bool of a single element PandasObject.</td>
</tr>
<tr>
<td><code>cat</code></td>
<td>alias of pandas.core.arrays.categorical.CategoricalAccessor</td>
</tr>
<tr>
<td><code>clip()</code></td>
<td>(lower, upper, axis, inplace) Trim values at input threshold(s).</td>
</tr>
<tr>
<td><code>clip_lower()</code></td>
<td>(threshold[, axis, inplace]) Return copy of the input with values below a threshold truncated.</td>
</tr>
<tr>
<td><code>clip_upper()</code></td>
<td>(threshold[, axis, inplace]) Return copy of input with values above given value(s) truncated.</td>
</tr>
<tr>
<td><code>combine()</code></td>
<td>(other, func[, fill_value]) Perform elementwise binary operation on two Series using given function with optional fill value when an index is missing from one Series or the other</td>
</tr>
<tr>
<td><code>combine_first()</code></td>
<td>(other) Combine Series values, choosing the calling Series’s values first.</td>
</tr>
<tr>
<td><code>compound()</code></td>
<td>(axis, skipna, level) Return the compound percentage of the values for the requested axis</td>
</tr>
<tr>
<td><code>compress()</code></td>
<td>(condition, *args, **kwargs) Return selected slices of an array along given axis as a Series</td>
</tr>
<tr>
<td><code>consolidate()</code></td>
<td>(inplace) (DEPRECATED) Compute NDFrame with “consolidated” internals (data of each dtype grouped together in a single ndarray).</td>
</tr>
<tr>
<td><code>convert_objects()</code></td>
<td>([convert_dates, ...]) (DEPRECATED) Attempt to infer better dtype for object columns.</td>
</tr>
<tr>
<td><code>copy()</code></td>
<td>([deep]) Make a copy of this object’s indices and data.</td>
</tr>
</tbody>
</table>

Continued on next page
Table 25 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>corr(</td>
<td>Compute correlation with other Series, excluding missing values</td>
</tr>
<tr>
<td>count(</td>
<td>Return number of non-NA/null observations in the Series</td>
</tr>
<tr>
<td>cov(</td>
<td>Compute covariance with Series, excluding missing values</td>
</tr>
<tr>
<td>cummax(</td>
<td>Return cumulative maximum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td>cummin(</td>
<td>Return cumulative minimum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td>cumprod(</td>
<td>Return cumulative product over a DataFrame or Series axis.</td>
</tr>
<tr>
<td>cumsum(</td>
<td>Return cumulative sum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td>describe(</td>
<td>Generates descriptive statistics that summarize the central</td>
</tr>
<tr>
<td>diff(</td>
<td>First discrete difference of element.</td>
</tr>
<tr>
<td>div(</td>
<td>Floating division of series and other, element-wise (binary</td>
</tr>
<tr>
<td>divide(</td>
<td>Floating division of series and other, element-wise (binary</td>
</tr>
<tr>
<td>divmod(</td>
<td>Integer division and modulo of series and other, element-wise</td>
</tr>
<tr>
<td>dot(</td>
<td>Matrix multiplication with DataFrame or inner-product with</td>
</tr>
<tr>
<td>drop(</td>
<td>Return Series with specified index labels removed.</td>
</tr>
<tr>
<td>drop_duplicates(</td>
<td>Return Series with duplicate values removed.</td>
</tr>
<tr>
<td>dropna(</td>
<td>Return a new Series with missing values removed.</td>
</tr>
<tr>
<td>dt</td>
<td>Alias of pandas.core.indexes.accessors. CombinedDatetimelikeProperties</td>
</tr>
<tr>
<td>duplicated(</td>
<td>Indicate duplicate Series values.</td>
</tr>
<tr>
<td>eq(</td>
<td>Equal to of series and other, element-wise (binary operator</td>
</tr>
<tr>
<td>equals</td>
<td>Determines if two NDFrame objects contain the same elements.</td>
</tr>
<tr>
<td>ewm(</td>
<td>Provides exponential weighted functions</td>
</tr>
<tr>
<td>expanding(</td>
<td>Provides expanding transformations.</td>
</tr>
<tr>
<td>factorize(</td>
<td>Encode the object as an enumerated type or categorical variable.</td>
</tr>
<tr>
<td>ffill(</td>
<td>Synonym for DataFrame. fillna(method='ffill')</td>
</tr>
<tr>
<td>fillna(</td>
<td>Fill NA/NaN values using the specified method</td>
</tr>
<tr>
<td>filter(</td>
<td>Subset rows or columns of dataframe according to labels in the</td>
</tr>
<tr>
<td>first(</td>
<td>Convenience method for subsetting initial periods of time</td>
</tr>
<tr>
<td>first_valid_index()</td>
<td>Return index for first non-NA/null value.</td>
</tr>
<tr>
<td>floordiv</td>
<td>Integer division of series and other, element-wise (binary</td>
</tr>
</tbody>
</table>

Continued on next page
### Table 25 – continued from previous page

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>from_array</code></td>
<td>Construct Series from array.</td>
</tr>
<tr>
<td><code>from_csv</code></td>
<td>(DEPRECATED) Read CSV file.</td>
</tr>
<tr>
<td><code>ge</code></td>
<td>Greater than or equal to of series and other, element-wise (binary operator <code>ge</code>).</td>
</tr>
<tr>
<td><code>get</code></td>
<td>Get item from object for given key (DataFrame column, Panel slice, etc.).</td>
</tr>
<tr>
<td><code>get_dtype_counts</code></td>
<td>Return counts of unique dtypes in this object.</td>
</tr>
<tr>
<td><code>get_ftype_counts</code></td>
<td>(DEPRECATED) Return counts of unique ftypes in this object.</td>
</tr>
<tr>
<td><code>get_value</code></td>
<td>(DEPRECATED) Quickly retrieve single value at passed index label</td>
</tr>
<tr>
<td><code>get_values</code></td>
<td>same as values (but handles sparseness conversions); is a view</td>
</tr>
<tr>
<td><code>groupby</code></td>
<td>Group series using mapper (dict or key function, apply given function to group, return result as series) or by a series of columns.</td>
</tr>
<tr>
<td><code>gt</code></td>
<td>Greater than of series and other, element-wise (binary operator <code>gt</code>).</td>
</tr>
<tr>
<td><code>head</code></td>
<td>Return the first ( n ) rows.</td>
</tr>
<tr>
<td><code>hist</code></td>
<td>Draw histogram of the input series using matplotlib</td>
</tr>
<tr>
<td><code>idxmax</code></td>
<td>Return the row label of the maximum value.</td>
</tr>
<tr>
<td><code>idxmin</code></td>
<td>Return the row label of the minimum value.</td>
</tr>
<tr>
<td><code>infer_objects</code></td>
<td>Attempt to infer better dtypes for object columns.</td>
</tr>
<tr>
<td><code>interpolate</code></td>
<td>Interpolate values according to different methods.</td>
</tr>
<tr>
<td><code>isin</code></td>
<td>Check whether ( \text{values} ) are contained in Series.</td>
</tr>
<tr>
<td><code>isna</code></td>
<td>Detect missing values.</td>
</tr>
<tr>
<td><code>isnull</code></td>
<td>Detect missing values.</td>
</tr>
<tr>
<td><code>item</code></td>
<td>return the first element of the underlying data as a python scalar</td>
</tr>
<tr>
<td><code>items</code></td>
<td>Lazily iterate over (index, value) tuples</td>
</tr>
<tr>
<td><code>iteritems</code></td>
<td>Lazily iterate over (index, value) tuples</td>
</tr>
<tr>
<td><code>keys</code></td>
<td>Alias for index</td>
</tr>
<tr>
<td><code>kurt</code></td>
<td>Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0).</td>
</tr>
<tr>
<td><code>kurtosis</code></td>
<td>Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0).</td>
</tr>
<tr>
<td><code>last</code></td>
<td>Convenience method for subsetting final periods of time series data based on a date offset.</td>
</tr>
<tr>
<td><code>last_valid_index</code></td>
<td>Return index for last non-NA/null value.</td>
</tr>
<tr>
<td><code>le</code></td>
<td>Less than or equal to of series and other, element-wise (binary operator <code>le</code>).</td>
</tr>
<tr>
<td><code>lt</code></td>
<td>Less than of series and other, element-wise (binary operator <code>lt</code>).</td>
</tr>
<tr>
<td><code>mad</code></td>
<td>Return the mean absolute deviation of the values for the requested axis</td>
</tr>
<tr>
<td><code>map</code></td>
<td>Map values of Series using input correspondence (a dict, Series, or function).</td>
</tr>
</tbody>
</table>

Continued on next page
### Table 25 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>mask()</code></td>
<td>Return an object of same shape as self and whose corresponding entries are from self where <code>cond</code> is False and otherwise are from <code>other</code>.</td>
</tr>
<tr>
<td><code>max()</code></td>
<td>This method returns the maximum of the values in the object.</td>
</tr>
<tr>
<td><code>mean()</code></td>
<td>Return the mean of the values for the requested axis.</td>
</tr>
<tr>
<td><code>median()</code></td>
<td>Return the median of the values for the requested axis.</td>
</tr>
<tr>
<td><code>memory_usage()</code></td>
<td>Return the memory usage of the Series.</td>
</tr>
<tr>
<td><code>min()</code></td>
<td>This method returns the minimum of the values in the object.</td>
</tr>
<tr>
<td><code>mod()</code></td>
<td>Modulo of series and other, element-wise (binary operator <code>mod</code>).</td>
</tr>
<tr>
<td><code>mode()</code></td>
<td>Return the mode(s) of the dataset.</td>
</tr>
<tr>
<td><code>mul()</code></td>
<td>Multiplication of series and other, element-wise (binary operator <code>mul</code>).</td>
</tr>
<tr>
<td><code>multiply()</code></td>
<td>Multiplication of series and other, element-wise (binary operator <code>mul</code>).</td>
</tr>
<tr>
<td><code>ne()</code></td>
<td>Not equal to of series and other, element-wise (binary operator <code>ne</code>).</td>
</tr>
<tr>
<td><code>nlargest()</code></td>
<td>Return the largest <code>n</code> elements.</td>
</tr>
<tr>
<td><code>nonzero()</code></td>
<td>Return the integer indices of the elements that are non-zero</td>
</tr>
<tr>
<td><code>notna()</code></td>
<td>Detect existing (non-missing) values.</td>
</tr>
<tr>
<td><code>notnull()</code></td>
<td>Detect existing (non-missing) values.</td>
</tr>
<tr>
<td><code>nsmallest()</code></td>
<td>Return the smallest <code>n</code> elements.</td>
</tr>
<tr>
<td><code>nunique()</code></td>
<td>Return number of unique elements in the object.</td>
</tr>
<tr>
<td><code>pct_change()</code></td>
<td>Percentage change between the current and a prior element.</td>
</tr>
<tr>
<td><code>pipe()</code></td>
<td>Apply func(self, *args, **kwargs)</td>
</tr>
<tr>
<td><code>plot</code></td>
<td>alias of pandas.plotting._core.SeriesPlotMethods</td>
</tr>
<tr>
<td><code>pop()</code></td>
<td>Return item and drop from frame.</td>
</tr>
<tr>
<td><code>pow()</code></td>
<td>Exponential power of series and other, element-wise (binary operator <code>pow</code>).</td>
</tr>
<tr>
<td><code>prod()</code></td>
<td>Return the product of the values for the requested axis</td>
</tr>
<tr>
<td><code>product()</code></td>
<td>Return the product of the values for the requested axis</td>
</tr>
<tr>
<td><code>ptp()</code></td>
<td>Returns the difference between the maximum value and the minimum value in the object.</td>
</tr>
<tr>
<td><code>put(*args, **kwargs)</code></td>
<td>Applies the <code>put</code> method to its <code>values</code> attribute if it has one.</td>
</tr>
<tr>
<td><code>quantile()</code></td>
<td>Return value at the given quantile, a la numpy.percentile.</td>
</tr>
<tr>
<td><code>radd()</code></td>
<td>Addition of series and other, element-wise (binary operator <code>radd</code>).</td>
</tr>
<tr>
<td><code>rank()</code></td>
<td>Compute numerical data ranks (1 through n) along axis.</td>
</tr>
<tr>
<td><code>ravel()</code></td>
<td>Return the flattened underlying data as an ndarray</td>
</tr>
</tbody>
</table>

Continued on next page
Table 25 – continued from previous page

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>rdiff</code></td>
<td>Floating division of series and other, element-wise (binary operator <code>rtruediv</code>).</td>
</tr>
<tr>
<td><code>reindex</code></td>
<td>Conform Series to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.</td>
</tr>
<tr>
<td><code>reindex_axis</code></td>
<td>(DEPRECATED) Conform Series to new index with optional filling logic.</td>
</tr>
<tr>
<td><code>reindex_like</code></td>
<td>Return an object with matching indices to myself.</td>
</tr>
<tr>
<td><code>rename</code></td>
<td>Alter Series index labels or name</td>
</tr>
<tr>
<td><code>rename_axis</code></td>
<td>Alter the name of the index or columns.</td>
</tr>
<tr>
<td><code>reorder_levels</code></td>
<td>Rearrange index levels using input order.</td>
</tr>
<tr>
<td><code>repeat</code></td>
<td>Repeat elements of an Series.</td>
</tr>
<tr>
<td><code>replace</code></td>
<td>Replace values given in <code>to_replace</code> with <code>value</code>.</td>
</tr>
<tr>
<td><code>resample</code></td>
<td>Convenience method for frequency conversion and resampling of time series.</td>
</tr>
<tr>
<td><code>reset_index</code></td>
<td>Generate a new DataFrame or Series with the index reset.</td>
</tr>
<tr>
<td><code>rfloordiv</code></td>
<td>Integer division of series and other, element-wise (binary operator <code>rfloordiv</code>).</td>
</tr>
<tr>
<td><code>rmod</code></td>
<td>Modulo of series and other, element-wise (binary operator <code>rmod</code>).</td>
</tr>
<tr>
<td><code>rmul</code></td>
<td>Multiplication of series and other, element-wise (binary operator <code>rmul</code>).</td>
</tr>
<tr>
<td><code>rolling</code></td>
<td>Provides rolling window calculations.</td>
</tr>
<tr>
<td><code>round</code></td>
<td>Round each value in a Series to the given number of decimals.</td>
</tr>
<tr>
<td><code>rpow</code></td>
<td>Exponential power of series and other, element-wise (binary operator <code>rpow</code>).</td>
</tr>
<tr>
<td><code>rsub</code></td>
<td>Subtraction of series and other, element-wise (binary operator <code>rsub</code>).</td>
</tr>
<tr>
<td><code>rtruediv</code></td>
<td>Floating division of series and other, element-wise (binary operator <code>rtruediv</code>).</td>
</tr>
<tr>
<td><code>sample</code></td>
<td>Return a random sample of items from an axis of object.</td>
</tr>
<tr>
<td><code>searchsorted</code></td>
<td>Find indices where elements should be inserted to maintain order.</td>
</tr>
<tr>
<td><code>select</code></td>
<td>(DEPRECATED) Return data corresponding to axis labels matching criteria.</td>
</tr>
<tr>
<td><code>sem</code></td>
<td>Return unbiased standard error of the mean over requested axis.</td>
</tr>
<tr>
<td><code>set_axis</code></td>
<td>Assign desired index to given axis.</td>
</tr>
<tr>
<td><code>set_value</code></td>
<td>(DEPRECATED) Quickly set single value at passed label.</td>
</tr>
<tr>
<td><code>shift</code></td>
<td>Shift index by desired number of periods with an optional time freq.</td>
</tr>
<tr>
<td><code>skew</code></td>
<td>Return unbiased skew over requested axis Normalized by N-1</td>
</tr>
<tr>
<td><code>slice_shift</code></td>
<td>Equivalent to <code>shift</code> without copying data.</td>
</tr>
<tr>
<td><code>sort_index</code></td>
<td>Sort Series by index labels.</td>
</tr>
<tr>
<td><code>sort_values</code></td>
<td>Sort by the values.</td>
</tr>
</tbody>
</table>

Continued on next page
Table 25 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sortlevel</td>
<td>(DEPRECATED) Sort Series with MultiIndex by chosen level.</td>
</tr>
<tr>
<td>squeeze</td>
<td>Squeeze length 1 dimensions.</td>
</tr>
<tr>
<td>std</td>
<td>Return sample standard deviation over requested axis.</td>
</tr>
<tr>
<td>str</td>
<td>alias of pandas.core.strings.StringMethods</td>
</tr>
<tr>
<td>sub</td>
<td>Subtraction of series and other, element-wise (binary operator sub).</td>
</tr>
<tr>
<td>subtract</td>
<td>Subtraction of series and other, element-wise (binary operator sub).</td>
</tr>
<tr>
<td>sum</td>
<td>Return the sum of the values for the requested axis</td>
</tr>
<tr>
<td>swapaxes</td>
<td>Interchange axes and swap values axes appropriately</td>
</tr>
<tr>
<td>swaplevel</td>
<td>Swap levels i and j in a MultiIndex</td>
</tr>
<tr>
<td>tail</td>
<td>Return the last n rows.</td>
</tr>
<tr>
<td>take</td>
<td>Return the elements in the given positional indices along an axis.</td>
</tr>
<tr>
<td>to_clipboard</td>
<td>Copy object to the system clipboard.</td>
</tr>
<tr>
<td>to_csv</td>
<td>Write Series to a comma-separated values (csv) file</td>
</tr>
<tr>
<td>to_dense</td>
<td>Return dense representation of NDFrame (as opposed to sparse)</td>
</tr>
<tr>
<td>to_dict</td>
<td>Convert Series to {label -&gt; value} dict or dict-like object.</td>
</tr>
<tr>
<td>to_excel</td>
<td>Write Series to an excel sheet</td>
</tr>
<tr>
<td>to_frame</td>
<td>Convert Series to DataFrame</td>
</tr>
<tr>
<td>to_hdf</td>
<td>Write the contained data to an HDF5 file using HDF-Store.</td>
</tr>
<tr>
<td>to_json</td>
<td>Convert the object to a JSON string.</td>
</tr>
<tr>
<td>to_latex</td>
<td>Render an object to a tabular environment table.</td>
</tr>
<tr>
<td>to_msgpack</td>
<td>msgpack (serialize) object to input file path</td>
</tr>
<tr>
<td>to_period</td>
<td>Convert Series from DatetimeIndex to PeriodIndex with desired frequency (inferred from index if not passed)</td>
</tr>
<tr>
<td>to_pickle</td>
<td>Pickle (serialize) object to file.</td>
</tr>
<tr>
<td>to_sparse</td>
<td>Convert Series to SparseSeries</td>
</tr>
<tr>
<td>to_sql</td>
<td>Write records stored in a DataFrame to a SQL database.</td>
</tr>
<tr>
<td>to_string</td>
<td>Render a string representation of the Series</td>
</tr>
<tr>
<td>to_timestamp</td>
<td>Cast to datetimeindex of timestamps, at beginning of period</td>
</tr>
<tr>
<td>to_xarray</td>
<td>Return an xarray object from the pandas object.</td>
</tr>
<tr>
<td>tolist</td>
<td>Return a list of the values.</td>
</tr>
<tr>
<td>transform</td>
<td>Call function producing a like-indexed NDFrame and return a NDFrame with the transformed values</td>
</tr>
<tr>
<td>transpose</td>
<td>return the transpose, which is by definition self</td>
</tr>
<tr>
<td>truediv</td>
<td>Floating division of series and other, element-wise (binary operator truediv).</td>
</tr>
<tr>
<td>truncate</td>
<td>Truncate a Series or DataFrame before and after some index value.</td>
</tr>
</tbody>
</table>

Continued on next page
Table 25 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>ts_shift</code> ([periods, freq, axis])</td>
<td>Shift the time index, using the index’s frequency if available.</td>
</tr>
<tr>
<td><code>tz_convert</code> (tz[, axis, level, copy])</td>
<td>Convert tz-aware axis to target time zone.</td>
</tr>
<tr>
<td><code>tz_localize</code> (tz[, axis, level, copy, ambiguous])</td>
<td>Localize tz-naive TimeSeries to target time zone.</td>
</tr>
<tr>
<td><code>unique()</code></td>
<td>Return unique values of Series object.</td>
</tr>
<tr>
<td><code>unstack</code> ([level, fill_value])</td>
<td>Unstack, a.k.a.</td>
</tr>
<tr>
<td><code>update</code> (other)</td>
<td>Modify Series in place using non-NA values from passed Series.</td>
</tr>
<tr>
<td><code>valid</code> ([inplace])</td>
<td>(DEPRECATED) Return Series without null values.</td>
</tr>
<tr>
<td><code>value_counts</code> ([normalize, sort, ascending, ...])</td>
<td>Returns object containing counts of unique values.</td>
</tr>
<tr>
<td><code>var</code> ([axis, skipna, level, ddof, numeric_only])</td>
<td>Return unbiased variance over requested axis.</td>
</tr>
<tr>
<td><code>view</code> ([dtype])</td>
<td>Create a new view of the Series.</td>
</tr>
<tr>
<td><code>where</code> (cond[, other, inplace, axis, level, ...])</td>
<td>Return an object of same shape as self and whose corresponding entries are from self where cond is True and otherwise are from other.</td>
</tr>
<tr>
<td><code>xs</code> (key[, axis, level, drop_level])</td>
<td>Returns a cross-section (row(s) or column(s)) from the Series/DataFrame.</td>
</tr>
</tbody>
</table>

**pandas.Series.abs**

*Series.abs()*

Return a Series/DataFrame with absolute numeric value of each element.

This function only applies to elements that are all numeric.

**Returns abs**

Series/DataFrame containing the absolute value of each element.

**See also:**

*numpy.absolute* calculate the absolute value element-wise.

**Notes**

For complex inputs, \(1.2 + 1j\), the absolute value is \(\sqrt{a^2 + b^2}\).

**Examples**

Absolute numeric values in a Series.

```python
>>> s = pd.Series([-1.10, 2, -3.33, 4])
>>> s.abs()
0    1.10
1    2.00
2    3.33
3    4.00
dtype: float64
```

Absolute numeric values in a Series with complex numbers.
```python
>>> s = pd.Series([1.2 + 1j])
>>> s.abs()
0    1.56205
dtype: float64
```

Absolute numeric values in a Series with a Timedelta element.

```python
>>> s = pd.Series([pd.Timedelta('1 days')])
>>> s.abs()
0   1 days
dtype: timedelta64[ns]
```

Select rows with data closest to certain value using argsort (from StackOverflow).

```python
>>> df = pd.DataFrame({
...     'a': [4, 5, 6, 7],
...     'b': [10, 20, 30, 40],
...     'c': [100, 50, -30, -50]
... })
>>> df
    a  b  c
0   4  10 100
1   5  20  50
2   6  30 -30
3   7  40 -50
>>> df.loc[(df.c - 43).abs().argsort()]
    a  b  c
0  4  10 100
1  5  20  50
2  6  30 -30
3  7  40 -50
```

**pandas.Series.add**

`Series.add(other, level=None, fill_value=None, axis=0)`

Addition of series and other, element-wise (binary operator `add`).

Equivalent to `series + other`, but with support to substitute a `fill_value` for missing data in one of the inputs.

**Parameters**

- `other` [Series or scalar value]
- `fill_value` : None or float value, default None (NaN)
  Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing
- `level` : int or name
  Broadcast across a level, matching Index values on the passed MultiIndex level

**Returns**

- `result` [Series]
See also:

`Series.radd`

Examples

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a 1.0
b 1.0
c 1.0
d NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a 1.0
b NaN
d 1.0
e NaN
dtype: float64
>>> a.add(b, fill_value=0)
a 2.0
b 1.0
c 1.0
d 1.0
e NaN
dtype: float64
```

### pandas.Series.add_prefix

`Series.add_prefix(prefix)`

Prefix labels with string `prefix`.

For Series, the row labels are prefixed. For DataFrame, the column labels are prefixed.

**Parameters**

- `prefix` : str
  
The string to add before each label.

**Returns**

- `Series` or `DataFrame`
  
New Series or DataFrame with updated labels.

See also:

- `Series.add_suffix` Suffix row labels with string `suffix`.
- `DataFrame.add_suffix` Suffix column labels with string `suffix`.

Examples

```python
>>> s = pd.Series([1, 2, 3, 4])
>>> s
0  1
1  2
(continues on next page)
```
2 3
3 4
dtype: int64

```python
>>> s.add_prefix('item_')
item_0  1
item_1  2
item_2  3
item_3  4
dtype: int64
```

```python
>>> df = pd.DataFrame({'A': [1, 2, 3, 4], 'B': [3, 4, 5, 6]})
```

```python
>>> df.add_prefix('col_')
col_A  col_B
0   1   3
1   2   4
2   3   5
3   4   6
```

**pandas.Series.add_suffix**

The `add_suffix()` method adds a suffix to the labels of a Series or DataFrame.

```python
pandas.Series.add_suffix(suffix)
```

- **suffix**: str
  - The string to add after each label.

- **Returns**: pandas.Series or pandas.DataFrame
  - A new Series or DataFrame with the labels suffixed.

- **See also**:
  - `pandas.Series.add_prefix`: Prefix row labels with a string.
  - `pandas.DataFrame.add_prefix`: Prefix column labels with a string.

### Examples

```python
>>> s = pd.Series([1, 2, 3, 4])
```

```python
>>> s
0  1
1  2
2  3
```

(continues on next page)
pandas: powerful Python data analysis toolkit, Release 0.23.2

(continued from previous page)

```python
3  4
dtype: int64
```

```python
>>> s.add_suffix('_item')
0_item  1
1_item  2
2_item  3
3_item  4
dtype: int64
```

```python
>>> df = pd.DataFrame({'A': [1, 2, 3, 4], 'B': [3, 4, 5, 6]})
>>> df
   A  B
0  1  3
1  2  4
2  3  5
3  4  6
```

```python
>>> df.add_suffix('_col')
   A_col  B_col
0       1     3
1       2     4
2       3     5
3       4     6
```

**pandas.Series.agg**

Series.agg *(func, axis=0, *args, **kwargs)*

Aggregate using one or more operations over the specified axis.

New in version 0.20.0.

- **Parameters**
  - `func`: function, string, dictionary, or list of string/functions
    
    Function to use for aggregating the data. If a function, must either work when passed a
    Series or when passed to Series.apply. For a DataFrame, can pass a dict, if the keys are
    DataFrame column names.
    
    Accepted combinations are:
    - string function name.
    - function.
    - list of functions.
    - dict of column names -> functions (or list of functions).

  - `axis`: {0 or ‘index’}
    
    Parameter needed for compatibility with DataFrame.

  - `*args`
    Positional arguments to pass to `func`.

  - `**kwargs`
    Keyword arguments to pass to `func`.
Returns

aggregated [Series]

See also:

pandas.Series.apply, pandas.Series.transform

Notes

agg is an alias for aggregate. Use the alias.
A passed user-defined-function will be passed a Series for evaluation.

Examples

```python
>>> s = Series(np.random.randn(10))

>>> s.agg('min')
-1.301805
>>> s.agg(['min', 'max'])
min -1.301805
max 1.127688
dtype: float64
```

**pandas.Series.aggregate**

**Series.aggregate** *(func, axis=0, *args, **kwargs)*

Aggregate using one or more operations over the specified axis.

New in version 0.20.0.

Parameters

**func** : function, string, dictionary, or list of string/functions

Function to use for aggregating the data. If a function, must either work when passed a Series or when passed to Series.apply. For a DataFrame, can pass a dict, if the keys are DataFrame column names.

Accepted combinations are:

• string function name.
• function.
• list of functions.
• dict of column names -> functions (or list of functions).

**axis** : {0 or ‘index’}

Parameter needed for compatibility with DataFrame.

**args**

Positional arguments to pass to func.

**kwargs**
Keyword arguments to pass to `func`.

**Returns**

- `aggregated` [Series]

**See also:**

`pandas.Series.apply, pandas.Series.transform`

**Notes**

`agg` is an alias for `aggregate`. Use the alias.

A passed user-defined-function will be passed a Series for evaluation.

**Examples**

```python
>>> s = Series(np.random.randn(10))

>>> s.agg('min')
-1.301805

>>> s.agg(['min', 'max'])
min   -1.301805
max    1.127688
dtype: float64
```

**pandas.Series.align**

`Series.align(other, join='outer', axis=None, level=None, copy=True, fill_value=None, method=None, limit=None, fill_axis=0, broadcast_axis=None)`

Align two objects on their axes with the specified join method for each axis Index

**Parameters**

- `other` [DataFrame or Series]
- `join` [‘outer’, ‘inner’, ‘left’, ‘right’], default ‘outer’
- `axis`: allowed axis of the other object, default None
  - Align on index (0), columns (1), or both (None)
- `level`: int or level name, default None
  - Broadcast across a level, matching Index values on the passed MultiIndex level
- `copy`: boolean, default True
  - Always returns new objects. If copy=False and no reindexing is required then original objects are returned.
- `fill_value`: scalar, default np.NaN
  - Value to use for missing values. Defaults to NaN, but can be any “compatible” value
- `method`: [str, default None]
limit  [int, default None]

fill_axis  :  {0 or ‘index’}, default 0
Filling axis, method and limit

broadcast_axis  :  {0 or ‘index’}, default None
Broadcast values along this axis, if aligning two objects of different dimensions

Returns  (left, right)  :  (Series, type of other)
Aligned objects

pandas.Series.all

Series  .all  (axis=0, bool_only=None, skipna=True, level=None, **kwargs)
Return whether all elements are True, potentially over an axis.
Returns True if all elements within a series or along a Dataframe axis are non-zero, not-empty or not-False.

Parameters  axis  :  {0 or ‘index’, 1 or ‘columns’, None}, default 0
Indicate which axis or axes should be reduced.
  •  0 / ‘index’ : reduce the index, return a Series whose index is the original column labels.
  •  1 / ‘columns’ : reduce the columns, return a Series whose index is the original index.
  •  None : reduce all axes, return a scalar.

skipna  :  boolean, default True
Exclude NA/null values. If an entire row/column is NA, the result will be NA.

level  :  int or level name, default None
If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar.

bool_only  :  boolean, default None
Include only boolean columns. If None, will attempt to use everything, then use only boolean data. Not implemented for Series.

**kwargs  :  any, default None
Additional keywords have no effect but might be accepted for compatibility with NumPy.

Returns

all  [scalar or Series (if level specified)]

See also:

pandas.Series.all  Return True if all elements are True
pandas.DataFrame.any  Return True if one (or more) elements are True
Examples

Series

```python
>>> pd.Series([True, True]).all()
True
>>> pd.Series([True, False]).all()
False
```

DataFrames

Create a dataframe from a dictionary.

```python
>>> df = pd.DataFrame({'col1': [True, True], 'col2': [True, False]})
>>> df
   col1  col2
0  True  True
1  True  False
```

Default behaviour checks if column-wise values all return True.

```python
>>> df.all()
   col1  col2
0    True  True
1    False False
dtype: bool
```

Specify `axis='columns'` to check if row-wise values all return True.

```python
>>> df.all(axis='columns')
0    True
1    False
dtype: bool
```

Or `axis=None` for whether every value is True.

```python
>>> df.all(axis=None)
False
```

**pandas.Series.any**

```
Series.any(axis=0, bool_only=None, skipna=True, level=None, **kwargs)
```

Return whether any element is True over requested axis.

Unlike `DataFrame.all()`, this performs an or operation. If any of the values along the specified axis is True, this will return True.

**Parameters**

- **axis**: {0 or ‘index’, 1 or ‘columns’, None}, default 0
  - Indicate which axis or axes should be reduced.
  - 0 / ‘index’ : reduce the index, return a Series whose index is the original column labels.
  - 1 / ‘columns’ : reduce the columns, return a Series whose index is the original index.
  - None : reduce all axes, return a scalar.

- **skipna**: boolean, default True
Exclude NA/null values. If an entire row/column is NA, the result will be NA.

**level** : int or level name, default None
If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar.

**bool_only** : boolean, default None
Include only boolean columns. If None, will attempt to use everything, then use only boolean data. Not implemented for Series.

**kwargs** : any, default None
Additional keywords have no effect but might be accepted for compatibility with NumPy.

**Returns**

any [scalar or Series (if level specified)]

**See also:**

pandas.DataFrame.all Return whether all elements are True.

**Examples**

**Series**
For Series input, the output is a scalar indicating whether any element is True.

```python
>>> pd.Series([True, False]).any()
True
```

**DataFrame**
Whether each column contains at least one True element (the default).

```python
>>> df = pd.DataFrame({"A": [1, 2], "B": [0, 2], "C": [0, 0]})
>>> df
   A  B  C
0  1  0  0
1  2  2  0
```

```python
>>> df.any()
A   True
B   True
C   False
dtype: bool
```

Aggregating over the columns.

```python
>>> df = pd.DataFrame({"A": [True, False], "B": [1, 2]})
>>> df
   A  B
0 True 1
1 False 2
```
>> df.any(axis='columns')
0  True
dtype: bool

Aggregating over the entire DataFrame with `axis=None`:

```python
>>> df.any(axis=None)
```

`any` for an empty DataFrame is an empty Series:

```python
>>> pd.DataFrame([]).any()
```

### pandas.Series.append

`Series.append(to_append, ignore_index=False, verify_integrity=False)`

Concatenate two or more Series.

**Parameters**

- `to_append` [Series or list/tuple of Series]
- `ignore_index` : boolean, default False
  
  If True, do not use the index labels.

  New in version 0.19.0.

- `verify_integrity` : boolean, default False
  
  If True, raise Exception on creating index with duplicates

**Returns**

- `appended` [Series]

**See also:**

- `pandas.concat` General function to concatenate DataFrame, Series or Panel objects

**Notes**

Iteratively appending to a Series can be more computationally intensive than a single concatenate. A better solution is to append values to a list and then concatenate the list with the original Series all at once.
Examples

```python
>>> s1 = pd.Series([1, 2, 3])
>>> s2 = pd.Series([4, 5, 6])
>>> s3 = pd.Series([4, 5, 6], index=[3, 4, 5])
>>> s1.append(s2)
0   1
1   2
2   3
0   4
1   5
2   6
dtype: int64
```

```python
>>> s1.append(s3)
0   1
1   2
2   3
3   4
4   5
5   6
dtype: int64
```

With `ignore_index` set to True:

```python
>>> s1.append(s2, ignore_index=True)
0   1
1   2
2   3
3   4
4   5
5   6
dtype: int64
```

With `verify_integrity` set to True:

```python
>>> s1.append(s2, verify_integrity=True)
Traceback (most recent call last):
...  
ValueError: Indexes have overlapping values: [0, 1, 2]
```

**pandas.Series.apply**

`Series.apply(func, convert_dtypes=True, args=(), **kwds)`

Invoke function on values of Series. Can be ufunc (a NumPy function that applies to the entire Series) or a Python function that only works on single values

**Parameters**

- `func` [function]
- `convert_dtypes` : boolean, default True
  - Try to find better dtype for elementwise function results. If False, leave as dtype=object
- `args` : tuple
  - Positional arguments to pass to function in addition to the value
**Examples**

Create a series with typical summer temperatures for each city.

```python
>>> import pandas as pd
>>> import numpy as np

>>> series = pd.Series([20, 21, 12], index=['London', 'New York', 'Helsinki'])
>>> series
London    20
New York  21
Helsinki  12
dtype: int64
```

Square the values by defining a function and passing it as an argument to `apply()`.

```python
>>> def square(x):
...     return x**2

>>> series.apply(square)
London    400
New York  441
Helsinki  144
dtype: int64
```

Square the values by passing an anonymous function as an argument to `apply()`.

```python
>>> series.apply(lambda x: x**2)
London    400
New York  441
Helsinki  144
dtype: int64
```

Define a custom function that needs additional positional arguments and pass these additional arguments using the `args` keyword.

```python
>>> def subtract_custom_value(x, custom_value):
...     return x-custom_value

>>> series.apply(subtract_custom_value, args=(5,))
London    15
New York  16
Helsinki   7
dtype: int64
```
Define a custom function that takes keyword arguments and pass these arguments to `apply`.

```python
>>> def add_custom_values(x, **kwargs):
...     for month in kwargs:
...         x += kwargs[month]
...     return x

>>> series.apply(add_custom_values, june=30, july=20, august=25)
London 95
New York 96
Helsinki 87
dtype: int64
```

Use a function from the Numpy library.

```python
>>> series.apply(np.log)
London    2.995732
New York  3.044522
Helsinki  2.484907
dtype: float64
```

**pandas.Series.argmax**

`Series.argmax(axis=0, skipna=True, *args, **kwargs)`

Deprecated since version 0.21.0:

‘argmax’ is deprecated, use ‘idxmax’ instead. The behavior of ‘argmax’ will be corrected to return the positional maximum in the future. Use ‘series.values.argmax’ to get the position of the maximum now.

Return the row label of the maximum value.

If multiple values equal the maximum, the first row label with that value is returned.

Parameters:

- **skipna** : boolean, default True
  
  Exclude NA/null values. If the entire Series is NA, the result will be NA.

- **axis** : int, default 0
  
  For compatibility with DataFrame.idxmax. Redundant for application on Series.

- **args, **kwargs
  
  Additional keywords have no effect but might be accepted for compatibility with NumPy.

Returns:

- **idxmax** [Index of maximum of values.]

Raises **ValueError**

If the Series is empty.

See also:

- `numpy.argmax` Return indices of the maximum values along the given axis.
- `DataFrame.idxmax` Return index of first occurrence of maximum over requested axis.
- `Series.idxmin` Return index *label* of the first occurrence of minimum of values.
Notes

This method is the Series version of `ndarray.argmax`. This method returns the label of the maximum, while `ndarray.argmax` returns the position. To get the position, use `series.values.argmax()`.

Examples

```python
>>> s = pd.Series(data=[1, None, 4, 3, 4],
                 index=['A', 'B', 'C', 'D', 'E'])
>>> s
A    1.0
B   NaN
C    4.0
D    3.0
E    4.0
dtype: float64

>>> s.idxmax()
'C'
```

If `skipna` is False and there is an NA value in the data, the function returns `nan`.

```python
>>> s.idxmax(skipna=False)
nan
```

**pandas.Series.argmin**

`Series.argmin(axis=None, skipna=True, *args, **kwargs)`

Deprecated since version 0.21.0:

‘argmin’ is deprecated, use ‘idxmin’ instead. The behavior of ‘argmin’ will be corrected to return the positional minimum in the future. Use ‘series.values.argmin’ to get the position of the minimum now.

Return the row label of the minimum value.

If multiple values equal the minimum, the first row label with that value is returned.

Parameters

- `skipna` : boolean, default True
  Exclude NA/null values. If the entire Series is NA, the result will be NA.
- `axis` : int, default 0
  For compatibility with DataFrame.idxmin. Redundant for application on Series.
- `*args`, `**kwargs`
  Additional keywors have no effect but might be accepted for compatibility with NumPy.

Returns

- `idxmin` [Index of minimum of values.]

Raises

- `ValueError`
  If the Series is empty.

See also:
numpy.argmin  Return indices of the minimum values along the given axis.

DataFrame.idxmin  Return index of first occurrence of minimum over requested axis.

Series.idxmax  Return index label of the first occurrence of maximum of values.

Notes

This method is the Series version of ndarray.argmin. This method returns the label of the minimum, while ndarray.argmin returns the position. To get the position, use series.values.argmin().

Examples

```python
>>> s = pd.Series(data=[1, None, 4, 1],
    ... index=['A', 'B', 'C', 'D'])
>>> s
A    1.0
B    NaN
C    4.0
D    1.0
dtype: float64

>>> s.idxmin()
'A'

If skipna is False and there is an NA value in the data, the function returns nan.

>>> s.idxmin(skipna=False)
nan
```

pandas.Series.argsort

Series.argsort (axis=0, kind=’quicksort’, order=None)

Overrides ndarray.argsort. Argsorts the value, omitting NA/null values, and places the result in the same locations as the non-NA values.

Parameters

- **axis** [int (can only be zero)]
- **kind** : {'mergesort', 'quicksort', 'heapsort'}, default ‘quicksort’

  Choice of sorting algorithm. See np.sort for more information. ‘mergesort’ is the only stable algorithm.

- **order** [ignored]

Returns

- **argsorted** [Series, with -1 indicated where nan values are present]

See also:

- numpy.ndarray.argsort
pandas.Series.as_blocks

Series.as_blocks (copy=True)
Convert the frame to a dict of dtype -> Constructor Types that each has a homogeneous dtype.
Deprecated since version 0.21.0.

NOTE: the dtypes of the blocks WILL BE PRESERVED HERE (unlike in as_matrix)

Parameters

copy [boolean, default True]

Returns

values [a dict of dtype -> Constructor Types]

pandas.Series.as_matrix

Series.as_matrix (columns=None)
Convert the frame to its Numpy-array representation.
Deprecated since version 0.23.0: Use DataFrame.values() instead.

Parameters columns: list, optional, default:None
If None, return all columns, otherwise, returns specified columns.

Returns values: ndarray
If the caller is heterogeneous and contains booleans or objects, the result will be of dtype=object. See Notes.

See also:
pandas.DataFrame.values

Notes

Return is NOT a Numpy-matrix, rather, a Numpy-array.
The dtype will be a lower-common-denominator dtype (implicit upcasting): that is to say if the dtypes (even of numeric types) are mixed, the one that accommodates all will be chosen. Use this with care if you are not dealing with the blocks.

e.g. If the dtypes are float16 and float32, dtype will be upcast to float32. If dtypes are int32 and uint8, dtype will be upcase to int32. By numpy.find_common_type convention, mixing int64 and uint64 will result in a flot64 dtype.

This method is provided for backwards compatibility. Generally, it is recommended to use `.values`.

pandas.Series.asfreq

Series.asfreq (freq, method=None, how=None, normalize=False, fill_value=None)
Convert TimeSeries to specified frequency.

Optionally provide filling method to pad/backfill missing values.
Returns the original data conformed to a new index with the specified frequency. resample is more appropriate if an operation, such as summarization, is necessary to represent the data at the new frequency.

**Parameters**

- **freq** [DateOffset object, or string]
- **method** : {'backfill'/‘bfill’, ‘pad’/‘ffill’}, default None
  Method to use for filling holes in reindexed Series (note this does not fill NaNs that already were present):
  - ‘pad’ / ‘ffill’: propagate last valid observation forward to next valid
  - ‘backfill’ / ‘bfill’: use NEXT valid observation to fill
- **how** : {'start', 'end'}, default end
  For PeriodIndex only, see PeriodIndex.asfreq
- **normalize** : bool, default False
  Whether to reset output index to midnight
- **fill_value** : scalar, optional
  Value to use for missing values, applied during upsampling (note this does not fill NaNs that already were present).
  New in version 0.20.0.

**Returns**

- **converted** [type of caller]

**See also:**

reindex

**Notes**

To learn more about the frequency strings, please see this link.

**Examples**

Start by creating a series with 4 one minute timestamps.

```
>>> index = pd.date_range('1/1/2000', periods=4, freq='T')
>>> series = pd.Series([0.0, None, 2.0, 3.0], index=index)
>>> df = pd.DataFrame({'s':series})
>>> df
    s
2000-01-01 00:00:00  0.0
2000-01-01 00:01:00  NaN
2000-01-01 00:02:00  2.0
2000-01-01 00:03:00  3.0
```

Upsample the series into 30 second bins.
Upsample again, providing a fill value.

```python
>>> df.asfreq(freq='30S', fill_value=9.0)
```

Upsample again, providing a method.

```python
>>> df.asfreq(freq='30S', method='bfill')
```

```
>>> df.asfreq(freq='30S')
```

```python
s
2000-01-01 00:00:00    0.0
2000-01-01 00:00:30   NaN
2000-01-01 00:01:00   NaN
2000-01-01 00:01:30   NaN
2000-01-01 00:02:00    2.0
2000-01-01 00:02:30   NaN
2000-01-01 00:03:00    3.0
```

```
>>> df.asfreq(freq='30S', fill_value=9.0)
```

```
2000-01-01 00:00:00    0.0
2000-01-01 00:00:30    9.0
2000-01-01 00:01:00   NaN
2000-01-01 00:01:30    9.0
2000-01-01 00:02:00    2.0
2000-01-01 00:02:30    9.0
2000-01-01 00:03:00    3.0
```

```
>>> df.asfreq(freq='30S', method='bfill')
```

```
2000-01-01 00:00:00    0.0
2000-01-01 00:00:30   NaN
2000-01-01 00:01:00   NaN
2000-01-01 00:01:30    2.0
2000-01-01 00:02:00    2.0
2000-01-01 00:02:30    3.0
2000-01-01 00:03:00    3.0
```

```
pandas.Series.asof
```

Series.asof( where , subset=None )
The last row without any NaN is taken (or the last row without NaN considering only the subset of columns in the case of a DataFrame)

New in version 0.19.0: For DataFrame

If there is no good value, NaN is returned for a Series a Series of NaN values for a DataFrame

Parameters

where [ date or array of dates ]

subset : string or list of strings, default None
    if not None use these columns for NaN propagation

Returns where is scalar

- value or NaN if input is Series
- Series if input is DataFrame

where is Index: same shape object as input
See also:

merge_asof

Notes

Dates are assumed to be sorted Raises if this is not the case

**pandas.Series.astype**

`Series.astype(dtype, copy=True, errors='raise', **kwargs)`

Cast a pandas object to a specified dtype `dtype`.

**Parameters**

da **dtype**: data type, or dict of column name -> data type

Use a numpy.dtype or Python type to cast entire pandas object to the same type. Alternatively, use `{col: dtype, ...}`, where `col` is a column label and `dtype` is a numpy.dtype or Python type to cast one or more of the DataFrame’s columns to column-specific types.

copy : bool, default True.

Return a copy when `copy=True` (be very careful setting `copy=False` as changes to values then may propagate to other pandas objects).

errors : `{raise`, `ignore`}, default `{raise`.

Control raising of exceptions on invalid data for provided dtype.

• raise: allow exceptions to be raised

• ignore: suppress exceptions. On error return original object

New in version 0.20.0.

raise_on_error : raise on invalid input

Deprecated since version 0.20.0: Use `errors` instead

**kwargs** [keyword arguments to pass on to the constructor]

Returns

casted [type of caller]

See also:

**pandas.to_datetime** Convert argument to datetime.

**pandas.to_timedelta** Convert argument to timedelta.

**pandas.to_numeric** Convert argument to a numeric type.

**numpy.ndarray.astype** Cast a numpy array to a specified type.

Examples
>>> ser = pd.Series([1, 2], dtype='int32')
>>> ser
0    1
1    2
dtype: int32
>>> ser.astype('int64')
0    1
1    2
dtype: int64

Convert to categorical type:

>>> ser.astype('category')
0    1
1    2
dtype: category
Categories (2, int64): [1, 2]

Convert to ordered categorical type with custom ordering:

>>> ser.astype('category', ordered=True, categories=[2, 1])
0    1
1    2
dtype: category
Categories (2, int64): [2 < 1]

Note that using `copy=False` and changing data on a new pandas object may propagate changes:

>>> s1 = pd.Series([1,2])
>>> s2 = s1.astype('int64', copy=False)
>>> s2[0] = 10
>>> s1  # note that s1[0] has changed too
0    10
1    2
dtype: int64

**pandas.Series.at_time**

`Series.at_time` *(time, asof=False)*

Select values at particular time of day (e.g. 9:30AM).

**Parameters**

- **time** [datetime.time or string]

**Returns**

- **values_at_time** [type of caller]

**Raises** **TypeError**

If the index is not a `DatetimeIndex`

**See also:**

- **between_time** Select values between particular times of the day
- **first** Select initial periods of time series based on a date offset
last  Select final periods of time series based on a date offset

DatetimeIndex.indexer_at_time Get just the index locations for values at particular time of the day

Examples

```python
>>> i = pd.date_range('2018-04-09', periods=4, freq='12H')
>>> ts = pd.DataFrame({'A': [1,2,3,4]}, index=i)
>>> ts
   A
2018-04-09 00:00:00 1
2018-04-09 12:00:00 2
2018-04-10 00:00:00 3
2018-04-10 12:00:00 4

>>> ts.at_time('12:00')
   A
2018-04-09 12:00:00 2
2018-04-10 12:00:00 4
```

pandas.Series.autocorr

Series.autocorr(lag=1)

Lag-N autocorrelation

Parameters

lag : int, default 1

Number of lags to apply before performing autocorrelation.

Returns

autocorr [float]

pandas.Series.between

Series.between(left, right, inclusive=True)

Return boolean Series equivalent to left <= series <= right.

This function returns a boolean vector containing True wherever the corresponding Series element is between the boundary values left and right. NA values are treated as False.

Parameters

left : scalar

Left boundary.

right : scalar

Right boundary.

inclusive : bool, default True

Include boundaries.

Returns

Series

Each element will be a boolean.
See also:

- `pandas.Series.gt` Greater than of series and other
- `pandas.Series.lt` Less than of series and other

Notes

This function is equivalent to `(left <= ser) & (ser <= right)`

Examples

```python
>>> s = pd.Series([2, 0, 4, 8, np.nan])
```

Boundary values are included by default:

```python
>>> s.between(1, 4)
0    True
1   False
2    True
3   False
4   False
dtype: bool
```

With `inclusive` set to `False` boundary values are excluded:

```python
>>> s.between(1, 4, inclusive=False)
0    True
1   False
2   False
3   False
4   False
dtype: bool
```

`left` and `right` can be any scalar value:

```python
>>> s = pd.Series(['Alice', 'Bob', 'Carol', 'Eve'])
>>> s.between('Anna', 'Daniel')
0   False
1    True
2    True
3   False
dtype: bool
```

`pandas.Series.between_time`

Series.between_time(start_time, end_time, include_start=True, include_end=True)

Select values between particular times of the day (e.g., 9:00-9:30 AM).

By setting `start_time` to be later than `end_time`, you can get the times that are not between the two times.

Parameters

- `start_time` [datetime.time or string]
end_time [datetime.time or string]
include_start [boolean, default True]
include_end [boolean, default True]

Returns
values_between_time [type of caller]

Raises TypeError
If the index is not a DatetimeIndex

See also:
at_time Select values at a particular time of the day
first Select initial periods of time series based on a date offset
last Select final periods of time series based on a date offset
DatetimeIndex.indexer_between_time Get just the index locations for values between particular times of the day

Examples

```python
>>> i = pd.date_range('2018-04-09', periods=4, freq='1D20min')
>>> ts = pd.DataFrame({'A': [1, 2, 3, 4]}, index=i)
>>> ts
          A
2018-04-09  00:00:00  1
2018-04-10  00:20:00  2
2018-04-11  00:40:00  3
2018-04-12  01:00:00  4

>>> ts.between_time('0:15', '0:45')
          A
2018-04-10  00:20:00  2
2018-04-11  00:40:00  3
```

You get the times that are not between two times by setting start_time later than end_time:

```python
>>> ts.between_time('0:45', '0:15')
          A
2018-04-09  00:00:00  1
2018-04-12  01:00:00  4
```

pandas.Series.bfill

Series.bfill (axis=None, inplace=False, limit=None, downcast=None)
Synonym for DataFrame.fillna(method='bfill')

pandas.Series.bool

Series.bool()
Return the bool of a single element PandasObject.
This must be a boolean scalar value, either True or False. Raise a ValueError if the PandasObject does not have exactly 1 element, or that element is not boolean

**pandas.Series.cat**

Series.cat()

Accessor object for categorical properties of the Series values.

Be aware that assigning to categories is a inplace operation, while all methods return new categorical data per default (but can be called with inplace=True).

**Parameters**

- **data** [Series or CategoricalIndex]

**Examples**

```python
>>> s.cat.categories
>>> s.cat.categories = list('abc')
>>> s.cat.rename_categories(list('cab'))
>>> s.cat.reorder_categories(list('cab'))
>>> s.cat.add_categories(['d','e'])
>>> s.cat.remove_categories(['d'])
>>> s.cat.remove_unused_categories()
>>> s.cat.set_categories(list('abcde'))
>>> s.cat.as_ordered()
>>> s.cat.as_unordered()
```

**pandas.Series.clip**

Series.clip(lower=None, upper=None, axis=None, inplace=False, *args, **kwargs)

Trim values at input threshold(s).

Assigns values outside boundary to boundary values. Thresholds can be singular values or array like, and in the latter case the clipping is performed element-wise in the specified axis.

**Parameters**

- **lower** : float or array_like, default None
  Minimum threshold value. All values below this threshold will be set to it.

- **upper** : float or array_like, default None
  Maximum threshold value. All values above this threshold will be set to it.

- **axis** : int or string axis name, optional
  Align object with lower and upper along the given axis.

- **inplace** : boolean, default False
  Whether to perform the operation in place on the data.

  New in version 0.21.0.

- ***args, **kwargs**
  Additional keywords have no effect but might be accepted for compatibility with numpy.

**Returns**

Series or DataFrame
Same type as calling object with the values outside the clip boundaries replaced

See also:

* **clip_lower** Clip values below specified threshold(s).
  
  * **clip_upper** Clip values above specified threshold(s).

**Examples**

```python
>>> data = {'col_0': [9, -3, 0, -1, 5], 'col_1': [-2, -7, 6, 8, -5]}
>>> df = pd.DataFrame(data)
>>> df
   col_0 col_1
0      9   -2
1     -3   -7
2      0    6
3     -1    8
4      5   -5

Clips per column using lower and upper thresholds:

```python
>>> df.clip(-4, 6)
   col_0 col_1
0      6   -2
1     -3   -4
2      0    6
3     -1    6
4      5   -4
```

Clips using specific lower and upper thresholds per column element:

```python
>>> t = pd.Series([2, -4, -1, 6, 3])
>>> t
0   2
1  -4
2  -1
3   6
4   3
dtype: int64

```python
>>> df.clip(t, t + 4, axis=0)
   col_0 col_1
0      6    2
1     -3   -4
2      0    3
3      6    8
4      5    3
```

**pandas.Series.clip_lower**

*Series.clip_lower*(threshold, axis=None, inplace=False)

Return copy of the input with values below a threshold truncated.

**Parameters**

* threshold : numeric or array-like
Minimum value allowed. All values below threshold will be set to this value.

- float: every value is compared to `threshold`.
- array-like: The shape of `threshold` should match the object it's compared to. When `self` is a Series, `threshold` should be the length. When `self` is a DataFrame, `threshold` should 2-D and the same shape as `self` for `axis=None`, or 1-D and the same length as the axis being compared.

```
axis: {0 or 'index', 1 or 'columns'}, default 0
```

Align `self` with `threshold` along the given axis.

```
inplace: boolean, default False
```

Whether to perform the operation in place on the data.

New in version 0.21.0.

Returns

clipped [same type as input]

See also:

- `Series.clip` Return copy of input with values below and above thresholds truncated.
- `Series.clip_upper` Return copy of input with values above threshold truncated.

Examples

Series single threshold clipping:

```
>>> s = pd.Series([5, 6, 7, 8, 9])
>>> s.clip_lower(8)
0   8
1   8
2   8
3   8
4   9
dtype: int64
```

Series clipping element-wise using an array of thresholds. `threshold` should be the same length as the Series.

```
>>> elemwise_thresholds = [4, 8, 7, 2, 5]
>>> s.clip_lower(elemwise_thresholds)
0   5
1   8
2   7
3   8
4   9
dtype: int64
```

DataFrames can be compared to a scalar.

```
>>> df = pd.DataFrame({'A': [1, 3, 5], 'B': [2, 4, 6]})
>>> df
   A B
0  1  2
1  3  4
2  5  6
```

(continues on next page)
Or to an array of values. By default, `threshold` should be the same shape as the DataFrame.

```python
>>> df.clip_lower(np.array([[3, 4], [2, 2], [6, 2]]))
```

Control how `threshold` is broadcast with `axis`. In this case `threshold` should be the same length as the axis specified by `axis`.

```python
>>> df.clip_lower(np.array([3, 3, 5]), axis='index')
```

```python
>>> df.clip_lower(np.array([4, 5]), axis='columns')
```

### pandas.Series.clip_upper

`Series.clip_upper(threshold, axis=None, inplace=False)`

Return copy of input with values above given value(s) truncated.

**Parameters**

- `threshold` [float or array_like]
- `axis` : int or string axis name, optional
  
  Align object with threshold along the given axis.
- `inplace` : boolean, default False
  
  Whether to perform the operation in place on the data

**Returns**

- `clipped` [same type as input]

**See also:**

`clip`
pandas.Series.combine

Series.combine(other, func, fill_value=nan)
Perform elementwise binary operation on two Series using given function with optional fill value when an
index is missing from one Series or the other

Parameters

other [Series or scalar value]

func : function
    Function that takes two scalars as inputs and return a scalar

fill_value [scalar value]

Returns

result [Series]

See also:

Series.combine_first  Combine Series values, choosing the calling Series's values first

Examples

```python
>>> s1 = Series([1, 2])
>>> s2 = Series([0, 3])
>>> s1.combine(s2, lambda x1, x2: x1 if x1 < x2 else x2)
0 0
1 2
dtype: int64
```

pandas.Series.combine_first

Series.combine_first(other)
Combine Series values, choosing the calling Series’s values first. Result index will be the union of the two
indexes

Parameters

other [Series]

Returns

combined [Series]

See also:

Series.combine  Perform elementwise operation on two Series using a given function

Examples
```python
>>> s1 = pd.Series([1, np.nan])
>>> s2 = pd.Series([3, 4])
>>> s1.combine_first(s2)
0  1.0
1  4.0
dtype: float64
```

### pandas.Series.compound

Series.compound (axis=None, skipna=None, level=None)

Return the compound percentage of the values for the requested axis

**Parameters**

- `axis` [[index (0)]]
- `skipna` : boolean, default True
  - Exclude NA/null values when computing the result.
- `level` : int or level name, default None
  - If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar
- `numeric_only` : boolean, default None
  - Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

- `compounded` [scalar or Series (if level specified)]

### pandas.Series.compress

Series.compress (condition, *args, **kwargs)

Return selected slices of an array along given axis as a Series

See also:

numpy.ndarray.compress

### pandas.Series.consolidate

Series.consolidate (inplace=False)

Compute NDFrame with “consolidated” internals (data of each dtype grouped together in a single ndarray).

Deprecated since version 0.20.0: Consolidate will be an internal implementation only.

### pandas.Series.convert_objects

Series.convert_objects (convert_dates=True, convert_numeric=False, convert_timedeltas=True, copy=True)

Attempt to infer better dtype for object columns.

Deprecated since version 0.21.0.
Parameters

**convert_dates** : boolean, default True

If True, convert to date where possible. If ‘coerce’, force conversion, with unconvertible values becoming NaT.

**convert_numeric** : boolean, default False

If True, attempt to coerce to numbers (including strings), with unconvertible values becoming NaN.

**convert_timedeltas** : boolean, default True

If True, convert to timedelta where possible. If ‘coerce’, force conversion, with unconvertible values becoming NaT.

**copy** : boolean, default True

If True, return a copy even if no copy is necessary (e.g. no conversion was done). Note: This is meant for internal use, and should not be confused with inplace.

Returns

**converted** [same as input object]

See also:

- `pandas.to_datetime` Convert argument to datetime.
- `pandas.to_timedelta` Convert argument to timedelta.
- `pandas.to_numeric` Return a fixed frequency timedelta index, with day as the default.

**pandas.Series.copy**

Series.copy (deep=True)

Make a copy of this object’s indices and data.

When deep=True (default), a new object will be created with a copy of the calling object’s data and indices. Modifications to the data or indices of the copy will not be reflected in the original object (see notes below).

When deep=False, a new object will be created without copying the calling object’s data or index (only references to the data and index are copied). Any changes to the data of the original will be reflected in the shallow copy (and vice versa).

Parameters

**deep** : bool, default True

Make a deep copy, including a copy of the data and the indices. With deep=False neither the indices nor the data are copied.

Returns

**copy** : Series, DataFrame or Panel

Object type matches caller.

Notes

When deep=True, data is copied but actual Python objects will not be copied recursively, only the reference to the object. This is in contrast to copy.deepcopy in the Standard Library, which recursively copies object data (see examples below).
While Index objects are copied when deep=True, the underlying numpy array is not copied for performance reasons. Since Index is immutable, the underlying data can be safely shared and a copy is not needed.

**Examples**

```python
>>> s = pd.Series([1, 2], index=["a", "b"])
>>> s
a 1
b 2
dtype: int64
```

```python
>>> s_copy = s.copy()
>>> s_copy
a 1
b 2
dtype: int64
```

**Shallow copy versus default (deep) copy:**

```python
>>> s = pd.Series([1, 2], index=["a", "b"])
>>> deep = s.copy()
>>> shallow = s.copy(deep=False)
```

Shallow copy shares data and index with original.

```python
>>> s is shallow
False
>>> s.values is shallow.values and s.index is shallow.index
True
```

Deep copy has own copy of data and index.

```python
>>> s is deep
False
>>> s.values is deep.values or s.index is deep.index
False
```

Updates to the data shared by shallow copy and original is reflected in both; deep copy remains unchanged.

```python
>>> s[0] = 3
>>> shallow[1] = 4
>>> s
a 3
b 4
dtype: int64
```

```python
>>> shallow
a 3
b 4
dtype: int64
```

```python
>>> deep
a 1
b 2
dtype: int64
```
Note that when copying an object containing Python objects, a deep copy will copy the data, but will not do so recursively. Updating a nested data object will be reflected in the deep copy.

```python
>>> s = pd.Series([[1, 2], [3, 4]])
>>> deep = s.copy()
>>> s[0][0] = 10

>>> s
0    [10, 2]
1    [3, 4]
dtype: object

>>> deep
0    [10, 2]
1    [3, 4]
dtype: object
```

### pandas.Series.corr

`Series.corr(other, method='pearson', min_periods=None)`  
Compute correlation with `other` Series, excluding missing values

**Parameters**

- `other` [Series]
- `method` : {'pearson', 'kendall', 'spearman'}
  - `pearson` : standard correlation coefficient
  - `kendall` : Kendall Tau correlation coefficient
  - `spearman` : Spearman rank correlation
- `min_periods` : int, optional
  Minimum number of observations needed to have a valid result

**Returns**

- `correlation` [float]

### pandas.Series.count

`Series.count(level=None)`  
Return number of non-NA/null observations in the Series

**Parameters**

- `level` : int or level name, default None
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a smaller Series

**Returns**

- `nobs` [int or Series (if level specified)]

### pandas.Series.cov

`Series.cov(other, min_periods=None)`  
Compute covariance with Series, excluding missing values
Parameters

other  [Series]

min_periods : int, optional

Minimum number of observations needed to have a valid result

Returns

covariance  [float]

Normalized by N-1 (unbiased estimator).

pandas.Series.cummax

Series.cummax (axis=None, skipna=True, *args, **kwargs)

Return cumulative maximum over a DataFrame or Series axis.

Returns a DataFrame or Series of the same size containing the cumulative maximum.

Parameters

axis  : {0 or ‘index’, 1 or ‘columns’}, default 0

The index or the name of the axis. 0 is equivalent to None or ‘index’.

skipna  : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA.

*args, **kwargs :

Additional keywords have no effect but might be accepted for compatibility with NumPy.

Returns

cummax  [scalar or Series]

See also:

pandas.core.window.Expanding.max  Similar functionality but ignores NaN values.

Series.max  Return the maximum over Series axis.

Series.cummax  Return cumulative maximum over Series axis.

Series.cummin  Return cumulative minimum over Series axis.

Series.cumsum  Return cumulative sum over Series axis.

Series.cumprod  Return cumulative product over Series axis.

Examples

Series

```python
>>> s = pd.Series([2, np.nan, 5, -1, 0])
```

(continues on next page)
4 0.0
dtype: float64

By default, NA values are ignored.

```python
>>> s.cummax()
0   2.0
1   NaN
2   5.0
3   5.0
4   5.0
dtype: float64
```

To include NA values in the operation, use `skipna=False`

```python
>>> s.cummax(skipna=False)
0   2.0
1   NaN
2   NaN
3   NaN
4   NaN
dtype: float64
```

**DataFrame**

```python
>>> df = pd.DataFrame([[2.0, 1.0],
...                     [3.0, np.nan],
...                     [1.0, 0.0]],
...                    columns=list('AB'))
>>> df
   A   B
0  2.0  1.0
1  3.0  NaN
2  1.0  0.0
```

By default, iterates over rows and finds the maximum in each column. This is equivalent to `axis=None` or `axis='index'`.

```python
>>> df.cummax()
   A   B
0  2.0  2.0
1  3.0  NaN
2  1.0  1.0
```

To iterate over columns and find the maximum in each row, use `axis=1`

```python
>>> df.cummax(axis=1)
   A   B
0  2.0  2.0
1  3.0  NaN
2  1.0  1.0
```
pandas.Series.cummin

Series.cummin(axis=None, skipna=True, *args, **kwargs)
Return cumulative minimum over a DataFrame or Series axis.

Returns a DataFrame or Series of the same size containing the cumulative minimum.

Parameters axis : {0 or ‘index’, 1 or ‘columns’}, default 0
The index or the name of the axis. 0 is equivalent to None or ‘index’.

skipna : boolean, default True
Exclude NA/null values. If an entire row/column is NA, the result will be NA.

*args, **kwargs :
Additional keywords have no effect but might be accepted for compatibility with NumPy.

Returns

cummin [scalar or Series]

See also:

pandas.core.window.Expanding.min  Similar functionality but ignores NaN values.
Series.min  Return the minimum over Series axis.
Series.cummax  Return cumulative maximum over Series axis.
Series.cummin  Return cumulative minimum over Series axis.
Series.cumsum  Return cumulative sum over Series axis.
Series.cumprod  Return cumulative product over Series axis.

Examples

Series

>>> s = pd.Series([2, np.nan, 5, -1, 0])
>>> s
0    2.0
1    NaN
2    5.0
3   -1.0
4    0.0
dtype: float64

By default, NA values are ignored.

>>> s.cummin()
0    2.0
1    NaN
2    2.0
3   -1.0
4   -1.0
dtype: float64

To include NA values in the operation, use skipna=False
>>> s.cummin(skipna=False)
0  2.0  
1  NaN  
2  NaN  
3  NaN  
4  NaN  
dtype: float64

DataFrame

>>> df = pd.DataFrame([[2.0, 1.0],  
...                     [3.0, np.nan]],  
...                     columns=list('AB'))
>>> df
   A  B
0  2.0  1.0
1  3.0  NaN
2  1.0  0.0

By default, iterates over rows and finds the minimum in each column. This is equivalent to axis=None or axis='index'.

>>> df.cummin()
   A  B
0  2.0  1.0
1  2.0  NaN
2  1.0  0.0

To iterate over columns and find the minimum in each row, use axis=1

>>> df.cummin(axis=1)
   A  B
0  2.0  1.0
1  3.0  NaN
2  1.0  0.0

pandas.Series.cumprod

Series.cumprod(axis=None, skipna=True, *args, **kwargs)

Return cumulative product over a DataFrame or Series axis.

Returns a DataFrame or Series of the same size containing the cumulative product.

Parameters axis : {0 or ‘index’, 1 or ‘columns’}, default 0

The index or the name of the axis. 0 is equivalent to None or ‘index’.

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA.

*args, **kwargs :

Additional keywords have no effect but might be accepted for compatibility with NumPy.

Returns
cumprod [scalar or Series]

See also:

pandas.core.window.Expanding.prod  Similar functionality but ignores NaN values.

Series.prod  Return the product over Series axis.

Series.cummax  Return cumulative maximum over Series axis.

Series.cummin  Return cumulative minimum over Series axis.

Series.cumsum  Return cumulative sum over Series axis.

Series.cumprod  Return cumulative product over Series axis.

Examples

Series

```python
>>> s = pd.Series([2, np.nan, 5, -1, 0])
>>> s
0    2.0
1  NaN
2    5.0
3   -1.0
4     0.0
dtype: float64
```

By default, NA values are ignored.

```python
>>> s.cumprod()
0    2.0
1  NaN
2  10.0
3 -10.0
4   0.0
dtype: float64
```

To include NA values in the operation, use skipna=False

```python
>>> s.cumprod(skipna=False)
0    2.0
1  NaN
2  NaN
3  NaN
4  NaN
dtype: float64
```

DataFrame

```python
>>> df = pd.DataFrame([[2.0, 1.0],
... [3.0, np.nan],
... [1.0, 0.0]],
... columns=list('AB'))
>>> df
   A  B
0  2.0  1.0
```
By default, iterates over rows and finds the product in each column. This is equivalent to axis=None or axis='index'.

```python
>>> df.cumprod()
   A   B
0  2.0  1.0
1  6.0   NaN
2  6.0  0.0
```

To iterate over columns and find the product in each row, use axis=1

```python
>>> df.cumprod(axis=1)
   A  B
0  2.0  2.0
1  3.0   NaN
2  1.0  0.0
```

### pandas.Series.cumsum

**Series.cumsum** (axis=None, skipna=True, *args, **kwargs)

Return cumulative sum over a DataFrame or Series axis.

Returns a DataFrame or Series of the same size containing the cumulative sum.

- **Parameters**
  - axis : {0 or 'index', 1 or 'columns'}, default 0
    - The index or the name of the axis. 0 is equivalent to None or 'index'.
  - skipna : boolean, default True
    - Exclude NA/null values. If an entire row/column is NA, the result will be NA.
  - *args, **kwargs :
    - Additional keywords have no effect but might be accepted for compatibility with NumPy.

- **Returns**
  - cumsum [scalar or Series]

**See also:**

- *pandas.core.window.Expanding.sum* Similar functionality but ignores NaN values.
- *Series.sum* Return the sum over Series axis.
- *Series.cummax* Return cumulative maximum over Series axis.
- *Series.cummin* Return cumulative minimum over Series axis.
- *Series.cumsum* Return cumulative sum over Series axis.
- *Series.cumprod* Return cumulative product over Series axis.
Examples

Series

```python
>>> s = pd.Series([2, np.nan, 5, -1, 0])
>>> s
0  2.0
1  NaN
2  5.0
3  -1.0
4   0.0
dtype: float64
```

By default, NA values are ignored.

```python
>>> s.cumsum()
0  2.0
1  NaN
2  7.0
3  6.0
4  6.0
dtype: float64
```

To include NA values in the operation, use `skipna=False`

```python
>>> s.cumsum(skipna=False)
0  2.0
1  NaN
2  NaN
3  NaN
4  NaN
dtype: float64
```

DataFrame

```python
>>> df = pd.DataFrame([[2.0, 1.0],
                     ...                     [3.0, np.nan],
                     ...                     [1.0, 0.0]],
                     ...                     columns=list('AB'))
>>> df
   A   B
0  2.0  1.0
1  3.0  NaN
2  1.0  0.0
```

By default, iterates over rows and finds the sum in each column. This is equivalent to `axis=None` or `axis='index'`.

```python
>>> df.cumsum()
   A   B
0  2.0  1.0
1  3.0  NaN
2  6.0  1.0
```

To iterate over columns and find the sum in each row, use `axis=1`
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
>>> df.cumsum(axis=1)
   A   B
0  2.0  3.0
1  3.0 NaN
2  1.0  1.0
```

**pandas.Series.describe**

`Series.describe(percentiles=None, include=None, exclude=None)`

Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset's distribution, excluding NaN values.

Analyzes both numeric and object series, as well as DataFrame column sets of mixed data types. The output will vary depending on what is provided. Refer to the notes below for more detail.

**Parameters**

- **percentiles** : list-like of numbers, optional
  
  The percentiles to include in the output. All should fall between 0 and 1. The default is 
  [.25, .5, .75], which returns the 25th, 50th, and 75th percentiles.

- **include** : 'all', list-like of dtypes or None (default), optional

  A white list of data types to include in the result. Ignored for Series. Here are the 
  options:

  - 'all' : All columns of the input will be included in the output.

  - A list-like of dtypes : Limits the results to the provided data types. To limit the result 
    to numeric types submit `numpy.number`. To limit it instead to object columns 
    submit the `numpy.object` data type. Strings can also be used in the style of 
    `select_dtypes` (e.g. `df.describe(include=['O']))). To select pandas 
    categorical columns, use 'category'

  - None (default) : The result will include all numeric columns.

- **exclude** : list-like of dtypes or None (default), optional,

  A black list of data types to omit from the result. Ignored for Series. Here are the 
  options:

  - A list-like of dtypes : Excludes the provided data types from the result. To exclu-
    de numeric types submit `numpy.number`. To exclude object columns submit 
    the data type `numpy.object`. Strings can also be used in the style of 
    `select_dtypes` (e.g. `df.describe(include=['O']))). To exclude pandas 
    categorical columns, use 'category'

  - None (default) : The result will exclude nothing.

**Returns**

- **summary** : Series/DataFrame of summary statistics

**See also:**

`DataFrame.count`, `DataFrame.max`, `DataFrame.min`, `DataFrame.mean`, `DataFrame.
std`, `DataFrame.select_dtypes`
Notes

For numeric data, the result’s index will include `count`, `mean`, `std`, `min`, `max` as well as lower, 50 and upper percentiles. By default the lower percentile is 25 and the upper percentile is 75. The 50 percentile is the same as the median.

For object data (e.g. strings or timestamps), the result’s index will include `count`, `unique`, `top`, and `freq`. The `top` is the most common value. The `freq` is the most common value’s frequency. Timestamps also include the `first` and `last` items.

If multiple object values have the highest count, then the `count` and `top` results will be arbitrarily chosen from among those with the highest count.

For mixed data types provided via a DataFrame, the default is to return only an analysis of numeric columns. If the dataframe consists only of object and categorical data without any numeric columns, the default is to return an analysis of both the object and categorical columns. If `include='all'` is provided as an option, the result will include a union of attributes of each type.

The `include` and `exclude` parameters can be used to limit which columns in a DataFrame are analyzed for the output. The parameters are ignored when analyzing a Series.

Examples

Describing a numeric Series.

```python
>>> s = pd.Series([1, 2, 3])
>>> s.describe()
count 3.0
mean 2.0
std 1.0
min 1.0
25% 1.5
50% 2.0
75% 2.5
max 3.0
```

Describing a categorical Series.

```python
>>> s = pd.Series(['a', 'a', 'b', 'c'])
>>> s.describe()
count 4
unique 3
top a
freq 2
dtype: object
```

Describing a timestamp Series.

```python
>>> s = pd.Series([...
... np.datetime64("2000-01-01"),
... np.datetime64("2010-01-01"),
... np.datetime64("2010-01-01")
...])
>>> s.describe()
count 3
unique 2
top 2010-01-01 00:00:00
```

(continues on next page)
Describing a DataFrame. By default only numeric fields are returned.

```python
>>> df = pd.DataFrame({
    'object': ['a', 'b', 'c'],
    'numeric': [1, 2, 3],
    'categorical': pd.Categorical(['d', 'e', 'f'])
})
```

```python
>>> df.describe()  # By default only numeric fields are returned.

<table>
<thead>
<tr>
<th>numeric</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>3.0</td>
</tr>
<tr>
<td>mean</td>
<td>2.0</td>
</tr>
<tr>
<td>std</td>
<td>1.0</td>
</tr>
<tr>
<td>min</td>
<td>1.0</td>
</tr>
<tr>
<td>25%</td>
<td>1.5</td>
</tr>
<tr>
<td>50%</td>
<td>2.0</td>
</tr>
<tr>
<td>75%</td>
<td>2.5</td>
</tr>
<tr>
<td>max</td>
<td>3.0</td>
</tr>
</tbody>
</table>
```

Describing all columns of a DataFrame regardless of data type.

```python
>>> df.describe(include='all')  # Describes all columns regardless of data type.

<table>
<thead>
<tr>
<th>object</th>
<th></th>
<th>numeric</th>
<th></th>
<th>categorical</th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>3.0</td>
<td>count</td>
<td>3.0</td>
<td>count</td>
</tr>
<tr>
<td>unique</td>
<td>3</td>
<td>unique</td>
<td>NaN</td>
<td>unique</td>
</tr>
<tr>
<td>top</td>
<td>f</td>
<td>top</td>
<td>NaN</td>
<td>top</td>
</tr>
<tr>
<td>freq</td>
<td>1</td>
<td>freq</td>
<td>NaN</td>
<td>freq</td>
</tr>
<tr>
<td>mean</td>
<td>NaN</td>
<td>mean</td>
<td>2.0</td>
<td>mean</td>
</tr>
<tr>
<td>std</td>
<td>NaN</td>
<td>std</td>
<td>1.0</td>
<td>std</td>
</tr>
<tr>
<td>min</td>
<td>NaN</td>
<td>min</td>
<td>1.0</td>
<td>min</td>
</tr>
<tr>
<td>25%</td>
<td>NaN</td>
<td>25%</td>
<td>1.5</td>
<td>25%</td>
</tr>
<tr>
<td>50%</td>
<td>NaN</td>
<td>50%</td>
<td>2.0</td>
<td>50%</td>
</tr>
<tr>
<td>75%</td>
<td>NaN</td>
<td>75%</td>
<td>2.5</td>
<td>75%</td>
</tr>
<tr>
<td>max</td>
<td>NaN</td>
<td>max</td>
<td>3.0</td>
<td>max</td>
</tr>
</tbody>
</table>
```

Describing a column from a DataFrame by accessing it as an attribute.

```python
>>> df.numeric.describe()  # Describes a numeric column.

<table>
<thead>
<tr>
<th>numeric</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>3.0</td>
</tr>
<tr>
<td>mean</td>
<td>2.0</td>
</tr>
<tr>
<td>std</td>
<td>1.0</td>
</tr>
<tr>
<td>min</td>
<td>1.0</td>
</tr>
<tr>
<td>25%</td>
<td>1.5</td>
</tr>
<tr>
<td>50%</td>
<td>2.0</td>
</tr>
<tr>
<td>75%</td>
<td>2.5</td>
</tr>
<tr>
<td>max</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Name: numeric, dtype: float64
```

Including only numeric columns in a DataFrame description.

```python
>>> df.describe(include=[np.number])  # Includes only numeric columns.

<table>
<thead>
<tr>
<th>numeric</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>3.0</td>
</tr>
</tbody>
</table>
```

(continues on next page)
Including only string columns in a DataFrame description.

```python
>>> df.describe(include=['object'])

object
count 3
unique 3
top c
freq 1
```

Including only categorical columns from a DataFrame description.

```python
>>> df.describe(include=['category'])

categorical
count 3
unique 3
top f
freq 1
```

Excluding numeric columns from a DataFrame description.

```python
>>> df.describe(exclude=[np.number])

categorical object
count 3 3
unique 3 3
top f c
freq 1 1
```

Excluding object columns from a DataFrame description.

```python
>>> df.describe(exclude=[np.object])

categorical numeric
count 3 3.0
unique 3 NaN
top f NaN
freq 1 NaN
mean NaN 2.0
std NaN 1.0
min NaN 1.0
25% NaN 1.5
50% NaN 2.0
75% NaN 2.5
max NaN 3.0
```

**pandas.Series.diff**

*Series.diff(periods=1)*

First discrete difference of element.
Calculates the difference of a Series element compared with another element in the Series (default is element in previous row).

**Parameters**

- **periods**: int, default 1
  
  Periods to shift for calculating difference, accepts negative values.

**Returns**

- **diffed** [Series]

**See also:**

- **Series.pct_change** Percent change over given number of periods.
- **Series.shift** Shift index by desired number of periods with an optional time freq.
- **DataFrame.diff** First discrete difference of object

**Examples**

Difference with previous row

```python
>>> s = pd.Series([1, 1, 2, 3, 5, 8])
>>> s.diff()  
0    NaN
1    0.0
2    1.0
3    1.0
4    2.0
5    3.0
dtype: float64
```

Difference with 3rd previous row

```python
>>> s.diff(periods=3)  
0    NaN
1    NaN
2    NaN
3    2.0
4    4.0
5    6.0
dtype: float64
```

Difference with following row

```python
>>> s.diff(periods=-1)  
0    0.0
1    -1.0
2    -1.0
3    -2.0
4    -3.0
5    NaN
dtype: float64
```
**Series.div**

Series.div(other, level=None, fill_value=None, axis=0)

Floating division of series and other, element-wise (binary operator `truediv`). Equivalent to `series / other`, but with support to substitute a `fill_value` for missing data in one of the inputs.

**Parameters**
- `other` [Series or scalar value]
- `fill_value`: None or float value, default None (NaN)
  Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing
- `level`: int or name
  Broadcast across a level, matching Index values on the passed MultiIndex level

**Returns**
- `result` [Series]

**See also:**
- `Series.rtruediv`

**Examples**

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a    1.0
b    1.0
c    1.0
d   NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a    1.0
b   NaN
d    1.0
e   NaN
dtype: float64
>>> a.add(b, fill_value=0)
a    2.0
b    1.0
c    1.0
d    1.0
e   NaN
dtype: float64
```

**Series.divide**

Series.divide(other, level=None, fill_value=None, axis=0)

Floating division of series and other, element-wise (binary operator `truediv`).
 Equivalent to `series / other`, but with support to substitute a `fill_value` for missing data in one of the inputs.

**Parameters**

- `other` [Series or scalar value]
- `fill_value` : None or float value, default None (NaN)
  
  Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing

- `level` : int or name
  
  Broadcast across a level, matching Index values on the passed MultiIndex level

**Returns**

- `result` [Series]

**See also:**

- `Series.rtruediv`

**Examples**

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a 1.0
b 1.0
c 1.0
d NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a 1.0
b NaN
d 1.0
e NaN
dtype: float64
>>> a.add(b, fill_value=0)
a 2.0
b 1.0
c 1.0
d 1.0
e NaN
dtype: float64
```
other  [Series or scalar value]

fill_value : None or float value, default None (NaN)

Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns

result [Series]

See also:

Series.None

Examples

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])

>>> a
a  1.0
b  1.0
c  1.0
d   NaN
dtype: float64

>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])

>>> b
a  1.0
b   NaN
d  1.0
e   NaN
dtype: float64

>>> a.add(b, fill_value=0)

a  2.0
b  1.0
c  1.0
d  1.0
e   NaN
dtype: float64
```

**pandas.Series.dot**

Series.dot(other)

Matrix multiplication with DataFrame or inner-product with Series objects. Can also be called using self @ other in Python >= 3.5.

Parameters

other  [Series or DataFrame]

Returns

dot_product  [scalar or Series]
pandas.Series.drop

Series.drop(labels=None, axis=0, index=None, columns=None, level=None, inplace=False, errors='raise')

Return Series with specified index labels removed.

Remove elements of a Series based on specifying the index labels. When using a multi-index, labels on different levels can be removed by specifying the level.

**Parameters**

- **labels**: single label or list-like
  
  Index labels to drop.

- **axis**: 0, default 0
  
  Redundant for application on Series.

- **index, columns**: None
  
  Redundant for application on Series, but index can be used instead of labels.
  
  New in version 0.21.0.

- **level**: int or level name, optional
  
  For MultiIndex, level for which the labels will be removed.

- **inplace**: bool, default False
  
  If True, do operation inplace and return None.

- **errors**: ‘ignore’, ‘raise’, default ‘raise’
  
  If ‘ignore’, suppress error and only existing labels are dropped.

**Returns**

- dropped [pandas.Series]

**Raises**

- **KeyError**

  If none of the labels are found in the index.

**See also:**

- **Series.reindex** Return only specified index labels of Series.

- **Series.dropna** Return series without null values.

- **Series.drop_duplicates** Return Series with duplicate values removed.

- **DataFrame.drop** Drop specified labels from rows or columns.

**Examples**

```python
>>> s = pd.Series(data=np.arange(3), index=['A', 'B', 'C'])

>>> s
A    0
B    1
C    2
Name: 0, dtype: int64

Drop labels B en C
```
>>> s.drop(labels=['B', 'C'])
A 0
dtype: int64

Drop 2nd level label in MultiIndex Series

>>> midx = pd.MultiIndex(levels=[['lama', 'cow', 'falcon'],
... ['speed', 'weight', 'length']],
... labels=[[0, 0, 0, 1, 1, 1, 2, 2, 2],
... [0, 1, 2, 0, 1, 2, 0, 1, 2]])
>>> s = pd.Series([45, 200, 1.2, 30, 250, 1.5, 320, 1, 0.3],
... index=midx)
>>> s
lama speed 45.0
     weight 200.0
     length 1.2
cow  speed 30.0
     weight 250.0
     length 1.5
falcon speed 320.0
     weight 1.0
     length 0.3
dtype: float64

>>> s.drop(labels='weight', level=1)
lama speed 45.0
     length 1.2
cow  speed 30.0
     length 1.5
falcon speed 320.0
     length 0.3
dtype: float64

**pandas.Series.drop_duplicates**

Series.drop_duplicates(keep='first', inplace=False)

Return Series with duplicate values removed.

Parameters:
- **keep**: {'first', 'last', False}, default 'first'
  - 'first': Drop duplicates except for the first occurrence.
  - 'last': Drop duplicates except for the last occurrence.
  - False: Drop all duplicates.
- **inplace**: boolean, default False
  - If True, performs operation inplace and returns None.

Returns:
- **deduplicated** [Series]

See also:

- **Index.drop_duplicates** equivalent method on Index
- **DataFrame.drop_duplicates** equivalent method on DataFrame
Series.duplicated related method on Series, indicating duplicate Series values.

Examples

Generate an Series with duplicated entries.

```python
>>> s = pd.Series(['lama', 'cow', 'lama', 'beetle', 'lama', 'hippo'],
...                   name='animal')

>>> s
0  lama
1  cow
2  lama
3  beetle
4  lama
5  hippo
Name: animal, dtype: object
```

With the ‘keep’ parameter, the selection behaviour of duplicated values can be changed. The value ‘first’ keeps the first occurrence for each set of duplicated entries. The default value of keep is ‘first’.

```python
>>> s.drop_duplicates()
0  lama
1  cow
3  beetle
5  hippo
Name: animal, dtype: object
```

The value ‘last’ for parameter ‘keep’ keeps the last occurrence for each set of duplicated entries.

```python
>>> s.drop_duplicates(keep='last')
1  cow
3  beetle
4  lama
5  hippo
Name: animal, dtype: object
```

The value False for parameter ‘keep’ discards all sets of duplicated entries. Setting the value of ‘inplace’ to True performs the operation inplace and returns None.

```python
>>> s.drop_duplicates(keep=False, inplace=True)
```

pandas.Series.dropna

Series.dropna (axis=0, inplace=False, **kwargs)

Return a new Series with missing values removed.

See the User Guide for more on which values are considered missing, and how to work with missing data.

Parameters axis : {0 or ‘index’}, default 0

There is only one axis to drop values from.
inplace : bool, default False

If True, do operation inplace and return None.

**kwargs

Not in use.

Returns

Series

Series with NA entries dropped from it.

See also:

Series.isna Indicate missing values.
Series.notna Indicate existing (non-missing) values.
Series.fillna Replace missing values.
DataFrame.dropna Drop rows or columns which contain NA values.
Index.dropna Drop missing indices.

Examples

```python
>>> ser = pd.Series([1., 2., np.nan])
>>> ser
  0 1.0
  1 2.0
  2 NaN
dtype: float64
Drop NA values from a Series.
```

```python
>>> ser.dropna()
  0 1.0
  1 2.0
dtype: float64
```

Keep the Series with valid entries in the same variable.

```python
>>> ser.dropna(inplace=True)
>>> ser
  0 1.0
  1 2.0
dtype: float64
```

Empty strings are not considered NA values. None is considered an NA value.

```python
>>> ser = pd.Series([np.NaN, 2, pd.NaT, '', None, 'I stay'])
>>> ser
  0  NaN
  1    2
  2    NaN
  3
  4  None
  5  I stay
dtype: object
```

(continues on next page)
pandas.Series.dt

Series.dt()  
Accessor object for datetimelike properties of the Series values.

**Examples**

```python
>>> s.dt.hour
>>> s.dt.second
>>> s.dt.quarter
```

Returns a Series indexed like the original Series. Raises TypeError if the Series does not contain datetimelike values.

pandas.Series.duplicated

Series.duplicated(keep='first')  
Indicate duplicate Series values.

Duplicated values are indicated as True values in the resulting Series. Either all duplicates, all except the first or all except the last occurrence of duplicates can be indicated.

**Parameters**  
keep : {'first', 'last', False}, default ‘first’

- ‘first’ : Mark duplicates as True except for the first occurrence.
- ‘last’ : Mark duplicates as True except for the last occurrence.
- False : Mark all duplicates as True.

**Returns**

pandas.core.series.Series

**See also:**

- **pandas.Index.duplicated** Equivalent method on pandas.Index
- **pandas.DataFrame.duplicated** Equivalent method on pandas.DataFrame
- **pandas.Series.drop_duplicates** Remove duplicate values from Series

**Examples**

By default, for each set of duplicated values, the first occurrence is set on False and all others on True:
>>> animals = pd.Series(['lama', 'cow', 'lama', 'beetle', 'lama'])
>>> animals.duplicated()
0   False
1   False
2    True
3    False
4    True
dtype: bool

which is equivalent to

>>> animals.duplicated(keep='first')
0    False
1    False
2    True
3    False
4    True
dtype: bool

By using ‘last’, the last occurrence of each set of duplicated values is set on False and all others on True:

>>> animals.duplicated(keep='last')
0    True
1    False
2    True
3    False
4    False
dtype: bool

By setting keep on False, all duplicates are True:

>>> animals.duplicated(keep=False)
0    True
1    False
2    True
3    False
4    True
dtype: bool

pandas.Series.eq

Series.eq(other, level=None, fill_value=None, axis=0)

Equal to of series and other, element-wise (binary operator eq).

Equivalent to series == other, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters

other [Series or scalar value]

fill_value: None or float value, default None (NaN)

Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing

level : int or name
Broadcast across a level, matching Index values on the passed MultiIndex level

Returns

result [Series]

See also:

Series.None

Examples

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a    1.0
b    1.0
c    1.0
d    NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a    1.0
b    NaN
d    1.0
e    NaN
dtype: float64
>>> a.add(b, fill_value=0)
a    2.0
b    1.0
c    1.0
d    1.0
e    NaN
dtype: float64
```

pandas.Series.equals

Series.equals(other)
Determine if two NDFrame objects contain the same elements. NaNs in the same location are considered equal.

pandas.Series.ewm

Series.ewm(com=None, span=None, halflife=None, alpha=None, min_periods=0, adjust=True, ignore_na=False, axis=0)
Provides exponential weighted functions
New in version 0.18.0.

Parameters

- **com**: float, optional
  Specify decay in terms of center of mass, \( \alpha = 1/(1 + \text{com}) \), for \( \text{com} \geq 0 \)
- **span**: float, optional
  Specify decay in terms of span, \( \alpha = 2/(\text{span} + 1) \), for \( \text{span} \geq 1 \)
- **halflife**: float, optional

Specify decay in terms of half-life, $\alpha = 1 - \exp(\log(0.5)/\text{half life})$, for $\text{half life} > 0$

**alpha** : float, optional

Specify smoothing factor $\alpha$ directly, $0 < \alpha \leq 1$

New in version 0.18.0.

**min_periods** : int, default 0

Minimum number of observations in window required to have a value (otherwise result is NA).

**adjust** : boolean, default True

Divide by decaying adjustment factor in beginning periods to account for imbalance in relative weightings (viewing EWMA as a moving average)

**ignore_na** : boolean, default False

Ignore missing values when calculating weights; specify True to reproduce pre-0.15.0 behavior

**Returns**

- a Window sub-classed for the particular operation

**See also:**

- **rolling** Provides rolling window calculations
- **expanding** Provides expanding transformations.

**Notes**

Exactly one of center of mass, span, half-life, and alpha must be provided. Allowed values and relationship between the parameters are specified in the parameter descriptions above; see the link at the end of this section for a detailed explanation.

When adjust is True (default), weighted averages are calculated using weights $(1-\alpha)^{(n-1)}$, $(1-\alpha)^{(n-2)}$, $\ldots$, $1-\alpha$, 1.

**When adjust is False, weighted averages are calculated recursively as:** weighted_average[0] = arg[0];

weighted_average[i] = (1-\alpha)*weighted_average[i-1] + \alpha*arg[i].

When ignore_na is False (default), weights are based on absolute positions. For example, the weights of $x$ and $y$ used in calculating the final weighted average of $[x, \text{None}, y]$ are $(1-\alpha)^{**2}$ and 1 (if adjust is True), and $(1-\alpha)^{**2}$ and $\alpha$ (if adjust is False).

When ignore_na is True (reproducing pre-0.15.0 behavior), weights are based on relative positions. For example, the weights of $x$ and $y$ used in calculating the final weighted average of $[x, \text{None}, y]$ are $1-\alpha$ and 1 (if adjust is True), and 1-\alpha and $\alpha$ (if adjust is False).

More details can be found at http://pandas.pydata.org/pandas-docs/stable/computation.html#exponentially-weighted-windows

**Examples**
pandas.Series.expanding

Series.expanding(min_periods=1, center=False, axis=0)
Provides expanding transformations.

New in version 0.18.0.

Parameters

- **min_periods**: int, default 1
  Minimum number of observations in window required to have a value (otherwise result is NA).

- **center**: boolean, default False
  Set the labels at the center of the window.

- **axis** [int or string, default 0]

Returns

a Window sub-classed for the particular operation

See also:

rolling Provides rolling window calculations

ewm Provides exponential weighted functions

Notes

By default, the result is set to the right edge of the window. This can be changed to the center of the window by setting center=True.

Examples
```python
>>> df = DataFrame({'B': [0, 1, 2, np.nan, 4]})
B
0 0.0
1 1.0
2 2.0
3 NaN
4 4.0
```

```python
>>> df.expanding(2).sum()
B
0 NaN
1 1.0
2 3.0
3 3.0
4 7.0
```

**pandas.Series.factorize**

`Series.factorize(sort=False, na_sentinel=-1)`

Encode the object as an enumerated type or categorical variable.

This method is useful for obtaining a numeric representation of an array when all that matters is identifying distinct values. `factorize` is available as both a top-level function `pandas.factorize()`, and as a method `Series.factorize()` and `Index.factorize()`.

**Parameters**

- **sort**: boolean, default False

  Sort `uniques` and shuffle `labels` to maintain the relationship.

- **na_sentinel**: int, default -1

  Value to mark “not found”.

**Returns**

- **labels**: ndarray

  An integer ndarray that’s an indexer into `uniques`. `uniques.take(labels)` will have the same values as `values`.

- **uniques**: ndarray, Index, or Categorical

  The unique valid values. When `values` is Categorical, `uniques` is a Categorical. When `values` is some other pandas object, an `Index` is returned. Otherwise, a 1-D ndarray is returned.

**Note**: Even if there’s a missing value in `values`, `uniques` will not contain an entry for it.

**See also:**

- **pandas.cut** Discretize continuous-valued array.
- **pandas.unique** Find the unique value in an array.

**Examples**

These examples all show factorize as a top-level method like `pd.factorize(values)`. The results are identical for methods like `Series.factorize()`.
>>> labels, uniques = pd.factorize(['b', 'b', 'a', 'c', 'b'])
>>> print(labels)
array([0, 0, 1, 2, 0])
>>> print(uniques)
array(['b', 'a', 'c'], dtype=object)

With `sort=True`, the `uniques` will be sorted, and `labels` will be shuffled so that the relationship is maintained.

```python
>>> labels, uniques = pd.factorize(['b', 'b', 'a', 'c', 'b'], sort=True)
>>> print(labels)
array([1, 1, 0, 2, 1])
>>> print(uniques)
array(['a', 'b', 'c'], dtype=object)
```

Missing values are indicated in `labels` with `na_sentinel` (-1 by default). Note that missing values are never included in `uniques`.

```python
>>> labels, uniques = pd.factorize(['b', None, 'a', 'c', 'b'])
>>> print(labels)
array([ 0, -1, 1, 2, 0])
>>> print(uniques)
array(['b', 'a', 'c'], dtype=object)
```

Thus far, we've only factorized lists (which are internally coerced to NumPy arrays). When factorizing pandas objects, the type of `uniques` will differ. For Categoricals, a `Categorical` is returned.

```python
>>> cat = pd.Categorical(['a', 'a', 'c'], categories=['a', 'b', 'c'])
>>> print(labels, uniques)
(array([0, 0, 1]), Index(['a', 'c'], dtype='object'))
```

Notice that 'b' is in `uniques.categories`, despite not being present in `cat.values`.

For all other pandas objects, an Index of the appropriate type is returned.

```python
>>> cat = pd.Series(['a', 'a', 'c'])
>>> print(labels, uniques)
(array([0, 0, 1]), Index(['a', 'c'], dtype='object'))
```

### pandas.Series.ffill

`Series.ffill`(`axis=None, inplace=False, limit=None, downcast=None`)  
**Synonym for** `DataFrame.fillna(method='ffill')`
**pandas.Series.fillna**

`pandas.Series.fillna(value=None, method=None, axis=None, inplace=False, limit=None, downcast=None, **kwargs)`

Fill NA/NaN values using the specified method

**Parameters**

- **value**: scalar, dict, Series, or DataFrame

  Value to use to fill holes (e.g. 0), alternately a dict/Series/DataFrame of values specifying which value to use for each index (for a Series) or column (for a DataFrame). (values not in the dict/Series/DataFrame will not be filled). This value cannot be a list.

- **method**: {'backfill', 'bfill', 'pad', 'ffill', None}, default None

  Method to use for filling holes in reindexed Series: pad/ffill: propagate last valid observation forward to next valid backfill/bfill: use NEXT valid observation to fill gap

- **axis**: [0 or 'index']

- **inplace**: boolean, default False

  If True, fill in place. Note: this will modify any other views on this object, (e.g. a no-copy slice for a column in a DataFrame).

- **limit**: int, default None

  If method is specified, this is the maximum number of consecutive NaN values to forward/backward fill. In other words, if there is a gap with more than this number of consecutive NaNs, it will only be partially filled. If method is not specified, this is the maximum number of entries along the entire axis where NaNs will be filled. Must be greater than 0 if not None.

- **downcast**: dict, default is None

  a dict of item->dtype of what to downcast if possible, or the string ‘infer’ which will try to downcast to an appropriate equal type (e.g. float64 to int64 if possible)

**Returns**

- **filled**: [Series]

**See also:**

- **interpolate**: Fill NaN values using interpolation.

- **reindex, asfreq**

**Examples**

```python
>>> df = pd.DataFrame([[np.nan, 2, np.nan, 0],
... [3, 4, np.nan, 1],
... [np.nan, np.nan, np.nan, 5],
... [np.nan, 3, np.nan, 4]],
... columns=list('ABCD'))
>>> df
   A   B   C   D
0  NaN  2.0  NaN  0.0
1  3.0  4.0  NaN  1.0
```
Replace all NaN elements with 0s.

```python
>>> df.fillna(0)
   A   B   C   D
0  0.0  2.0  0.0  0.0
1  3.0  4.0  0.0  1.0
2  0.0  0.0  0.0  5.0
3  0.0  3.0  0.0  4.0
```

We can also propagate non-null values forward or backward.

```python
>>> df.fillna(method='ffill')
   A   B   C   D
0  NaN  2.0  NaN  0.0
1  3.0  4.0  NaN  1.0
2  3.0  4.0  NaN  5.0
3  3.0  3.0  NaN  4.0
```

Replace all NaN elements in column ‘A’, ‘B’, ‘C’, and ‘D’, with 0, 1, 2, and 3 respectively.

```python
>>> values = {'A': 0, 'B': 1, 'C': 2, 'D': 3}
>>> df.fillna(value=values)
   A   B   C   D
0  0.0  2.0  2.0  0.0
1  3.0  4.0  2.0  1.0
2  0.0  1.0  2.0  5.0
3  0.0  3.0  2.0  4.0
```

Only replace the first NaN element.

```python
>>> df.fillna(value=values, limit=1)
   A   B   C   D
0  0.0  2.0  2.0  0.0
1  3.0  4.0  NaN  1.0
2  NaN  1.0  NaN  5.0
3  NaN  3.0  NaN  4.0
```

**pandas.Series.filter**

Series.filter(items=None, like=None, regex=None, axis=None)

Subset rows or columns of dataframe according to labels in the specified index. Note that this routine does not filter a dataframe on its contents. The filter is applied to the labels of the index.

**Parameters**

- **items**: list-like
  List of info axis to restrict to (must not all be present)
- **like**: string
  Keep info axis where “arg in col == True”
- **regex**: string (regular expression)
Keep info axis with re.search(regex, col) == True

axis : int or string axis name

The axis to filter on. By default this is the info axis, ‘index’ for Series, ‘columns’ for DataFrame

Returns

same type as input object

See also:
pandas.DataFrame.loc

Notes

The items, like, and regex parameters are enforced to be mutually exclusive.

axis defaults to the info axis that is used when indexing with [].

Examples

```python
>>> df
  one  two  three
mouse  1   2   3
rabbit 4   5   6

>>> # select columns by name
>>> df.filter(items=['one', 'three'])
  one  three
  mouse 1  3
  rabbit 4  6

>>> # select columns by regular expression
>>> df.filter(regex='e$', axis=1)
  one  three
  mouse 1  3
  rabbit 4  6

>>> # select rows containing 'bbi'
>>> df.filter(like='bbi', axis=0)
  one  two  three
  rabbit 4  5  6
```

pandas.Series.first

Series.first(offset)

Convenience method for subsetting initial periods of time series data based on a date offset.

Parameters

offset [string, DateOffset, dateutil.relativedelta]

Returns
subset [type of caller]

Raises TypeError

If the index is not a DatetimeIndex

See also:

last  Select final periods of time series based on a date offset
at_time  Select values at a particular time of the day
between_time  Select values between particular times of the day

Examples

```python
>>> i = pd.date_range('2018-04-09', periods=4, freq='2D')
>>> ts = pd.DataFrame({'A': [1,2,3,4]}, index=i)
>>> ts
   A
2018-04-09  1
2018-04-11  2
2018-04-13  3
2018-04-15  4

Get the rows for the first 3 days:

```python
>>> ts.first('3D')
   A
2018-04-09  1
2018-04-11  2
```

Notice the data for 3 first calender days were returned, not the first 3 days observed in the dataset, and therefore data for 2018-04-13 was not returned.

pandas.Series.first_valid_index

Series.first_valid_index()

Return index for first non-NA/null value.

Returns

scalar  [type of index]

Notes

If all elements are non-NA/null, returns None. Also returns None for empty NDFrame.

pandas.Series.floordiv

Series.floordiv(other, level=None, fill_value=None, axis=0)

Integer division of series and other, element-wise (binary operator floordiv).

Equivalent to series // other, but with support to substitute a fill_value for missing data in one of the inputs.
Parameters

other [Series or scalar value]

fill_value : None or float value, default None (NaN)

Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns

result [Series]

See also:

Series.rfloordiv

Examples

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a 1.0
b 1.0
c 1.0
d NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a 1.0
b NaN
d 1.0
e NaN
dtype: float64
>>> a.add(b, fill_value=0)
   a  b  c  d
--- --- --- ---
 a  2.0 1.0 1.0 NaN
dtype: float64
```

pandas.Series.from_array

classmethod Series.from_array(arr, index=None, name=None, dtype=None, copy=False, fastpath=False)

Construct Series from array.

Deprecated since version 0.23.0: Use pd.Series(.) constructor instead.
**pandas.Series.from_csv**

**classmethod** `Series.from_csv(path, sep=',', parse_dates=True, header=None, index_col=0, encoding=None, infer_datetime_format=False)`

Read CSV file.

Deprecated since version 0.21.0: Use `pandas.read_csv()` instead.

It is preferable to use the more powerful `pandas.read_csv()` for most general purposes, but `from_csv` makes for an easy roundtrip to and from a file (the exact counterpart of `to_csv`), especially with a time Series.

This method only differs from `pandas.read_csv()` in some defaults:

- `index_col` is `0` instead of `None` (take first column as index by default)
- `header` is `None` instead of `0` (the first row is not used as the column names)
- `parse_dates` is `True` instead of `False` (try parsing the index as datetime by default)

With `pandas.read_csv()`, the option `squeeze=True` can be used to return a Series like `from_csv`.

**Parameters**

- `path` [string file path or file handle / StringIO]
- `sep` : string, default `','`
  
  Field delimiter
- `parse_dates` : boolean, default `True`
  
  Parse dates. Different default from `read_table`
- `header` : int, default `None`
  
  Row to use as header (skip prior rows)
- `index_col` : int or sequence, default `0`
  
  Column to use for index. If a sequence is given, a MultiIndex is used. Different default from `read_table`
- `encoding` : string, optional
  
  a string representing the encoding to use if the contents are non-ascii, for python versions prior to 3
- `infer_datetime_format` : boolean, default `False`
  
  If True and `parse_dates` is True for a column, try to infer the datetime format based on the first datetime string. If the format can be inferred, there often will be a large parsing speed-up.

**Returns**

- `y` [Series]

See also:

`pandas.read_csv`
pandas.Series.ge

Series.ge(other, level=None, fill_value=None, axis=0)
Greater than or equal to of series and other, element-wise (binary operator ge).
Equivalent to series >= other, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters

other [Series or scalar value]
fill_value : None or float value, default None (NaN)
    Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing
level : int or name
    Broadcast across a level, matching Index values on the passed MultiIndex level

Returns

result [Series]

See also:
Series.None

Examples

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a   1.0
b   1.0
c   1.0
d   NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a   1.0
b   NaN
d   1.0
e   NaN
dtype: float64
>>> a.add(b, fill_value=0)
a   2.0
b   1.0
c   1.0
d   1.0
e   NaN
dtype: float64
```

pandas.Series.get

Series.get(key, default=None)
Get item from object for given key (DataFrame column, Panel slice, etc.). Returns default value if not
found.

Parameters

key [object]

Returns

type [type of items contained in object]

pandas.Series.get_dtype_counts

Series.get_dtype_counts()

Return counts of unique dtypes in this object.

Returns dtype : Series

Series with the count of columns with each dtype.

See also:

dtypes Return the dtypes in this object.

Examples

```python
>>> a = [['a', 1, 1.0], ['b', 2, 2.0], ['c', 3, 3.0]]
>>> df = pd.DataFrame(a, columns=['str', 'int', 'float'])
>>> df
      str  int  float
0     a   1   1.0
1     b   2   2.0
2     c   3   3.0
```

```python
>>> df.get_dtype_counts()
float64    1
int64      1
object     1
dtype: int64
```

pandas.Series.get_ftype_counts

Series.get_ftype_counts()

Return counts of unique ftypes in this object.

Deprecated since version 0.23.0.

This is useful for SparseDataFrame or for DataFrames containing sparse arrays.

Returns(dtype : Series

Series with the count of columns with each type and sparsity (dense/sparse)

See also:

ftypes Return ftypes (indication of sparse/dense and dtype) in this object.
Examples

```python
>>> a = [['a', 1, 1.0], ['b', 2, 2.0], ['c', 3, 3.0]]
>>> df = pd.DataFrame(a, columns=['str', 'int', 'float'])
>>> df
    str int  float
0    a  1  1.0
1    b  2  2.0
2    c  3  3.0

>>> df.get_ftype_counts()
float64:dense 1
int64:dense 1
object:dense 1
dtype: int64
```

**pandas.Series.get_value**

`Series.get_value(label, takeable=False)`

Quickly retrieve single value at passed index label

Deprecated since version 0.21.0: Please use .at[] or .iat[] accessors.

**Parameters**

- **label** [object]
- **takeable** [interpret the index as indexers, default False]

**Returns**

- **value** [scalar value]

**pandas.Series.get_values**

`Series.get_values()`

same as values (but handles sparseness conversions); is a view

**pandas.Series.groupby**

`Series.groupby(by=None, axis=0, level=None, as_index=True, sort=True, group_keys=True, squeeze=False, observed=False, **kwargs)`

Group series using mapper (dict or key function, apply given function to group, return result as series) or by a series of columns.

**Parameters**

- **by** : mapping, function, label, or list of labels

  Used to determine the groups for the groupby. If by is a function, it’s called on each value of the object’s index. If a dict or Series is passed, the Series or dict VALUES will be used to determine the groups (the Series’ values are first aligned; see .align() method). If an ndarray is passed, the values are used as-is determine the groups. A label or list of labels may be passed to group by the columns in self. Notice that a tuple is interpreted a (single) key.

- **axis** [int, default 0]
**level**: int, level name, or sequence of such, default None

If the axis is a MultiIndex (hierarchical), group by a particular level or levels

**as_index**: boolean, default True

For aggregated output, return object with group labels as the index. Only relevant for DataFrame input. as_index=False is effectively “SQL-style” grouped output.

**sort**: boolean, default True

Sort group keys. Get better performance by turning this off. Note this does not influence the order of observations within each group. groupby preserves the order of rows within each group.

**group_keys**: boolean, default True

When calling apply, add group keys to index to identify pieces

**squeeze**: boolean, default False

Reduce the dimensionality of the return type if possible, otherwise return a consistent type

**observed**: boolean, default False

This only applies if any of the groupers are Categoricals If True: only show observed values for categorical groupers. If False: show all values for categorical groupers.

New in version 0.23.0.

**Returns**

GroupBy object

**See also**:

resample  Convenience method for frequency conversion and resampling of time series.

**Notes**

See the user guide for more.

**Examples**

DataFrame results

```python
>>> data.groupby(func, axis=0).mean()
```

```python
>>> data.groupby(['col1', 'col2'])['col3'].mean()
```

DataFrame with hierarchical index

```python
>>> data.groupby(['col1', 'col2']).mean()
```

**pandas.Series.gt**

Series.gt (other, level=None, fill_value=None, axis=0)

Greater than of series and other, element-wise (binary operator gt).
Equivalent to `series > other`, but with support to substitute a `fill_value` for missing data in one of the inputs.

**Parameters**

- `other` [Series or scalar value]
- `fill_value` : None or float value, default None (NaN)

  Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing

- `level` : int or name

  Broadcast across a level, matching Index values on the passed MultiIndex level

**Returns**

- `result` [Series]

**See also:**

Series.None

**Examples**

```python
g = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
g
a 1.0
b 1.0
c 1.0
d NaN

dtype: float64
```

```python
b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
b
a 1.0
b NaN
d 1.0
e NaN

dtype: float64
```

```python
ga.add(b, fill_value=0)
ga
a 2.0
b 1.0
c 1.0
d 1.0
e NaN

dtype: float64
```

**Series.head**

`Series.head(n=5)`

Return the first `n` rows.

This function returns the first `n` rows for the object based on position. It is useful for quickly testing if your object has the right type of data in it.

**Parameters**

- `n` : int, default 5
Number of rows to select.

Returns `obj_head` : type of caller

The first $n$ rows of the caller object.

See also:

-pandas.DataFrame.tail- Returns the last $n$ rows.

Examples

```python
>>> df = pd.DataFrame({'animal':['alligator', 'bee', 'falcon', 'lion',
...                         'monkey', 'parrot', 'shark', 'whale', 'zebra']})
>>> df
animal
0 alligator
1 bee
2 falcon
3 lion
4 monkey
5 parrot
6 shark
7 whale
8 zebra
```

Viewing the first 5 lines

```python
>>> df.head()
animal
0 alligator
1 bee
2 falcon
3 lion
4 monkey
```

Viewing the first $n$ lines (three in this case)

```python
>>> df.head(3)
animal
0 alligator
1 bee
2 falcon
```

`pandas.Series.hist`

`Series.hist(by=None, ax=None, grid=True, xlabelsize=None, xrot=None, ylabelsize=None, yrot=None, figsize=None, bins=10, **kwds)`

Draw histogram of the input series using matplotlib

Parameters `by` : object, optional

If passed, then used to form histograms for separate groups

`ax` : matplotlib axis object

If not passed, uses gca()
grid : boolean, default True
    Whether to show axis grid lines
xlabelsize : int, default None
    If specified changes the x-axis label size
xrot : float, default None
    rotation of x axis labels
ylabelsize : int, default None
    If specified changes the y-axis label size
yrot : float, default None
    rotation of y axis labels
figsize : tuple, default None
    figure size in inches by default
bins : integer or sequence, default 10
    Number of histogram bins to be used. If an integer is given, bins + 1 bin edges are calculated and returned. If bins is a sequence, gives bin edges, including left edge of first bin and right edge of last bin. In this case, bins is returned unmodified.

**kwds**: keywords
    To be passed to the actual plotting function

See also:

matplotlib.axes.Axes.hist  Plot a histogram using matplotlib.

pandas.Series.idxmax

Series.idxmax (axis=0, skipna=True, *args, **kwargs)
    Return the row label of the maximum value.

    If multiple values equal the maximum, the first row label with that value is returned.

    Parameters  skipna : boolean, default True
        Exclude NA/null values. If the entire Series is NA, the result will be NA.

    axis : int, default 0
        For compatibility with DataFrame.idxmax. Redundant for application on Series.

    *args, **kwargs
        Additional keyword have no effect but might be accepted for compatibility with NumPy.

Returns

idxmax  [Index of maximum of values.]

Raises ValueError
If the Series is empty.

See also:

- `numpy.argmax` Return indices of the maximum values along the given axis.
- `DataFrame.idxmax` Return index of first occurrence of maximum over requested axis.
- `Series.idxmin` Return index label of the first occurrence of minimum of values.

Notes

This method is the Series version of `ndarray.argmax`. This method returns the label of the maximum, while `ndarray.argmax` returns the position. To get the position, use `series.values.argmax()`.

Examples

```python
code_snippet
>>> s = pd.Series(data=[1, None, 4, 3, 4],
                 index=['A', 'B', 'C', 'D', 'E'])
>>> s
A    1.0
B    NaN
C    4.0
D    3.0
E    4.0
dtype: float64

>>> s.idxmax()
'C'

If `skipna` is False and there is an NA value in the data, the function returns `nan`.
```
```python
code_snippet
>>> s.idxmax(skipna=False)
nan
```
Raises ValueError

If the Series is empty.

See also:

numpy.argmin Return indices of the minimum values along the given axis.

DataFrame.idxmin Return index of first occurrence of minimum over requested axis.

Series.idxmax Return index label of the first occurrence of maximum of values.

Notes

This method is the Series version of ndarray.argmin. This method returns the label of the minimum, while ndarray.argmin returns the position. To get the position, use series.values.argmin().

Examples

```python
>>> s = pd.Series(data=[1, None, 4, 1],
...                index=['A', 'B', 'C', 'D'])
>>> s
A    1.0
B    NaN
C    4.0
D    1.0
dtype: float64

>>> s.idxmin()
'A'
```

If skipna is False and there is an NA value in the data, the function returns nan.

```python
>>> s.idxmin(skipna=False)
nan
```

pandas.Series.infer_objects

Series.infer_objects()

Attempt to infer better dtypes for object columns.

Attempts soft conversion of object-dtyped columns, leaving non-object and unconvertible columns unchanged. The inference rules are the same as during normal Series/DataFrame construction.

New in version 0.21.0.

Returns

converted [same type as input object]

See also:

pandas.to_datetime Convert argument to datetime.

pandas.to_timedelta Convert argument to timedelta.

pandas.to_numeric Convert argument to numeric type
pandas: powerful Python data analysis toolkit, Release 0.23.2

Examples
>>> df = pd.DataFrame({"A": ["a", 1, 2, 3]})
>>> df = df.iloc[1:]
>>> df
A
1 1
2 2
3 3
>>> df.dtypes
A
object
dtype: object
>>> df.infer_objects().dtypes
A
int64
dtype: object

pandas.Series.interpolate
Series.interpolate(method=’linear’,
axis=0,
limit=None,
inplace=False,
limit_direction=’forward’, limit_area=None, downcast=None, **kwargs)
Interpolate values according to different methods.
Please note that only method='linear' is supported for DataFrames/Series with a MultiIndex.
• ‘linear’: ignore the index and treat the values as equally spaced. This is the only
method supported on MultiIndexes. default
• ‘time’: interpolation works on daily and higher resolution data to interpolate given
length of interval
• ‘index’, ‘values’: use the actual numerical values of the index
to scipy.interpolate.interp1d. Both ‘polynomial’ and ‘spline’ require
that you also specify an order (int), e.g. df.interpolate(method=’polynomial’, order=4). These use the actual numerical values of the index.
• ‘krogh’, ‘piecewise_polynomial’, ‘spline’, ‘pchip’ and ‘akima’ are all wrappers
around the scipy interpolation methods of similar names. These use the actual numerical values of the index. For more information on their behavior, see the scipy
documentation and tutorial documentation
• ‘from_derivatives’ refers to BPoly.from_derivatives which replaces ‘piecewise_polynomial’ interpolation method in scipy 0.18
New in version 0.18.1: Added support for the ‘akima’ method Added interpolate method
‘from_derivatives’ which replaces ‘piecewise_polynomial’ in scipy 0.18; backwardscompatible with scipy < 0.18
axis : {0, 1}, default 0
1520

Chapter 34. API Reference


• 0: fill column-by-column
• 1: fill row-by-row

**limit**: int, default None.

Maximum number of consecutive NaNs to fill. Must be greater than 0.

**limit_direction**: [‘forward’, ‘backward’, ‘both’], default ‘forward’

**limit_area**: {‘inside’, ‘outside’}, default None

- None: (default) no fill restriction
- ‘inside’ Only fill NaNs surrounded by valid values (interpolate).
- ‘outside’ Only fill NaNs outside valid values (extrapolate).

If limit is specified, consecutive NaNs will be filled in this direction.

New in version 0.21.0.

**inplace**: bool, default False

Update the NDFrame in place if possible.

**downcast**: optional, ‘infer’ or None, defaults to None

Downcast dtypes if possible.

**kwargs**: [keyword arguments to pass on to the interpolating function.]

**Returns**

Series or DataFrame of same shape interpolated at the NaNs

**See also:**

reindex, replace, fillna

**Examples**

Filling in NaNs

```python
>>> s = pd.Series([0, 1, np.nan, 3])
>>> s.interpolate()
0    0
1    1
2    2
3    3
dtype: float64
```

**pandas.Series.isin**

Series.isin(values)

Check whether values are contained in Series.

Return a boolean Series showing whether each element in the Series matches an element in the passed sequence of values exactly.

**Parameters** values : set or list-like
The sequence of values to test. Passing in a single string will raise a `TypeError`. Instead, turn a single string into a list of one element.

New in version 0.18.1: Support for values as a set.

**Returns**

- `isin` [Series (bool dtype)]

**Raises** `TypeError`

- If `values` is a string

**See also:**

`pandas.DataFrame.isin` equivalent method on DataFrame

**Examples**

```python
>>> s = pd.Series(['lama', 'cow', 'lama', 'beetle', 'lama', ...
                          'hippo'], name='animal')
>>> s.isin(['cow', 'lama'])
0   True
1   True
2   True
3  False
4   True
5  False
Name: animal, dtype: bool
```

Passing a single string as `s.isin('lama')` will raise an error. Use a list of one element instead:

```python
>>> s.isin(['lama'])
0   True
1  False
2   True
3  False
4   True
5  False
Name: animal, dtype: bool
```

**pandas.Series.isna**

Series.isna()  
Detect missing values.

Return a boolean same-sized object indicating if the values are NA. NA values, such as `None` or `numpy.Nan`, gets mapped to `True` values. Everything else gets mapped to `False` values. Characters such as empty strings `' '` or `numpy.inf` are not considered NA values (unless you set `pandas.options.mode.use_inf_as_na = True`).

**Returns** Series

Mask of bool values for each element in Series that indicates whether an element is not an NA value.

**See also:**
Series.isnull alias of isna

Series.notna boolean inverse of isna

Series.dropna omit axes labels with missing values

isna top-level isna

Examples

Show which entries in a DataFrame are NA.

```python
>>> df = pd.DataFrame({'age': [5, 6, np.NaN],
...                    'born': [pd.NaT, pd.Timestamp('1939-05-27'),
...                             pd.Timestamp('1940-04-25')],
...                    'name': ['Alfred', 'Batman', ''],
...                    'toy': [None, 'Batmobile', 'Joker']})

>>> df
   age   born       name   toy
0  5.0  NaT    Alfred   None
1  6.0 1939-05-27  Batman  Batmobile
2  NaN 1940-04-25   Joker    NaN

>>> df.isna()
   age  born  name  toy
0  False  True  False  True
1  False  False  False  False
2   True  False  False  False
```

Show which entries in a Series are NA.

```python
>>> ser = pd.Series([5, 6, np.NaN])

>>> ser
0    5.0
1    6.0
2    NaN
dtype: float64

>>> ser.isna()
0  False
1  False
2   True
dtype: bool
```

pandas.Series.isnull

Series.isnull() Detect missing values.

Return a boolean same-sized object indicating if the values are NA. NA values, such as None or numpy.NaN, gets mapped to True values. Everything else gets mapped to False values. Characters such as empty strings '' or numpy.inf are not considered NA values (unless you set pandas.options.mode.use_inf_as_na = True).

Returns Series
Mask of bool values for each element in Series that indicates whether an element is not an NA value.

See also:

- **Series.isnull** alias of isna
- **Series.notna** boolean inverse of isna
- **Series.dropna** omit axes labels with missing values
- **isna** top-level isna

Examples

Show which entries in a DataFrame are NA.

```python

>>> df
     age  born            name  toy
0     5.0  NaT    Alfred    None
1     6.0 1939-05-27  Batman  Batmobile
2    NaN 1940-04-25  Joker

>>> df.isna()
     age  born            name  toy
0   False  True         False  True
1   False  False        False  False
2    True  False        False  False

Show which entries in a Series are NA.

```python
>>> ser = pd.Series([5, 6, np.NaN])

>>> ser
0   5.0
1   6.0
2  NaN
dtype: float64

>>> ser.isna()
0   False
1   False
2    True
dtype: bool
```

*pandas.Series.item*

Series.item() return the first element of the underlying data as a python scalar
**pandas.Series.items**

`Series.items()`  
Lazily iterate over (index, value) tuples

**pandas.Series.iteritems**

`Series.iteritems()`  
Lazily iterate over (index, value) tuples

**pandas.Series.keys**

`Series.keys()`  
Alias for index

**pandas.Series.kurt**

`Series.kurt(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)`  
Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0). Normalized by N-1

**Parameters**

- `axis` ([index (0)])
- `skipna` : boolean, default True  
  Exclude NA/null values when computing the result.
- `level` : int or level name, default None  
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar
- `numeric_only` : boolean, default None  
  Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

- `kurt` [scalar or Series (if level specified)]

**pandas.Series.kurtosis**

`Series.kurtosis(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)`  
Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0). Normalized by N-1

**Parameters**

- `axis` ([index (0)])
- `skipna` : boolean, default True  
  Exclude NA/null values when computing the result.
level : int or level name, default None
If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None
Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns
kurt [scalar or Series (if level specified)]

pandas.Series.last

Series.last(offset)
Convenience method for subsetting final periods of time series data based on a date offset.

Parameters
offset [string, DateOffset, dateutil.relativedelta]

Returns
subset [type of caller]

Raises TypeError
If the index is not a DatetimeIndex

See also:
first Select initial periods of time series based on a date offset
at_time Select values at a particular time of the day
between_time Select values between particular times of the day

Examples

```python
>>> i = pd.date_range('2018-04-09', periods=4, freq='2D')
>>> ts = pd.DataFrame({'A': [1,2,3,4]}, index=i)
>>> ts
   A
2018-04-09  1
2018-04-11  2
2018-04-13  3
2018-04-15  4

Get the rows for the last 3 days:

```python
>>> ts.last('3D')
   A
2018-04-13  3
2018-04-15  4
```

Notice the data for 3 last calendar days were returned, not the last 3 observed days in the dataset, and therefore data for 2018-04-11 was not returned.
pandas.Series.last_valid_index

Series.last_valid_index()
Return index for last non-NA/null value.

Returns
scalar [type of index]

Notes
If all elements are non-NA/null, returns None. Also returns None for empty NDFrame.

pandas.Series.le

Series.le(other, level=None, fill_value=None, axis=0)
Less than or equal to of series and other, element-wise (binary operator le).

Equivalent to series <= other, but with support to substitute a fill_value for missing data in one of
the inputs.

Parameters
other [Series or scalar value]
fill_value: None or float value, default None (NaN)
Fill existing missing (NaN) values, and any new element needed for successful Series
alignment, with this value before computation. If data in both corresponding Series
locations is missing the result will be missing
level : int or name
Broadcast across a level, matching Index values on the passed MultiIndex level

Returns
result [Series]

See also:
Series.None

Examples

>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a 1.0
b 1.0
c 1.0
d NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a 1.0
b NaN
d 1.0
(continues on next page)
pandas: powerful Python data analysis toolkit, Release 0.23.2

(continued from previous page)

```python
e NaN
dtype: float64
>>> a.add(b, fill_value=0)
a  2.0
b  1.0
c  1.0
d  1.0
e  NaN
dtype: float64
```

**pandas.Series.lt**

`Series.lt(other, level=None, fill_value=None, axis=0)`

Less than of series and other, element-wise (binary operator `lt`).

Equivalent to `series < other`, but with support to substitute a `fill_value` for missing data in one of the inputs.

**Parameters**

- `other` [Series or scalar value]
- `fill_value`: None or float value, default None (NaN)
  Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing
- `level`: int or name
  Broadcast across a level, matching Index values on the passed MultiIndex level

**Returns**

- `result` [Series]

**See also:**

`Series.None`

**Examples**

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a   1.0
b   1.0
c   1.0
d  NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a   1.0
b  NaN
c   1.0
d  NaN
dtype: float64
>>> a.add(b, fill_value=0)
```

(continues on next page)
pandas.Series.mad

Series.mad (axis=None, skipna=None, level=None)

Return the mean absolute deviation of the values for the requested axis

Parameters

axis [{index (0)}]

skipna : boolean, default True

Exclude NA/null values when computing the result.

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns

mad [scalar or Series (if level specified)]

pandas.Series.map

Series.map (arg, na_action=None)

Map values of Series using input correspondence (a dict, Series, or function).

Parameters arg : function, dict, or Series

Mapping correspondence.

na_action : {None, ‘ignore’}

If ‘ignore’, propagate NA values, without passing them to the mapping correspondence.

Returns y : Series

Same index as caller.

See also:

Series.apply For applying more complex functions on a Series.

Dataframe.apply Apply a function row-/column-wise.

Dataframe.applymap Apply a function elementwise on a whole DataFrame.
Notes

When `arg` is a dictionary, values in Series that are not in the dictionary (as keys) are converted to NaN. However, if the dictionary is a dict subclass that defines `__missing__` (i.e. provides a method for default values), then this default is used rather than NaN:

```python
>>> from collections import Counter
>>> counter = Counter()
>>> counter['bar'] += 1
>>> y.map(counter)
1    0
2    1
3    0
dtype: int64
```

Examples

Map inputs to outputs (both of type `Series`):

```python
>>> x = pd.Series([1, 2, 3], index=['one', 'two', 'three'])
>>> x
one    1
two    2
three  3
dtype: int64

>>> y = pd.Series(['foo', 'bar', 'baz'], index=[1, 2, 3])
>>> y
1    foo
2    bar
3    baz

>>> x.map(y)
one    foo
two    bar
three  baz
dtype: object

If `arg` is a dictionary, return a new Series with values converted according to the dictionary’s mapping:

```python
>>> z = {1: 'A', 2: 'B', 3: 'C'}

>>> x.map(z)
one    A
two    B	hree  C
dtype: object
```

Use `na_action` to control whether NA values are affected by the mapping function.

```python
>>> s = pd.Series([1, 2, 3, np.nan])

>>> s2 = s.map('this is a string {}'.format, na_action='drop')
      0  1  2
0  this is a string 1.0
1  this is a string 2.0
2  this is a string 3.0
```

(continues on next page)
pandas: powerful Python data analysis toolkit, Release 0.23.2

3 this is a string nan
dtype: object

>>> s3 = s.map('this is a string {}'.format, na_action='ignore')
0 this is a string 1.0
1 this is a string 2.0
2 this is a string 3.0
3 NaN
dtype: object

**pandas.Series.mask**

Series.mask (cond, other=nan, inplace=False, axis=None, level=None, errors='raise',
try_cast=False, raise_on_error=None)

Return an object of same shape as self and whose corresponding entries are from self where cond is False and otherwise are from other.

**Parameters**

- **cond** : boolean NDFrame, array-like, or callable
  Where cond is False, keep the original value. Where True, replace with corresponding value from other. If cond is callable, it is computed on the NDFrame and should return boolean NDFrame or array. The callable must not change input NDFrame (though pandas doesn’t check it).

New in version 0.18.1: A callable can be used as cond.

- **other** : scalar, NDFrame, or callable
  Entries where cond is True are replaced with corresponding value from other. If other is callable, it is computed on the NDFrame and should return scalar or NDFrame. The callable must not change input NDFrame (though pandas doesn’t check it).

New in version 0.18.1: A callable can be used as other.

- **inplace** : boolean, default False
  Whether to perform the operation in place on the data

- **axis** [alignment axis if needed, default None]

- **level** [alignment level if needed, default None]

- **errors** : str, {'raise', 'ignore'}, default 'raise'
  - raise: allow exceptions to be raised
  - ignore: suppress exceptions. On error return original object
  Note that currently this parameter won’t affect the results and will always coerce to a suitable dtype.

- **try_cast** : boolean, default False
  try to cast the result back to the input type (if possible),

- **raise_on_error** : boolean, default True
  Whether to raise on invalid data types (e.g. trying to where on strings)
  Deprecated since version 0.21.0.
Returns

wh [same type as caller]

See also:

DataFrame.where()

Notes

The mask method is an application of the if-then idiom. For each element in the calling DataFrame, if cond is False the element is used; otherwise the corresponding element from the DataFrame other is used.

The signature for DataFrame.where() differs from numpy.where(). Roughly df1.where(m, df2) is equivalent to np.where(m, df1, df2).

For further details and examples see the mask documentation in indexing.

Examples

```python
>>> s = pd.Series(range(5))
>>> s.where(s > 0)
0    NaN
1    1.0
2    2.0
3    3.0
4    4.0
>>> s.mask(s > 0)
0    0.0
1    NaN
2    NaN
3    NaN
4    NaN
>>> s.where(s > 1, 10)
0   10.0
1   10.0
2    2.0
3    3.0
4    4.0
```

```python
>>> df = pd.DataFrame(np.arange(10).reshape(-1, 2), columns=['A', 'B'])
>>> m = df % 3 == 0
>>> df.where(m, -df)
   A    B
0  0  -1
1  1    3
2  2   -5
3  3   -7
4  4    9
>>> df.where(m, -df) == np.where(m, df, -df)
   A    B
0  True  True
(continues on next page)
pandas.Series.max

Series.max (axis=None, skipna=None, level=None, numeric_only=None, **kwargs)

This method returns the maximum of the values in the object. If you want the index of the maximum, use idxmax. This is the equivalent of the numpy.ndarray method argmax.

Parameters

axis [{index (0)}]
skipna : boolean, default True
   Exclude NA/null values when computing the result.
level : int or level name, default None
   If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar
numeric_only : boolean, default None
   Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns

max [scalar or Series (if level specified)]

pandas.Series.mean

Series.mean (axis=None, skipna=None, level=None, numeric_only=None, **kwargs)

Return the mean of the values for the requested axis

Parameters

axis [{index (0)}]
skipna : boolean, default True
   Exclude NA/null values when computing the result.
level : int or level name, default None
   If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar
numeric_only : boolean, default None
Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns

mean [scalar or Series (if level specified)]

**pandas.Series.median**

Series.median (axis=None, skipna=None, level=None, numeric_only=None, **kwargs)

Return the median of the values for the requested axis

Parameters

axis [{index (0)}]

skipna : boolean, default True

Exclude NA/null values when computing the result.

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns

median [scalar or Series (if level specified)]

**pandas.Series.memory_usage**

Series.memory_usage (index=True, deep=False)

Return the memory usage of the Series.

The memory usage can optionally include the contribution of the index and of elements of object dtype.

Parameters index : bool, default True

Specifies whether to include the memory usage of the Series index.

depth : bool, default False

If True, introspect the data deeply by interrogating object dtypes for system-level memory consumption, and include it in the returned value.

Returns int

Bytes of memory consumed.

See also:

- `numpy.ndarray.nbytes` Total bytes consumed by the elements of the array.
- `DataFrame.memory_usage` Bytes consumed by a DataFrame.
Examples

```python
>>> s = pd.Series(range(3))
>>> s.memory_usage()
104
```

Not including the index gives the size of the rest of the data, which is necessarily smaller:

```python
>>> s.memory_usage(index=False)
24
```

The memory footprint of object values is ignored by default:

```python
>>> s = pd.Series(['a', 'b'])
>>> s.values
array(['a', 'b'], dtype=object)
>>> s.memory_usage()
96
>>> s.memory_usage(deep=True)
212
```

**pandas.Series.min**

`Series.min(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)`

This method returns the minimum of the values in the object. If you want the index of the minimum, use `idxmin`. This is the equivalent of the `numpy.ndarray` method `argmin`.

**Parameters**

- **axis**: [index (0)]
- **skipna**: boolean, default True
  - Exclude NA/null values when computing the result.
- **level**: int or level name, default None
  - If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar
- **numeric_only**: boolean, default None
  - Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

- **min**: [scalar or Series (if level specified)]

**pandas.Series.mod**

`Series.mod(other, level=None, fill_value=None, axis=0)`

Modulo of series and other, element-wise (binary operator `mod`).

Equivalent to `series % other`, but with support to substitute a `fill_value` for missing data in one of the inputs.
Parameters

other [Series or scalar value]

fill_value : None or float value, default None (NaN)

Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns

result [Series]

See also:

Series.rmod

Examples

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a  1.0
b  1.0
c  1.0
d  NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a  1.0
b  NaN
d  1.0
e  NaN
dtype: float64
>>> a.add(b, fill_value=0)
 a  2.0
b  1.0
c  1.0
d  1.0
e  NaN
dtype: float64
```

pandas.Series.mode

Series.mode()

Return the mode(s) of the dataset.

Always returns Series even if only one value is returned.

Returns

modes [Series (sorted)]
### pandas.Series.mul

**Series.mul**(other, level=None, fill_value=None, axis=0)

Multiplication of series and other, element-wise (binary operator `mul`).

Equivalent to `series * other`, but with support to substitute a fill_value for missing data in one of the inputs.

**Parameters**

- **other** [Series or scalar value]
- **fill_value** : None or float value, default None (NaN)
  
  Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing.

- **level** : int or name
  
  Broadcast across a level, matching Index values on the passed MultiIndex level

**Returns**

- **result** [Series]

**See also:**

- `Series.rmul`

**Examples**

```
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a    1.0
b    1.0
c    1.0
d   NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a    1.0
b   NaN
d    1.0
e   NaN
dtype: float64
>>> a.add(b, fill_value=0)
a    2.0
b    1.0
c    1.0
d    1.0
e   NaN
dtype: float64
```

### pandas.Series.multiply

**Series.multiply**(other, level=None, fill_value=None, axis=0)

Multiplication of series and other, element-wise (binary operator `mul`).

34.3. Series 1537
Equivalent to \texttt{series * other}, but with support to substitute a \texttt{fill\_value} for missing data in one of the inputs.

**Parameters**

- \texttt{other} [Series or scalar value]
- \texttt{fill\_value} : None or float value, default None (NaN)
  
  Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing

- \texttt{level} : int or name
  
  Broadcast across a level, matching Index values on the passed MultiIndex level

**Returns**

- \texttt{result} [Series]

See also:

\texttt{Series.rmul}

**Examples**

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a  1.0  
b  1.0  
c  1.0  
d  NaN  
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a  1.0  
b  NaN  
d  1.0  
e  NaN  
dtype: float64
>>> a.add(b, fill_value=0)
    a  b
d  0.0
```

\texttt{pandas.Series.ne}

\texttt{Series.ne (other, \text{level=\text{None}}, fill\_value=\text{None}, \text{axis=0})}

Not equal to of series and other, element-wise (binary operator \texttt{ne}).

Equivalent to \texttt{series \!\!= \text{other}}, but with support to substitute a \texttt{fill\_value} for missing data in one of the inputs.

**Parameters**
other  [Series or scalar value]

dfill_value  : None or float value, default None (NaN)

Fill existing missing (NaN) values, and any new element needed for successful Series
alignment, with this value before computation. If data in both corresponding Series
locations is missing the result will be missing

dlevel  : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns

dresult  [Series]

See also:

Series.None

Examples

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a  1.0
b  1.0
c  1.0
d  NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a  1.0
b  NaN
d  1.0
e  NaN
dtype: float64
>>> a.add(b, fill_value=0)
a  2.0
b  1.0
c  1.0
d  1.0
e  NaN
dtype: float64
```

pandas.Series.nlargest

Series.nlargest(n=5, keep='first')

Return the largest n elements.

Parameters n  : int

Return this many descending sorted values

keep  : {'first', 'last'}, default ‘first’

Where there are duplicate values: - first : take the first occurrence. - last : take
the last occurrence.

Returns top_n  : Series
The n largest values in the Series, in sorted order

See also:

Series.nsmallest

Notes

Faster than .sort_values(ascending=False).head(n) for small n relative to the size of the Series object.

Examples

```python
>>> import pandas as pd
>>> import numpy as np

>>> s = pd.Series(np.random.randn(10**6))
>>> s.nlargest(10)  # only sorts up to the N requested
219921  4.644710
82124  4.608745
421689  4.564644
425277  4.447014
718691  4.414137
43154  4.403520
283187  4.313922
595519  4.273635
503969  4.250236
121637  4.240952
dtype: float64
```

pandas.Series.nonzero

Series.nonzero()

Return the integer indices of the elements that are non-zero

This method is equivalent to calling numpy.nonzero on the series data. For compatibility with NumPy, the return value is the same (a tuple with an array of indices for each dimension), but it will always be a one-item tuple because series only have one dimension.

See also:

numpy.nonzero

Examples

```python
>>> s = pd.Series([0, 3, 0, 4])
>>> s.nonzero()
(array([1, 3]),)
>>> s.iloc[s.nonzero()[0]]
1  3
3  4
dtype: int64
```
```python
>>> s = pd.Series([0, 3, 0, 4], index=['a', 'b', 'c', 'd'])
# same return although index of s is different
>>> s.nonzero()
(array([1, 3]),)
>>> s.iloc[s.nonzero()[0]]
b 3
d 4
dtype: int64
```

### pandas.Series.notna

`Series.notna()`  
Detect existing (non-missing) values.  
Return a boolean same-sized object indicating if the values are not NA. Non-missing values get mapped to True. Characters such as empty strings '' or `numpy.inf` are not considered NA values (unless you set `pandas.options.mode.use_inf_as_na = True`). NA values, such as `None` or `numpy.NaN`, get mapped to False values.

**Returns**  
Mask of bool values for each element in Series that indicates whether an element is not an NA value.

**See also:**  
- `Series.notnull` alias of notna  
- `Series.isna` boolean inverse of notna  
- `Series.dropna` omit axes labels with missing values  
- `notna` top-level notna

**Examples**

Show which entries in a DataFrame are not NA.

```python
>>> df = pd.DataFrame({'age': [5, 6, np.NaN],
...                     'born': [pd.NaT, pd.Timestamp('1939-05-27'),
...                             pd.Timestamp('1940-04-25')],
...                     'name': ['Alfred', 'Batman', ''],
...                     'toy': [None, 'Batmobile', 'Joker']})

>>> df
   age     born     name    toy
0  5.0  NaT     Alfred  None
1  6.0 1939-05-27  Batman  Batmobile
2 NaN  1940-04-25   Batman  Joker

>>> df.notna()
   age     born     name    toy
0  True   False   True   False
1  True    True    True    True
2  False   True    True    True
```

Show which entries in a Series are not NA.

>>> ser = pd.Series([5, 6, np.NaN])
>>> ser
0    5.0
1    6.0
2   NaN
dtype: float64

>>> ser.notna()
0   True
1   True
2  False
dtype: bool

pandas.Series.notnull

Series.notnull()
Detect existing (non-missing) values.

Return a boolean same-sized object indicating if the values are not NA. Non-missing values get mapped to True. Characters such as empty strings '' or numpy.inf are not considered NA values (unless you set pandas.options.mode.use_inf_as_na = True). NA values, such as None or numpy.NaN, get mapped to False values.

Returns Series
Mask of bool values for each element in Series that indicates whether an element is not an NA value.

See also:

Series.notnull alias of notna
Series.isna boolean inverse of notna
Series.dropna omit axes labels with missing values
notna top-level notna

Examples

Show which entries in a DataFrame are not NA.

```python
>>> df = pd.DataFrame({'age': [5, 6, np.NaN],
...                    'born': [pd.NaT, pd.Timestamp('1939-05-27'),
...                             pd.Timestamp('1940-04-25')],
...                    'name': ['Alfred', 'Batman', ''],
...                    'toy': [None, 'Batmobile', 'Joker']})
>>> df
   age   born    name    toy
0  5.0       NaT  Alfred     None
1  6.0 1939-05-27 Batman  Batmobile
2  NaN 1940-04-25  Joker
```
>>> df.notna()
   age  born  name  toy
0   True False  True  False
1   True   True  True   True
2  False  True  True   True

Show which entries in a Series are not NA.

>>> ser = pd.Series([5, 6, np.NaN])
>>> ser
0    5.0
1    6.0
2    NaN
dtype: float64

>>> ser.notna()
0   True
1   True
2  False
dtype: bool

**pandas.Series.nsmallest**

Series.nsmallest \((n=5, \text{keep}='first')\)
Return the smallest \(n\) elements.

**Parameters**

- **n**: int
  
  Return this many ascending sorted values

- **keep**: \{'first', 'last', \} default 'first'
  
  Where there are duplicate values: - first : take the first occurrence. - last : take the last occurrence.

**Returns**

- **bottom_n**: Series
  
  The \(n\) smallest values in the Series, in sorted order

**See also:**

Series.nlargest

**Notes**

Faster than .sort_values().head\((n)\) for small \(n\) relative to the size of the Series object.

**Examples**

```python
>>> import pandas as pd
>>> import numpy as np

>>> s = pd.Series(np.random.randn(10**6))
>>> s.nsmallest(10)  # only sorts up to the N requested
288532  -4.954580
```

(continues on next page)
pandas: powerful Python data analysis toolkit, Release 0.23.2

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>732345</td>
<td>-4.835960</td>
<td></td>
<td></td>
</tr>
<tr>
<td>64803</td>
<td>-4.812550</td>
<td></td>
<td></td>
</tr>
<tr>
<td>446457</td>
<td>-4.609998</td>
<td></td>
<td></td>
</tr>
<tr>
<td>501225</td>
<td>-4.483945</td>
<td></td>
<td></td>
</tr>
<tr>
<td>669476</td>
<td>-4.472935</td>
<td></td>
<td></td>
</tr>
<tr>
<td>973615</td>
<td>-4.401699</td>
<td></td>
<td></td>
</tr>
<tr>
<td>621279</td>
<td>-4.355126</td>
<td></td>
<td></td>
</tr>
<tr>
<td>773916</td>
<td>-4.347355</td>
<td></td>
<td></td>
</tr>
<tr>
<td>359919</td>
<td>-4.331927</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dtype: float64</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**pandas.Series.nunique**

Series.nunique (dropna=True)

Return number of unique elements in the object.

Excludes NA values by default.

Parameters dropna : boolean, default True

  Don’t include NaN in the count.

Returns

nunique [int]

**pandas.Series.pct_change**

Series.pct_change (periods=1, fill_method='pad', limit=None, freq=None, **kwargs)

Percentage change between the current and a prior element.

Computes the percentage change from the immediately previous row by default. This is useful in comparing the percentage of change in a time series of elements.

Parameters periods : int, default 1

  Periods to shift for forming percent change.

fill_method : str, default ‘pad’

  How to handle NAs before computing percent changes.

limit : int, default None

  The number of consecutive NAs to fill before stopping.

freq : DateOffset, timedelta, or offset alias string, optional

  Increment to use from time series API (e.g. ‘M’ or BDay()).

**kwargs

Additional keyword arguments are passed into DataFrame.shift or Series.shift.

Returns chg : Series or DataFrame

  The same type as the calling object.

See also:

  Series.diff Compute the difference of two elements in a Series.
**DataFrame.diff** Compute the difference of two elements in a DataFrame.

**Series.shift** Shift the index by some number of periods.

**DataFrame.shift** Shift the index by some number of periods.

### Examples

#### Series

```python
>>> s = pd.Series([90, 91, 85])
>>> s
0    90
1    91
2    85
dtype: int64
```

```python
>>> s.pct_change()
0    NaN
1    0.011111
2   -0.065934
dtype: float64
```

```python
>>> s.pct_change(periods=2)
0    NaN
1    NaN
2   -0.055556
dtype: float64
```

See the percentage change in a Series where filling NAs with last valid observation forward to next valid.

```python
>>> s = pd.Series([90, 91, None, 85])
>>> s
0    90.0
1    91.0
2     NaN
3    85.0
dtype: float64
```

```python
>>> s.pct_change(fill_method='ffill')
0    NaN
1    0.011111
2    0.000000
3   -0.065934
dtype: float64
```

#### DataFrame

Percentage change in French franc, Deutsche Mark, and Italian lira from 1980-01-01 to 1980-03-01.

```python
>>> df = pd.DataFrame({
...     'FR': [4.0405, 4.0963, 4.3149],
...     'GR': [1.7246, 1.7482, 1.8519],
...     'IT': [804.74, 810.01, 860.13]
...     }, index=['1980-01-01', '1980-02-01', '1980-03-01'])
>>> df
```

(continues on next page)
Percentage of change in GOOG and APPL stock volume. Shows computing the percentage change between columns.

>>> df = pd.DataFrame(
...   '2016': [1769950, 30586265],
...   '2015': [1500923, 40912316],
...   '2014': [1371819, 41403351],
...   index=['GOOG', 'APPL'])

>>> df
   2016  2015  2014
GOOG  1769950  1500923  1371819
APPL  30586265  40912316  41403351

>>> df.pct_change(axis='columns')
    2016  2015  2014
GOOG  NaN -0.151997 -0.086016
APPL  NaN  0.337604  0.012002

**pandas.Series.pipe**

Series.pipe(func, *args, **kwargs)
Apply func(self, *args, **kwargs)

**Parameters**

*func*: function

function to apply to the NDFrame. *args* and *kwargs* are passed into *func*. Alternatively a (callable, data_keyword) tuple where data_keyword is a string indicating the keyword of callable that expects the NDFrame.

*args*: iterable, optional

positional arguments passed into *func*.

*kwargs*: mapping, optional

a dictionary of keyword arguments passed into *func*.

**Returns**

object [the return type of *func*.]

See also:

pandas.DataFrame.apply, pandas.DataFrame.applymap, pandas.Series.map
Notes

Use .pipe when chaining together functions that expect Series, DataFrames or GroupBy objects. Instead of writing

```python
>>> f(g(h(df), arg1=a), arg2=b, arg3=c)
```

You can write

```python
>>> (df.pipe(h)
...    .pipe(g, arg1=a)
...    .pipe(f, arg2=b, arg3=c)
...)
```

If you have a function that takes the data as (say) the second argument, pass a tuple indicating which keyword expects the data. For example, suppose `f` takes its data as `arg2`:

```python
>>> (df.pipe(h)
...    .pipe(g, arg1=a)
...    .pipe((f, 'arg2'), arg1=a, arg3=c)
...)
```

### pandas.Series.plot

`Series.plot(kind='line', ax=None, figsize=None, use_index=True, title=None, grid=None, legend=False, style=None, logx=False, logy=False, loglog=False, xticks=None, yticks=None, xlim=None, ylim=None, rot=None, fontsize=None, colormap=None, table=False, yerr=None, xerr=None, label=None, secondary_y=False, **kwds)`

Make plots of Series using matplotlib / pylab.

New in version 0.17.0: Each plot kind has a corresponding method on the `Series.plot` accessor: `s.plot(kind='line')` is equivalent to `s.plot.line()`.

#### Parameters

- **data** [Series]
- **kind** : str
  - ‘line’ : line plot (default)
  - ‘bar’ : vertical bar plot
  - ‘barh’ : horizontal bar plot
  - ‘hist’ : histogram
  - ‘box’ : boxplot
  - ‘kde’ : Kernel Density Estimation plot
  - ‘density’ : same as ‘kde’
  - ‘area’ : area plot
  - ‘pie’ : pie plot
- **ax** : matplotlib axes object
  If not passed, uses gca()
**figsize**  [a tuple (width, height) in inches]

**use_index**  : boolean, default True
   Use index as ticks for x axis

**title**  : string or list
   Title to use for the plot. If a string is passed, print the string at the top of the figure. If a list is passed and **subplots** is True, print each item in the list above the corresponding subplot.

**grid**  : boolean, default None (matlab style default)
   Axis grid lines

**legend**  : False/True/'reverse'
   Place legend on axis subplots

**style**  : list or dict
   matplotlib line style per column

**logx**  : boolean, default False
   Use log scaling on x axis

**logy**  : boolean, default False
   Use log scaling on y axis

**loglog**  : boolean, default False
   Use log scaling on both x and y axes

**xticks**  : sequence
   Values to use for the xticks

**yticks**  : sequence
   Values to use for the yticks

**xlim**  [2-tuple/list]

**ylim**  [2-tuple/list]

**rot**  : int, default None
   Rotation for ticks (xticks for vertical, yticks for horizontal plots)

**fontsize**  : int, default None
   Font size for xticks and yticks

**colormap**  : str or matplotlib colormap object, default None
   Colormap to select colors from. If string, load colormap with that name from matplotlib.

**colorbar**  : boolean, optional
   If True, plot colorbar (only relevant for ‘scatter’ and ‘hexbin’ plots)

**position**  : float
   Specify relative alignments for bar plot layout. From 0 (left/bottom-end) to 1 (right/top-end). Default is 0.5 (center)
table : boolean, Series or DataFrame, default False

If True, draw a table using the data in the DataFrame and the data will be transposed to meet matplotlib’s default layout. If a Series or DataFrame is passed, use passed data to draw a table.

yerr : DataFrame, Series, array-like, dict and str

See Plotting with Error Bars for detail.

xerr [same types as yerr.]

label [label argument to provide to plot]

secondary_y : boolean or sequence of ints, default False

If True then y-axis will be on the right

mark_right : boolean, default True

When using a secondary_y axis, automatically mark the column labels with “(right)” in the legend

**kwds : keywords

Options to pass to matplotlib plotting method

Returns

axes [matplotlib.axes.Axes or numpy.ndarray of them]

Notes

• See matplotlib documentation online for more on this subject

• If kind = ‘bar’ or ‘barh’, you can specify relative alignments for bar plot layout by position keyword. From 0 (left/bottom-end) to 1 (right/top-end). Default is 0.5 (center)

pandas.Series.pop

Series.pop (item)

Return item and drop from frame. Raise KeyError if not found.

Parameters item : str

Column label to be popped

Returns

popped [Series]

Examples

```python
>>> df = pd.DataFrame([('falcon', 'bird', 389.0),
...                     ('parrot', 'bird', 24.0),
...                     ('lion', 'mammal', 80.5),
...                     ('monkey', 'mammal', np.nan)],
...                   columns=['name', 'class', 'max_speed'])
```
>>> df
    name  class  max_speed
 0  falcon  bird     389.0
 1  parrot  bird      24.0
 2    lion mammal     80.5
 3  monkey mammal     NaN

>>> df.pop('class')
  0    bird
  1    bird
  2  mammal
  3  mammal
Name: class, dtype: object

>>> df
    name  max_speed
 0  falcon     389.0
 1  parrot      24.0
 2    lion      80.5
 3  monkey      NaN

pandas.Series.pow

Series.pow(other, level=None, fill_value=None, axis=0)
Exponential power of series and other, element-wise (binary operator pow).
Equivalent to series ** other, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters

- **other** [Series or scalar value]
- **fill_value** : None or float value, default None (NaN)
  Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing
- **level** : int or name
  Broadcast across a level, matching Index values on the passed MultiIndex level

Returns

- **result** [Series]

See also:

Series.rpow

Examples

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a   1.0
```
b 1.0
c 1.0
d NaN
dtype: float64

>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a 1.0
b NaN
d 1.0
e NaN
dtype: float64

>>> a.add(b, fill_value=0)

a 2.0
b 1.0
c 1.0
d 1.0
e NaN
dtype: float64

pandas.Series.prod

Series.prod (axis=None, skipna=None, level=None, numeric_only=None, min_count=0, **kwargs)
Return the product of the values for the requested axis

Parameters

axis [{index (0)}]
skipna : boolean, default True
Exclude NA/null values when computing the result.
level : int or level name, default None
If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar
numeric_only : boolean, default None
Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.
min_count : int, default 0
The required number of valid values to perform the operation. If fewer than min_count non-NA values are present the result will be NA.

New in version 0.22.0: Added with the default being 0. This means the sum of an all-NA or empty Series is 0, and the product of an all-NA or empty Series is 1.

Returns

prod [scalar or Series (if level specified)]

Examples

By default, the product of an empty or all-NA Series is 1
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
>>> pd.Series([]).prod()
1.0
```

This can be controlled with the `min_count` parameter

```python
>>> pd.Series([]).prod(min_count=1)
nan
```

Thanks to the `skipna` parameter, `min_count` handles all-NA and empty series identically.

```python
>>> pd.Series([np.nan]).prod()
1.0
>>> pd.Series([np.nan]).prod(min_count=1)
nan
```

**pandas.Series.product**

`Series.product(axis=None, skipna=None, level=None, numeric_only=None, min_count=0, **kwargs)`

Return the product of the values for the requested axis

**Parameters**

- `axis` (*{index (0)}*
- `skipna` : boolean, default True
  - Exclude NA/null values when computing the result.
- `level` : int or level name, default None
  - If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar
- `numeric_only` : boolean, default None
  - Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.
- `min_count` : int, default 0
  - The required number of valid values to perform the operation. If fewer than `min_count` non-NA values are present the result will be NA.

**Returns**

- `prod` [scalar or Series (if level specified)]

**Examples**

By default, the product of an empty or all-NA Series is 1

```python
>>> pd.Series([]).prod()
1.0
```
This can be controlled with the `min_count` parameter

```python
>>> pd.Series([]).prod(min_count=1)
nan
```

Thanks to the `skipna` parameter, `min_count` handles all-NA and empty series identically.

```python
>>> pd.Series([np.nan]).prod()
1.0

>>> pd.Series([np.nan]).prod(min_count=1)
nan
```

**pandas.Series.ptp**

Series.ptp (axis=None, skipna=None, level=None, numeric_only=None, **kwargs)

Returns the difference between the maximum value and the minimum value in the object. This is the equivalent of the numpy.ndarray method ptp.

**Parameters**

- `axis` ([index (0)])
- `skipna` : boolean, default True
  
  Exclude NA/null values when computing the result.
- `level` : int or level name, default None
  
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar.
- `numeric_only` : boolean, default None
  
  Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

- `ptp` [scalar or Series (if level specified)]

**pandas.Series.put**

Series.put (*args, **kwargs)

Applies the put method to its values attribute if it has one.

See also:

- numpy.ndarray.put

**pandas.Series.quantile**

Series.quantile (q=0.5, interpolation='linear')

Return value at the given quantile, a la numpy.percentile.

**Parameters**

- `q` : float or array-like, default 0.5 (50% quantile)
0 <= q <= 1, the quantile(s) to compute

**interpolation**: ['linear', 'lower', 'higher', 'midpoint', 'nearest']

New in version 0.18.0.

This optional parameter specifies the interpolation method to use, when the desired quantile lies between two data points \( i \) and \( j \):

- **linear**: \( i + (j - i) \times \text{fraction} \), where \( \text{fraction} \) is the fractional part of the index surrounded by \( i \) and \( j \).
- **lower**: \( i \).
- **higher**: \( j \).
- **nearest**: \( i \) or \( j \) whichever is nearest.
- **midpoint**: \( (i + j) / 2 \).

**Returns** **quantile**: float or Series

if \( q \) is an array, a Series will be returned where the index is \( q \) and the values are the quantiles.

**See also:**

*pandas.core.window.Rolling.quantile*

**Examples**

```python
>>> s = Series([1, 2, 3, 4])
>>> s.quantile(.5)
2.5
>>> s.quantile([.25, .5, .75])
0.25 1.75
0.50 2.50
0.75 3.25
dtype: float64
```

**pandas.Series.radd**

Series **radd** (other, level=None, fill_value=None, axis=0)

Addition of series and other, element-wise (binary operator **radd**).

Equivalent to **other + series**, but with support to substitute a fill_value for missing data in one of the inputs.

**Parameters**

- **other** [Series or scalar value]
- **fill_value** : None or float value, default None (NaN)

  Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing

- **level** : int or name

  Broadcast across a level, matching Index values on the passed MultiIndex level
pandas.Series.rank

Series.rank(axis=0, method='average', numeric_only=None, na_option='keep', ascending=True, pct=False)

Compute numerical data ranks (1 through n) along axis. Equal values are assigned a rank that is the average of the ranks of those values.

**Parameters**
- **axis**: {0 or ‘index’, 1 or ‘columns’}, default 0
  - index to direct ranking
- **method**: {‘average’, ‘min’, ‘max’, ‘first’, ‘dense’}
  - average: average rank of group
  - min: lowest rank in group
  - max: highest rank in group
  - first: ranks assigned in order they appear in the array
  - dense: like ‘min’, but rank always increases by 1 between groups
- **numeric_only**: boolean, default None
  - Include only float, int, boolean data. Valid only for DataFrame or Panel objects
- **na_option**: {'keep', 'top', 'bottom'}
• keep: leave NA values where they are
• top: smallest rank if ascending
• bottom: smallest rank if descending

ascending : boolean, default True
False for ranks by high (1) to low (N)

pct : boolean, default False
Computes percentage rank of data

Returns
ranks [same type as caller]

pandas.Series.ravel

Series.ravel(order='C')
Return the flattened underlying data as an ndarray

See also:
numpy.ndarray.ravel

pandas.Series.rdiv

Series.rdiv(other, level=None, fill_value=None, axis=0)
Floating division of series and other, element-wise (binary operator rtruediv).
Equivalent to other / series, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters
other [Series or scalar value]
fill_value : None or float value, default None (NaN)
    Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing
level : int or name
    Broadcast across a level, matching Index values on the passed MultiIndex level

Returns
result [Series]

See also:
Series.truediv

Examples
pandas.Series.reindex

Series.reindex(index=None, **kwargs)
Conform Series to new index with optional filling logic, placing NA/NaN in locations having no value in
the previous index. A new object is produced unless the new index is equivalent to the current one and
copy=False

Parameters

index : array-like, optional (should be specified using keywords)
New labels / index to conform to. Preferably an Index object to avoid duplicating data

method to use for filling holes in reindexed DataFrame. Please note: this is only applicable
to DataFrames/Series with a monotonically increasing/decreasing index.
• default: don’t fill gaps
• pad / ffill: propagate last valid observation forward to next valid
• backfill / bfill: use next valid observation to fill gap
• nearest: use nearest valid observations to fill gap

copy : boolean, default True
Return a new object, even if the passed indexes are the same

level : int or name
Broadcast across a level, matching Index values on the passed MultiIndex level

fill_value : scalar, default np.NaN
Value to use for missing values. Defaults to NaN, but can be any “compatible” value

limit : int, default None
Maximum number of consecutive elements to forward or backward fill
tolerance : optional

Maximum distance between original and new labels for inexact matches. The values of
the index at the matching locations most satisfy the equation \( \text{abs}(\text{index}[\text{indexer}] - \text{target}) \leq \text{tolerance} \).

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-
like, which applies variable tolerance per element. List-like includes list, tuple, array,
Series, and must be the same size as the index and its dtype must exactly match the
index’s type.

New in version 0.21.0: (list-like tolerance)

Returns

reindexed [Series]

Examples

DataFrame.reindex supports two calling conventions

* (index=index_labels, columns=column_labels, ...)
* (labels, axis={'index', 'columns'}, ...)

We highly recommend using keyword arguments to clarify your intent.

Create a dataframe with some fictional data.

```python
>>> index = ['Firefox', 'Chrome', 'Safari', 'IE10', 'Konqueror']
>>> df = pd.DataFrame({
    ... 'http_status': [200, 200, 404, 404, 301],
    ... 'response_time': [0.04, 0.02, 0.07, 0.08, 1.0],
    ... index=index)
>>> df
            http_status  response_time
Firefox         200          0.04
Chrome         200          0.02
Safari         404          0.07
IE10           404          0.08
Konqueror      301          1.00
```

Create a new index and reindex the dataframe. By default values in the new index that do not have
corresponding records in the dataframe are assigned NaN.

```python
>>> new_index = ['Safari', 'Iceweasel', 'Comodo Dragon', 'IE10',
    ... 'Chrome']
>>> df.reindex(new_index)
            http_status  response_time
Safari       404.0          0.07
Iceweasel     NaN           NaN
Comodo Dragon     NaN           NaN
IE10          404.0          0.08
Chrome       200.0          0.02
```

We can fill in the missing values by passing a value to the keyword fill_value. Because the index is
not monotonically increasing or decreasing, we cannot use arguments to the keyword method to fill the
NaN values.
>> df.reindex(new_index, fill_value=0)

<table>
<thead>
<tr>
<th>http_status</th>
<th>response_time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safari</td>
<td>404</td>
</tr>
<tr>
<td>Iceweasel</td>
<td>0</td>
</tr>
<tr>
<td>Comodo Dragon</td>
<td>0</td>
</tr>
<tr>
<td>IE10</td>
<td>404</td>
</tr>
<tr>
<td>Chrome</td>
<td>200</td>
</tr>
</tbody>
</table>

>> df.reindex(new_index, fill_value='missing')

<table>
<thead>
<tr>
<th>http_status</th>
<th>response_time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safari</td>
<td>404</td>
</tr>
<tr>
<td>Iceweasel</td>
<td>missing</td>
</tr>
<tr>
<td>Comodo Dragon</td>
<td>missing</td>
</tr>
<tr>
<td>IE10</td>
<td>404</td>
</tr>
<tr>
<td>Chrome</td>
<td>200</td>
</tr>
</tbody>
</table>

We can also reindex the columns.

>> df.reindex(columns=['http_status', 'user_agent'])

<table>
<thead>
<tr>
<th>http_status</th>
<th>user_agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firefox</td>
<td>200</td>
</tr>
<tr>
<td>Chrome</td>
<td>200</td>
</tr>
<tr>
<td>Safari</td>
<td>404</td>
</tr>
<tr>
<td>IE10</td>
<td>404</td>
</tr>
<tr>
<td>Konqueror</td>
<td>301</td>
</tr>
</tbody>
</table>

Or we can use “axis-style” keyword arguments

>> df.reindex([['http_status', 'user_agent'], axis="columns")

<table>
<thead>
<tr>
<th>http_status</th>
<th>user_agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firefox</td>
<td>200</td>
</tr>
<tr>
<td>Chrome</td>
<td>200</td>
</tr>
<tr>
<td>Safari</td>
<td>404</td>
</tr>
<tr>
<td>IE10</td>
<td>404</td>
</tr>
<tr>
<td>Konqueror</td>
<td>301</td>
</tr>
</tbody>
</table>

To further illustrate the filling functionality in reindex, we will create a dataframe with a monotonically increasing index (for example, a sequence of dates).

>> date_index = pd.date_range('1/1/2010', periods=6, freq='D')
>> df2 = pd.DataFrame({'prices': [100, 101, np.nan, 100, 89, 88]}, index=date_index)

settings date_index

<table>
<thead>
<tr>
<th>prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-01-01 100</td>
</tr>
<tr>
<td>2010-01-02 101</td>
</tr>
<tr>
<td>2010-01-03 NaN</td>
</tr>
<tr>
<td>2010-01-04 100</td>
</tr>
<tr>
<td>2010-01-05 89</td>
</tr>
<tr>
<td>2010-01-06 88</td>
</tr>
</tbody>
</table>

Suppose we decide to expand the dataframe to cover a wider date range.

>> date_index2 = pd.date_range('12/29/2009', periods=10, freq='D')
>> df2.reindex(date_index2)

(continues on next page)
The index entries that did not have a value in the original data frame (for example, ‘2009-12-29’) are by default filled with NaN. If desired, we can fill in the missing values using one of several options.

For example, to backpropagate the last valid value to fill the NaN values, pass bfill as an argument to the method keyword.

```python
>>> df2.reindex(date_index2, method='bfill')
```

Please note that the NaN value present in the original dataframe (at index value 2010-01-03) will not be filled by any of the value propagation schemes. This is because filling while reindexing does not look at dataframe values, but only compares the original and desired indexes. If you do want to fill in the NaN values present in the original dataframe, use the fillna() method.

See the user guide for more.

**pandas.Series.reindex_axis**

`Series.reindex_axis(labels, axis=0, **kwargs)`

Conform Series to new index with optional filling logic.

Deprecated since version 0.21.0: Use `Series.reindex` instead.

**pandas.Series.reindex_like**

`Series.reindex_like(other, method=None, copy=True, limit=None, tolerance=None)`

Return an object with matching indices to myself.

**Parameters**

- `other` [Object]
- `method` [string or None]
- `copy` [boolean, default True]
- `limit` : int, default None
Maximum number of consecutive labels to fill for inexact matches.

**tolerance**: optional

Maximum distance between labels of the other object and this object for inexact matches. Can be list-like.

New in version 0.21.0: (list-like tolerance)

**Returns**

reindexed [same as input]

**Notes**

Like calling `s.reindex(index=other.index, columns=other.columns, method=...)`.

**pandas.Series.rename**

`Series.rename(index=None, **kwargs)`

Alter Series index labels or name

Function / dict values must be unique (1-to-1). Labels not contained in a dict / Series will be left as-is. Extra labels listed don’t throw an error.

Alternatively, change `Series.name` with a scalar value.

See the [user guide](https://pandas.pydata.org/pandas-docs/stable/user_guide.html) for more.

**Parameters**

- **index**: scalar, hashable sequence, dict-like or function, optional
  
dict-like or functions are transformations to apply to the index. Scalar or hashable sequence-like will alter the `Series.name` attribute.

- **copy**: boolean, default True
  
Also copy underlying data

- **inplace**: boolean, default False
  
Whether to return a new Series. If True then value of copy is ignored.

- **level**: int or level name, default None
  
In case of a MultiIndex, only rename labels in the specified level.

**Returns**

renamed [Series (new object)]

See also:

`pandas.Series.rename_axis`

**Examples**

```python
>>> s = pd.Series([1, 2, 3])
>>> s
0  1
1  2
```
pandas.Series.rename_axis

Series.rename_axis(mapper, axis=0, copy=True, inplace=False)

Alter the name of the index or columns.

Parameters mapper : scalar, list-like, optional

Value to set as the axis name attribute.

axis : {0 or ‘index’, 1 or ‘columns’}, default 0

The index or the name of the axis.

copy : boolean, default True

Also copy underlying data.

inplace : boolean, default False

Modifies the object directly, instead of creating a new Series or DataFrame.

Returns renamed : Series, DataFrame, or None

The same type as the caller or None if inplace is True.

See also:

pandas.Series.rename Alter Series index labels or name
pandas.DataFrame.rename Alter DataFrame index labels or name
pandas.Index.rename Set new names on index

Notes

Prior to version 0.21.0, rename_axis could also be used to change the axis labels by passing a mapping or scalar. This behavior is deprecated and will be removed in a future version. Use rename instead.
Examples

Series

```python
>>> s = pd.Series([1, 2, 3])
>>> s.rename_axis("foo")
foo
0  1
1  2
2  3
dtype: int64
```

DataFrame

```python
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
>>> df.rename_axis("foo")
    A  B
foo 0  1  4
    1  2  5
    2  3  6
```

```python
>>> df.rename_axis("bar", axis="columns")
    bar  A  B
  0    1  1  4
  1    2  2  5
  2    3  3  6
```

`pandas.Series.reorder_levels`

`Series.reorder_levels(order)`
Rearrange index levels using input order. May not drop or duplicate levels

Parameters
- `order`: list of int representing new level order.
  (reference level by number or key)
- `axis`: where to reorder levels

Returns
type of caller (new object)

`pandas.Series.repeat`

`Series.repeat(repeats, *args, **kwargs)`
Repeat elements of a Series. Refer to `numpy.ndarray.repeat` for more information about the `repeats` argument.

See also:
- `numpy.ndarray.repeat`
pandas.Series.replace

```
Series.replace(to_replace=None, value=None, inplace=False, limit=None, regex=False, method='pad')
```

Replace values given in `to_replace` with `value`.

Values of the Series are replaced with other values dynamically. This differs from updating with `.loc` or `.iloc`, which require you to specify a location to update with some value.

**Parameters**

- **to_replace**: str, regex, list, dict, Series, int, float, or None
  How to find the values that will be replaced.
  - numeric, str or regex:
    - numeric: numeric values equal to `to_replace` will be replaced with `value`
    - str: string exactly matching `to_replace` will be replaced with `value`
    - regex: regexs matching `to_replace` will be replaced with `value`
  - list of str, regex, or numeric:
    - First, if `to_replace` and `value` are both lists, they must be the same length.
    - Second, if `regex=True` then all of the strings in both lists will be interpreted as regexs otherwise they will match directly. This doesn’t matter much for `value` since there are only a few possible substitution regexes you can use.
    - str, regex and numeric rules apply as above.
  - dict:
    - Dicts can be used to specify different replacement values for different existing values. For example, `{'a': 'b', 'y': 'z'}` replaces the value ‘a’ with ‘b’ and ‘y’ with ‘z’. To use a dict in this way the `value` parameter should be `None`.
    - For a DataFrame a dict can specify that different values should be replaced in different columns. For example, `{'a': 1, 'b': 'z'}` looks for the value 1 in column ‘a’ and the value ‘z’ in column ‘b’ and replaces these values with whatever is specified in `value`. The `value` parameter should not be `None` in this case. You can treat this as a special case of passing two lists except that you are specifying the column to search in.
    - For a DataFrame nested dictionaries, e.g., `{'a': {'b': np.nan}}`, are read as follows: look in column ‘a’ for the value ‘b’ and replace it with NaN. The `value` parameter should be `None` to use a nested dict in this way. You can nest regular expressions as well. Note that column names (the top-level dictionary keys in a nested dictionary) cannot be regular expressions.
  - None:
    - This means that the `regex` argument must be a string, compiled regular expression, or list, dict, ndarray or Series of such elements. If `value` is also `None` then this must be a nested dictionary or Series.

See the examples section for examples of each of these.

- **value**: scalar, dict, list, str, regex, default None
  Value to replace any values matching `to_replace` with. For a DataFrame a dict of values can be used to specify which value to use for each column (columns not in the dict will not be filled). Regular expressions, strings and lists or dicts of such objects are also allowed.
**inplace** : boolean, default False

If True, in place. Note: this will modify any other views on this object (e.g. a column from a DataFrame). Returns the caller if this is True.

**limit** : int, default None

Maximum size gap to forward or backward fill.

**regex** : bool or same types as to_replace, default False

Whether to interpret to_replace and/or value as regular expressions. If this is True then to_replace must be a string. Alternatively, this could be a regular expression or a list, dict, or array of regular expressions in which case to_replace must be None.

**method** : {'pad', 'ffill', 'bfill', None}

The method to use when for replacement, when to_replace is a scalar, list or tuple and value is None.

Changed in version 0.23.0: Added to DataFrame.

**Returns** Series

Object after replacement.

**Raises** AssertionError

- If regex is not a bool and to_replace is not None.

**Raises** TypeError

- If to_replace is a dict and value is not a list, dict, ndarray, or Series
- If to_replace is None and regex is not compilable into a regular expression or is a list, dict, ndarray, or Series.
- When replacing multiple bool or datetime64 objects and the arguments to to_replace does not match the type of the value being replaced

**Raises** ValueError

- If a list or an ndarray is passed to to_replace and value but they are not the same length.

**See also:**

*Seriesfillna* Fill NA values

*Series.where* Replace values based on boolean condition

*Series.str.replace* Simple string replacement.

**Notes**

- Regex substitution is performed under the hood with re.sub. The rules for substitution for re.sub are the same.

- Regular expressions will only substitute on strings, meaning you cannot provide, for example, a regular expression matching floating point numbers and expect the columns in your frame that have a numeric dtype to be matched. However, if those floating point numbers are strings, then you can do this.
• This method has a lot of options. You are encouraged to experiment and play with this method to gain intuition about how it works.

• When dict is used as the to_replace value, it is like key(s) in the dict are the to_replace part and value(s) in the dict are the value parameter.

Examples

Scalar ‘to_replace’ and ‘value’

```python
>>> s = pd.Series([0, 1, 2, 3, 4])
>>> s.replace(0, 5)
0 5
1 1
2 2
3 3
4 4
dtype: int64
```

```python
>>> df = pd.DataFrame({'A': [0, 1, 2, 3, 4],
...                    'B': [5, 6, 7, 8, 9],
...                    'C': ['a', 'b', 'c', 'd', 'e']})
>>> df.replace(0, 5)
   A  B   C
0 5  5   a
1 1  6   b
2 2  7   c
3 3  8   d
4 4  9   e
```

List-like ‘to_replace’

```python
>>> df.replace([0, 1, 2, 3], 4)
   A  B   C
0 4  5   a
1 4  6   b
2 4  7   c
3 4  8   d
4 4  9   e
```

```python
>>> df.replace([0, 1, 2, 3], [4, 3, 2, 1])
   A  B   C
0 4  5   a
1 3  6   b
2 2  7   c
3 1  8   d
4 4  9   e
```

```python
>>> s.replace([1, 2], method='bfill')
0 0
1 3
2 3
3 3
4 4
dtype: int64
```
dict-like ‘to_replace’

```python
>>> df.replace({0: 10, 1: 100})
   A  B  C
0  10  5  a
1 100  6  b
2  2  7  c
3  3  8  d
4  4  9  e
```

```python
>>> df.replace({'A': 0, 'B': 5}, 100)
   A  B  C
0 100  100  a
1   1   6  b
2   2   7  c
3   3   8  d
4   4   9  e
```

```python
>>> df.replace({'A': {0: 100, 4: 400}})
   A  B  C
0 100   5  a
1   1   6  b
2   2   7  c
3   3   8  d
4  400   9  e
```

Regular expression ‘to_replace’

```python
>>> df = pd.DataFrame({'A': ['bat', 'foo', 'bait'],
                    'B': ['abc', 'bar', 'xyz']})
>>> df.replace(to_replace=r'^ba.$', value='new', regex=True)
   A  B
0 new abc
1 foo new
2 bait xyz
```

```python
>>> df.replace({'A': r'^ba.$'}, {'A': 'new'}, regex=True)
   A  B
0 new abc
1 foo bar
2 bait xyz
```

```python
>>> df.replace(regex=r'^ba.$', value='new')
   A  B
0 new abc
1 foo new
2 bait xyz
```

```python
>>> df.replace(regex={r'^ba.$': 'new', 'foo': 'xyz'})
   A  B
0 new abc
1 xyz new
2 bait xyz
```

```python
>>> df.replace(regex=[r'^ba.$', 'foo'], value='new')
   A  B
0 new abc
1 foo new
2 bait xyz
```

(continues on next page)
Note that when replacing multiple bool or datetime64 objects, the data types in the `to_replace` parameter must match the data type of the value being replaced:

```python
>>> df = pd.DataFrame({'A': [True, False, True],
...                    'B': [False, True, False]})
>>> df.replace({'a string': 'new value', True: False})  # raises
Traceback (most recent call last):
  ...  # Can't compare 'ndarray' and 'str'
```

This raises a TypeError because one of the dict keys is not of the correct type for replacement.

Compare the behavior of `s.replace({'a': None})` and `s.replace('a', None)` to understand the peculiarities of the `to_replace` parameter:

```python
>>> s = pd.Series([10, 'a', 'a', 'b', 'a'])
>>> s.replace({'a': None})
0     10
1  None
2  None
3     b
4  None
dtype: object
```

When `value=None` and `to_replace` is a scalar, list or tuple, `replace` uses the method parameter (default ‘pad’) to do the replacement. So this is why the ‘a’ values are being replaced by 10 in rows 1 and 2 and ‘b’ in row 4 in this case. The command `s.replace('a', None)` is actually equivalent to `s.replace(to_replace='a', value=None, method='pad')`:

```python
>>> s.replace('a', None)
0     10
1     10
2     10
3     b
4     b
dtype: object
```

```python
pandas.Series.resample
```

Series.resample(rule, how=None, axis=0, fill_method=None, closed=None, label=None, convention='start', kind=None, loffset=None, limit=None, base=0, on=None, level=None)

Convenience method for frequency conversion and resampling of time series. Object must have a datetime-like index (DatetimeIndex, PeriodIndex, or TimedeltaIndex), or pass datetime-like values to the on or level keyword.
Parameters  

**rule**: string  

the offset string or object representing target conversion  

**axis**: [int, optional, default 0]  

**closed**: {'right', 'left'}  

Which side of bin interval is closed. The default is ‘left’ for all frequency offsets except for ‘M’, ‘A’, ‘Q’, ‘BM’, ‘BA’, ‘BQ’, and ‘W’ which all have a default of ‘right’.  

**label**: {'right', 'left'}  

Which bin edge label to label bucket with. The default is ‘left’ for all frequency offsets except for ‘M’, ‘A’, ‘Q’, ‘BM’, ‘BA’, ‘BQ’, and ‘W’ which all have a default of ‘right’.

**convention**: {'start', 'end', 's', 'e'}  

For PeriodIndex only, controls whether to use the start or end of **rule**

**kind**: {'timestamp', 'period'}, optional  

Pass ‘timestamp’ to convert the resulting index to a DateTimeIndex or ‘period’ to convert it to a PeriodIndex. By default the input representation is retained.

**loffset**: timedelta  

Adjust the resampled time labels  

**base**: int, default 0  

For frequencies that evenly subdivide 1 day, the “origin” of the aggregated intervals. For example, for ‘5min’ frequency, base could range from 0 through 4. Defaults to 0  

**on**: string, optional  

For a DataFrame, column to use instead of index for resampling. Column must be datetime-like.

New in version 0.19.0.  

**level**: string or int, optional  

For a MultiIndex, level (name or number) to use for resampling. Level must be datetime-like.

New in version 0.19.0.

Returns

Resampler object

See also:

**groupby**  

Group by mapping, function, label, or list of labels.
Notes

See the user guide for more.

To learn more about the offset strings, please see this link.

Examples

Start by creating a series with 9 one minute timestamps.

```python
>>> index = pd.date_range('1/1/2000', periods=9, freq='T')
>>> series = pd.Series(range(9), index=index)
>>> series
2000-01-01 00:00:00    0
2000-01-01 00:01:00    1
2000-01-01 00:02:00    2
2000-01-01 00:03:00    3
2000-01-01 00:04:00    4
2000-01-01 00:05:00    5
2000-01-01 00:06:00    6
2000-01-01 00:07:00    7
2000-01-01 00:08:00    8
Freq: T, dtype: int64
```

Downsample the series into 3 minute bins and sum the values of the timestamps falling into a bin.

```python
>>> series.resample('3T').sum()
2000-01-01 00:00:00    3
2000-01-01 00:03:00   12
2000-01-01 00:06:00   21
Freq: 3T, dtype: int64
```

Downsample the series into 3 minute bins as above, but label each bin using the right edge instead of the left. Please note that the value in the bucket used as the label is not included in the bucket, which it labels. For example, in the original series the bucket 2000-01-01 00:03:00 contains the value 3, but the summed value in the resampled bucket with the label 2000-01-01 00:03:00 does not include 3 (if it did, the summed value would be 6, not 3). To include this value close the right side of the bin interval as illustrated in the example below this one.

```python
>>> series.resample('3T', label='right').sum()
2000-01-01 00:03:00    3
2000-01-01 00:06:00   12
2000-01-01 00:09:00   21
Freq: 3T, dtype: int64
```

Downsample the series into 3 minute bins as above, but close the right side of the bin interval.

```python
>>> series.resample('3T', label='right', closed='right').sum()
2000-01-01 00:00:00    0
2000-01-01 00:03:00    6
2000-01-01 00:06:00   15
2000-01-01 00:09:00   15
Freq: 3T, dtype: int64
```

Upsample the series into 30 second bins.
Upsample the series into 30 second bins and fill the NaN values using the `pad` method.

```
>>> series.resample('30S').pad()[0:5]
2000-01-01 00:00:00   0
2000-01-01 00:00:30  0
2000-01-01 00:01:00   1
2000-01-01 00:01:30   1
2000-01-01 00:02:00   2
Freq: 30S, dtype: int64
```

Upsample the series into 30 second bins and fill the NaN values using the `bfill` method.

```
>>> series.resample('30S').bfill()[0:5]
2000-01-01 00:00:00   0
2000-01-01 00:00:30   1
2000-01-01 00:01:00   1
2000-01-01 00:01:30   2
2000-01-01 00:02:00   2
Freq: 30S, dtype: int64
```

Pass a custom function via `apply`

```
>>> def custom_resampler(array_like):
...     return np.sum(array_like)+5

>>> series.resample('3T').apply(custom_resampler)
2000-01-01 00:00:00    8
2000-01-01 00:03:00   17
2000-01-01 00:06:00   26
Freq: 3T, dtype: int64
```

For a Series with a PeriodIndex, the keyword `convention` can be used to control whether to use the start or end of `rule`.

```
>>> s = pd.Series([1, 2], index=pd.period_range('2012-01-01', freq='A', periods=2))

>>> s
2012   1
2013   2
Freq: A-DEC, dtype: int64

>>> s.resample('M', convention='start').asfreq().head()
2012-01   1.0
2012-02   NaN
2012-03   NaN
2012-04   NaN
```

(continues on next page)
Resample by month using ‘end’ convention. Values are assigned to the last month of the period.

```python
>>> s.resample('M', convention='end').asfreq()
2012-12 1.0
2013-01 NaN
2013-02 NaN
2013-03 NaN
2013-04 NaN
2013-05 NaN
2013-06 NaN
2013-07 NaN
2013-08 NaN
2013-09 NaN
2013-10 NaN
2013-11 NaN
2013-12 2.0
Freq: M, dtype: float64
```

For DataFrame objects, the keyword `on` can be used to specify the column instead of the index for resampling.

```python
>>> df = pd.DataFrame(data=9*[range(4)], columns=['a', 'b', 'c', 'd'])
>>> df['time'] = pd.date_range('1/1/2000', periods=9, freq='T')
>>> df.resample('3T', on='time').sum()
a  b  c  d
<table>
<thead>
<tr>
<th>time</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-01 00:00:00</td>
</tr>
<tr>
<td>2000-01-01 00:03:00</td>
</tr>
<tr>
<td>2000-01-01 00:06:00</td>
</tr>
</tbody>
</table>
```

For a DataFrame with MultiIndex, the keyword `level` can be used to specify on level the resampling needs to take place.

```python
>>> time = pd.date_range('1/1/2000', periods=5, freq='T')
>>> df2 = pd.DataFrame(data=10*[range(4)], columns=['a', 'b', 'c', 'd'],
                   index=pd.MultiIndex.from_product([time, [1, 2]])
                   )
>>> df2.resample('3T', level=0).sum()
a  b  c  d
<table>
<thead>
<tr>
<th>time</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-01 00:00:00</td>
</tr>
<tr>
<td>2000-01-01 00:03:00</td>
</tr>
</tbody>
</table>
```

**pandas.Series.reset_index**

Series.reset_index(level=None, drop=False, name=None, inplace=False)

Generate a new DataFrame or Series with the index reset.

This is useful when the index needs to be treated as a column, or when the index is meaningless and needs to be reset to the default before another operation.

**Parameters**

- `level` : int, str, tuple, or list, default optional
For a Series with a MultiIndex, only remove the specified levels from the index. 
Removes all levels by default.

**drop**: bool, default False

Just reset the index, without inserting it as a column in the new DataFrame.

**name**: object, optional

The name to use for the column containing the original Series values. Uses 
self.name by default. This argument is ignored when **drop** is True.

**inplace**: bool, default False

Modify the Series in place (do not create a new object).

**Returns** Series or DataFrame

When **drop** is False (the default), a DataFrame is returned. The newly created 
columns will come first in the DataFrame, followed by the original Series values. 
When **drop** is True, a Series is returned. In either case, if **inplace=True**, no 
value is returned.

See also:

`DataFrame.reset_index` Analogous function for DataFrame.

**Examples**

```python
>>> s = pd.Series([1, 2, 3, 4], name='foo', 
                 index=pd.Index(['a', 'b', 'c', 'd'], name='idx'))
```

Generate a DataFrame with default index.

```python
>>> s.reset_index()
   idx  foo
0   a   1
1   b   2
2   c   3
3   d   4
```

To specify the name of the new column use **name**.

```python
>>> s.reset_index(name='values')
   idx  values
0   a     1
1   b     2
2   c     3
3   d     4
```

To generate a new Series with the default set **drop** to True.

```python
>>> s.reset_index(drop=True)
0   1
1   2
2   3
3   4
Name: foo, dtype: int64
```
To update the Series in place, without generating a new one set *inplace* to True. Note that it also requires *drop=True*.

```python
>>> s.reset_index(inplace=True, drop=True)
```

```python
>>> s
0 1
1 2
2 3
3 4
Name: foo, dtype: int64
```

The *level* parameter is interesting for Series with a multi-level index.

```python
>>> arrays = [np.array(['bar', 'bar', 'baz', 'baz']),
...           np.array(['one', 'two', 'one', 'two'])]
>>> s2 = pd.Series(...
...                  range(4), name='foo',
...                  index=pd.MultiIndex.from_arrays(arrays,
...                                                   names=['a', 'b']))
```

To remove a specific level from the Index, use *level*.

```python
>>> s2.reset_index(level='a')
   a  foo
   b
   one  bar  0
   two  bar  1
   one  baz  2
   two  baz  3
```

If *level* is not set, all levels are removed from the Index.

```python
>>> s2.reset_index()
   a  b  foo
   0  bar  one  0
   1  bar  two  1
   2  baz  one  2
   3  baz  two  3
```

### pandas.Series.rfloordiv

`Series.rfloordiv(other, level=None, fill_value=None, axis=0)`

Integer division of series and other, element-wise (binary operator `rfloordiv`).

Equivalent to `other // series`, but with support to substitute a `fill_value` for missing data in one of the inputs.

**Parameters**

- **other** [Series or scalar value]
- **fill_value** : None or float value, default None (NaN)

  Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing
- **level** : int or name
Broadcast across a level, matching Index values on the passed MultiIndex level

Returns

result [Series]

See also:

Series.floordiv

Examples

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a 1.0
b 1.0
c 1.0
d NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a 1.0
b NaN
d 1.0
e NaN
dtype: float64
>>> a.add(b, fill_value=0)
a 2.0
b 1.0
c 1.0
d 1.0
e NaN
dtype: float64
```

**pandas.Series.rmod**

Series.rmod(other, level=None, fill_value=None, axis=0)

Modulo of series and other, element-wise (binary operator rmod).

Equivalent to other % series, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters

other [Series or scalar value]

fill_value : None or float value, default None (NaN)

Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

Returns

result [Series]
See also:

*Series.mod*

**Examples**

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a    1.0
b    1.0
c    1.0
d    NaN
dtype: float64

>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a    1.0
b    NaN
d    1.0
e    NaN
dtype: float64

>>> a.add(b, fill_value=0)
```

**pandas.Series.rmul**

*Series.rmul* (*other*, *level=None*, *fill_value=None*, *axis=0*)

Multiplication of series and other, element-wise (binary operator *rmul*).

Equivalent to *other * series, but with support to substitute a fill_value for missing data in one of the inputs.

**Parameters**

- **other** [Series or scalar value]
- **fill_value** : None or float value, default None (NaN)
  
  Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing
- **level** : int or name
  
  Broadcast across a level, matching Index values on the passed MultiIndex level

**Returns**

- **result** [Series]

**See also:**

*Series.mul*
Examples

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a 1.0
b 1.0
c 1.0
d NaN
dtype: float64
```

```python
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a 1.0
b NaN
d 1.0
e NaN
dtype: float64
```

```python
>>> a.add(b, fill_value=0)
a 2.0
b 1.0
c 1.0
d 1.0
e NaN
dtype: float64
```

**pandas.Series.rolling**

`Series.rolling`(window, min_periods=None, center=False, win_type=None, on=None, axis=0, closed=None)

Provides rolling window calculations.

New in version 0.18.0.

**Parameters**

- `window` : int, or offset
  
  Size of the moving window. This is the number of observations used for calculating the statistic. Each window will be a fixed size.

  If it’s an offset then this will be the time period of each window. Each window will be a variable sized based on the observations included in the time-period. This is only valid for datetimelike indexes. This is new in 0.19.0

- `min_periods` : int, default None
  
  Minimum number of observations in window required to have a value (otherwise result is NA). For a window that is specified by an offset, this will default to 1.

- `center` : boolean, default False
  
  Set the labels at the center of the window.

- `win_type` : string, default None
  
  Provide a window type. If None, all points are evenly weighted. See the notes below for further information.

- `on` : string, optional
  
  For a DataFrame, column on which to calculate the rolling window, rather than the index
closed : string, default None

Make the interval closed on the ‘right’, ‘left’, ‘both’ or ‘neither’ endpoints. For
offset-based windows, it defaults to ‘right’. For fixed windows, defaults to ‘both’.
Remaining cases not implemented for fixed windows.

New in version 0.20.0.

axis [int or string, default 0]

Returns

a Window or Rolling sub-classed for the particular operation

See also:

expanding Provides expanding transformations.

ewm Provides exponential weighted functions

Notes

By default, the result is set to the right edge of the window. This can be changed to the center of the
window by setting center=True.

To learn more about the offsets & frequency strings, please see this link.

The recognized win_types are:

• boxcar
• triang
• blackman
• hamming
• bartlett
• parzen
• bohman
• blackmanharris
• nuttall
• barthann
• kaiser (needs beta)
• gaussian (needs std)
• general_gaussian (needs power, width)
• slepian (needs width).

If win_type= None all points are evenly weighted. To learn more about different window types see
scipy.signal window functions.
Examples

```python
>>> df = pd.DataFrame({'B': [0, 1, 2, np.nan, 4]})
>>> df
   B
0  0.0
1  1.0
2  2.0
3   NaN
4  4.0

Rolling sum with a window length of 2, using the 'triang' window type.

```python
code=>>> df.rolling(2, win_type='triang').sum()

```
   B
0   NaN
1  1.0
2  2.5
3   NaN
4   NaN
```

Rolling sum with a window length of 2, min_periods defaults to the window length.

```python
code=>>> df.rolling(2).sum()

```
   B
0   NaN
1  1.0
2  3.0
3   NaN
4   NaN

Same as above, but explicitly set the min_periods

```python
code=>>> df.rolling(2, min_periods=1).sum()

```
   B
0   0.0
1   1.0
2   3.0
3   2.0
4   4.0

A ragged (meaning not-a-regular frequency), time-indexed DataFrame

```python
code=>>> df = pd.DataFrame({'B': [0, 1, 2, np.nan, 4]},
index = [pd.Timestamp('20130101 09:00:00'),
         pd.Timestamp('20130101 09:00:02'),
         pd.Timestamp('20130101 09:00:03'),
         pd.Timestamp('20130101 09:00:05'),
         pd.Timestamp('20130101 09:00:06')])

```
   B
2013-01-01 09:00:00   0.0
2013-01-01 09:00:02   1.0
2013-01-01 09:00:03   2.0
2013-01-01 09:00:05   NaN
2013-01-01 09:00:06   4.0

34.3. Series
Contrasting to an integer rolling window, this will roll a variable length window corresponding to the time period. The default for `min_periods` is 1.

```python
>>> df.rolling('2s').sum()
    B
2013-01-01 09:00:00    0.0
2013-01-01 09:00:02    1.0
2013-01-01 09:00:03    3.0
2013-01-01 09:00:05   NaN
2013-01-01 09:00:06    4.0
```

### Pandas.Series.round

`Series.round(decimals=0, *args, **kwargs)`

Round each value in a Series to the given number of decimals.

**Parameters**

- `decimals` : int
  
  Number of decimal places to round to (default: 0). If `decimals` is negative, it specifies the number of positions to the left of the decimal point.

**Returns**

- Series object

**See also:**

- `numpy.around`, `DataFrame.round`

### Pandas.Series.rpow

`Series.rpow(other, level=None, fill_value=None, axis=0)`

Exponential power of series and other, element-wise (binary operator `rpow`).

Equivalent to `other ** series`, but with support to substitute a `fill_value` for missing data in one of the inputs.

**Parameters**

- `other` [Series or scalar value]
- `fill_value` : None or float value, default None (NaN)
  
  Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing
- `level` : int or name
  
  Broadcast across a level, matching Index values on the passed MultiIndex level

**Returns**

- `result` [Series]

**See also:**

- `Series.pow`
Examples

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a 1.0
b 1.0
c 1.0
d NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a 1.0
b NaN
d 1.0
e NaN
dtype: float64
>>> a.add(b, fill_value=0)
a 2.0
b 1.0
c 1.0
d 1.0
e NaN
dtype: float64
```

**pandas.Series.rsub**

Series.rsub(other, level=None, fill_value=None, axis=0)

Subtraction of series and other, element-wise (binary operator \( \text{rsub} \)).

Equivalent to other - series, but with support to substitute a fill_value for missing data in one of the inputs.

**Parameters**

other [Series or scalar value]

fill_value : None or float value, default None (NaN)

Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

**Returns**

result [Series]

**See also:**

Series.sub

**Examples**
pandas.Series.rtruediv

**Series.rtruediv** *(other, level=None, fill_value=None, axis=0)*

Floating division of series and other, element-wise (binary operator `rtruediv`).

Equivalent to `other / series`, but with support to substitute a fill_value for missing data in one of the inputs.

**Parameters**

- **other** [Series or scalar value]
- **fill_value** : None or float value, default None (NaN)
  
  Fill existing missing (NaN) values, and any new element needed for successful 
  Series alignment, with this value before computation. If data in both correspond-
  ing Series locations is missing the result will be missing
- **level** : int or name
  
  Broadcast across a level, matching Index values on the passed MultiIndex level

**Returns**

- **result** [Series]

**See also:**

*Series.truediv*

**Examples**

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a 1.0
b 1.0
c 1.0
d NaN
dtype: float64

>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a 1.0
b NaN
d 1.0
e NaN
dtype: float64

>>> a.add(b, fill_value=0)
a 2.0
b 1.0
c 1.0
d 1.0
e NaN
dtype: float64
```

(continues on next page)
b 1.0
c 1.0
d NaN
dtype: float64

```python
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a 1.0
b NaN
d 1.0
e NaN
dtype: float64
```

```python
da.add(b, fill_value=0)
```

```javascript
a 2.0
b 1.0
c 1.0
d 1.0
e NaN
dtype: float64
```

**pandas.Series.sample**

Series.sample(n=None, frac=None, replace=False, weights=None, random_state=None, axis=None)

Return a random sample of items from an axis of object.

You can use random_state for reproducibility.

**Parameters**

- **n**: int, optional
  Number of items from axis to return. Cannot be used with frac. Default = 1 if frac = None.

- **frac**: float, optional
  Fraction of axis items to return. Cannot be used with n.

- **replace**: boolean, optional
  Sample with or without replacement. Default = False.

- **weights**: str or ndarray-like, optional
  Default ‘None’ results in equal probability weighting. If passed a Series, will align with target object on index. Index values in weights not found in sampled object will be ignored and index values in sampled object not in weights will be assigned weights of zero. If called on a DataFrame, will accept the name of a column when axis = 0. Unless weights are a Series, weights must be same length as axis being sampled. If weights do not sum to 1, they will be normalized to sum to 1. Missing values in the weights column will be treated as zero. inf and -inf values not allowed.

- **random_state**: int or numpy.random.RandomState, optional
  Seed for the random number generator (if int), or numpy RandomState object.

- **axis**: int or string, optional
  Axis to sample. Accepts axis number or name. Default is stat axis for given data type (0 for Series and DataFrames, 1 for Panels).
Returns

A new object of same type as caller.

Examples

Generate an example Series and DataFrame:

```python
>>> s = pd.Series(np.random.randn(50))
>>> s.head()
0    -0.038497
1     1.820773
2     1.972766
3    -1.598270
4    -1.095526
dtype: float64

>>> df = pd.DataFrame(np.random.randn(50, 4), columns=list('ABCD'))
>>> df.head()
   A            B            C            D
0  0.016443    -2.318952    -0.566372    -1.028078
1 -1.051921     0.438836     0.658280    -0.175797
2 -1.243569    -0.364626    -0.215065     0.057736
3  1.768216     0.404512    -0.385604    -1.457834
4  1.072446    -1.137172     0.314194    -0.046661
dtype: float64
```

Next extract a random sample from both of these objects...

3 random elements from the Series:

```python
>>> s.sample(n=3)
27    0.994689
55   -1.049016
67   -0.224565
dtype: float64
```

And a random 10% of the DataFrame with replacement:

```python
>>> df.sample(frac=0.1, replace=True)
   A        B        C        D
35  1.981780  0.142106  1.817165 -0.290805
49 -1.336199 -0.448634 -0.789640  0.217116
40  0.823173 -0.078816  1.009536  1.015108
15  1.421154 -0.055301 -1.922594 -0.019696
  6 -0.148339  0.832938  1.787600 -1.383767
```

You can use random state for reproducibility:

```python
>>> df.sample(random_state=1)
   A       B       C       D
37 -2.027662  0.103611  0.237496 -0.165867
43 -0.259323 -0.583426  1.516140 -0.479118
12 -1.686325 -0.579510  0.985195  0.460286
  8  1.167946  0.429082  1.215742 -1.636041
  9  1.197475 -0.864188  1.554031 -1.505264
```

Series.searchsorted(value, side='left', sorter=None)

Find indices where elements should be inserted to maintain order.

Find the indices into a sorted Series self such that, if the corresponding elements in value were inserted before the indices, the order of self would be preserved.

Parameters

value : array_like
    Values to insert into self.

side : {'left', 'right'}, optional
    If 'left', the index of the first suitable location found is given. If 'right', return the last such index. If there is no suitable index, return either 0 or N (where N is the length of self).

sorter : 1-D array_like, optional
    Optional array of integer indices that sort self into ascending order. They are typically the result of np.argsort.

Returns

indices : array of ints
    Array of insertion points with the same shape as value.

See also:

numpy.searchsorted

Notes

Binary search is used to find the required insertion points.

Examples

```python
>>> x = pd.Series([1, 2, 3])
>>> x
0 1
1 2
2 3
dtype: int64

>>> x.searchsorted(4)
array([3])

>>> x.searchsorted([0, 4])
array([0, 3])

>>> x.searchsorted([1, 3], side='left')
array([0, 2])

>>> x.searchsorted([1, 3], side='right')
array([1, 3])
```
```python
>>> x = pd.Categorical(['apple', 'bread', 'bread', 'cheese', 'milk'], ordered=True)
[apple, bread, bread, cheese, milk]
Categories (4, object): [apple < bread < cheese < milk]

>>> x.searchsorted('bread')
array([1])  # Note: an array, not a scalar

>>> x.searchsorted(['bread'], side='right')
array([3])
```

**pandas.Series.select**

Series.select (crit, axis=0)

Return data corresponding to axis labels matching criteria.

Deprecated since version 0.21.0: Use df.loc[df.index.map(crit)] to select via labels

**Parameters**

- crit : function
  To be called on each index (label). Should return True or False

- axis : int

**Returns**

- selection : [type of caller]

**pandas.Series.sem**

Series.sem (axis=None, skipna=None, level=None, ddof=1, numeric_only=None, **kwargs)

Return unbiased standard error of the mean over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument

**Parameters**

- axis : [index (0)]

- skipna : boolean, default True
  Exclude NA/null values. If an entire row/column is NA, the result will be NA

- level : int or level name, default None
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar

- ddof : int, default 1
  Delta Degrees of Freedom. The divisor used in calculations is N - ddof, where N represents the number of elements.

- numeric_only : boolean, default None
  Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**
sem  [scalar or Series (if level specified)]

pandas.Series.set_axis

Series.set_axis(labels, axis=0, inplace=None)
Assign desired index to given axis.
Indexes for column or row labels can be changed by assigning a list-like or Index.
Changed in version 0.21.0: The signature is now labels and axis, consistent with the rest of pandas API.
Previously, the axis and labels arguments were respectively the first and second positional arguments.

Parameters labels : list-like, Index
    The values for the new index.
axis : {0 or ‘index’, 1 or ‘columns’}, default 0
    The axis to update. The value 0 identifies the rows, and 1 identifies the columns.
inplace : boolean, default None
    Whether to return a new %%(klass)s instance.

Warning: inplace=None currently falls back to to True, but in a future version, will default to False. Use inplace=True explicitly rather than relying on the default.

Returns renamed : %%(klass)s or None
    An object of same type as caller if inplace=False, None otherwise.

See also:
pandas.DataFrame.rename_axis Alter the name of the index or columns.

Examples

Series

>>> s = pd.Series([1, 2, 3])
>>> s
0  1
1  2
2  3
dtype: int64

>>> s.set_axis(['a', 'b', 'c'], axis=0, inplace=False)
a  1
b  2
c  3
dtype: int64

The original object is not modified.
```python
>>> s
0  1
1  2
2  3
dtype: int64
```

DataFrame

```python
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
```

Change the row labels.

```python
>>> df.set_axis(['a', 'b', 'c'], axis='index', inplace=False)
   A  B
a 1  4
b 2  5
c 3  6
```

Change the column labels.

```python
>>> df.set_axis(['I', 'II'], axis='columns', inplace=False)
   I  II
0 1  4
1 2  5
2 3  6
```

Now, update the labels inplace.

```python
>>> df.set_axis(['i', 'ii'], axis='columns', inplace=True)
>>> df
   i  ii
0 1  4
1 2  5
2 3  6
```

**pandas.Series.set_value**

```
Series.set_value(label, value, takeable=False)
```

Quickly set single value at passed label. If label is not contained, a new object is created with the label placed at the end of the result index.

Deprecated since version 0.21.0: Please use .at[] or .iat[] accessors.

**Parameters**

- **label**: object
  - Partial indexing with MultiIndex not allowed
- **value**: object
  - Scalar value
- **takeable**: [interpret the index as indexers, default False]

**Returns**

- **series**: Series
  - If label is contained, will be reference to calling Series, otherwise a new object
pandas.Series.shift

Series.shift((periods=1, freq=None, axis=0))
Shift index by desired number of periods with an optional time freq

Parameters

periods : int
    Number of periods to move, can be positive or negative
freq : DateOffset, timedelta, or time rule string, optional
    Increment to use from the tseries module or time rule (e.g. ‘EOM’). See Notes.
axis [{0 or ‘index’}]

Returns

shifted [Series]

Notes

If freq is specified then the index values are shifted but the data is not realigned. That is, use freq if you would like to extend the index when shifting and preserve the original data.

pandas.Series.skew

Series.skew((axis=None, skipna=None, level=None, numeric_only=None, **kwargs))
Return unbiased skew over requested axis Normalized by N-1

Parameters

axis [{index (0)}]
skipna : boolean, default True
    Exclude NA/null values when computing the result.
level : int or level name, default None
    If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar
numeric_only : boolean, default None
    Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns

skew [scalar or Series (if level specified)]

pandas.Series.slice_shift

Series.slice_shift((periods=1, axis=0))
Equivalent to shift without copying data. The shifted data will not include the dropped periods and the shifted axis will be smaller than the original.

Parameters

periods : int
Number of periods to move, can be positive or negative

Returns

- shifted [same type as caller]

Notes

While the `slice_shift` is faster than `shift`, you may pay for it later during alignment.

**pandas.Series.sort_index**

```python
call = Series.sort_index(axis=0, level=None, ascending=True, inplace=False, kind='quicksort', na_position='last', sort_remaining=True)
```

Sort Series by index labels.

- Returns a new Series sorted by label if `inplace` argument is `False`, otherwise updates the original series and returns `None`.

**Parameters**

- **axis**: int, default 0
  - Axis to direct sorting. This can only be 0 for Series.

- **level**: int, optional
  - If not `None`, sort on values in specified index level(s).

- **ascending**: bool, default `True`
  - Sort ascending vs. descending.

- **inplace**: bool, default `False`
  - If `True`, perform operation in-place.

- **kind**: {'quicksort', 'mergesort', 'heapsort'}, default ‘quicksort’
  - Choice of sorting algorithm. See also `numpy.sort()` for more information. ‘mergesort’ is the only stable algorithm. For DataFrames, this option is only applied when sorting on a single column or label.

- **na_position**: {'first', 'last'}, default ‘last’
  - If ‘first’ puts NaNs at the beginning, ‘last’ puts NaNs at the end. Not implemented for MultiIndex.

- **sort_remaining**: bool, default `True`
  - If `True and sorting by level and index is multilevel, sort by other levels too (in order) after sorting by specified level.

Returns **pandas.Series**

- The original Series sorted by the labels

See also:

- `DataFrame.sort_index` Sort DataFrame by the index
- `DataFrame.sort_values` Sort DataFrame by the value
- `Series.sort_values` Sort Series by the value
Examples

```python
>>> s = pd.Series(['a', 'b', 'c', 'd'], index=[3, 2, 1, 4])
>>> s.sort_index()
1   c
2   b
3   a
4   d
dtype: object

Sort Descending

```python
>>> s.sort_index(ascending=False)
4   d
3   a
2   b
1   c
dtype: object

Sort Inplace

```python
>>> s.sort_index(inplace=True)
```  
```python
>>> s
1   c
2   b
3   a
4   d
dtype: object

By default NaNs are put at the end, but use na_position to place them at the beginning

```python
>>> s = pd.Series(['a', 'b', 'c', 'd'], index=[3, 2, 1, np.nan])
>>> s.sort_index(na_position='first')
NaN   d
1.0   c
2.0   b
3.0   a
dtype: object

Specify index level to sort

```python
>>> arrays = [np.array(['qux', 'qux', 'foo', 'foo',  
'baz', 'baz', 'bar', 'bar']),  
...     np.array(['two', 'one', 'two', 'one', 
'one', 'two', 'two', 'one'])]
>>> s = pd.Series([1, 2, 3, 4, 5, 6, 7, 8], index=arrays)
>>> s.sort_index(level=1)
bar one    8
baz one    6
foo one    4
qux one    2
bar two    7
baz two    5
foo two    3
qux two    1
dtype: int64

Does not sort by remaining levels when sorting by levels

34.3. Series
pandas.Series.sort_values

Series.sort_values (axis=0, ascending=True, inplace=False, kind='quicksort', na_position='last')
Sort by the values.
Sort a Series in ascending or descending order by some criterion.

Parameters axis : {0 or ‘index’}, default 0
Axis to direct sorting. The value ‘index’ is accepted for compatibility with DataFrame.sort_values.
ascending : bool, default True
If True, sort values in ascending order, otherwise descending.
inplace : bool, default False
If True, perform operation in-place.
kind : {‘quicksort’, ‘mergesort’ or ‘heapsort’}, default ‘quicksort’
Choice of sorting algorithm. See also numpy.sort() for more information. ‘mergesort’ is the only stable algorithm.
na_position : {‘first’ or ‘last’}, default ‘last’
Argument ‘first’ puts NaNs at the beginning, ‘last’ puts NaNs at the end.

Returns Series
Series ordered by values.

See also:
Series.sort_index Sort by the Series indices.
DataFrame.sort_values Sort DataFrame by the values along either axis.
DataFrame.sort_index Sort DataFrame by indices.

Examples

```python
>>> s = pd.Series([np.nan, 1, 3, 10, 5])
>>> s
0   NaN
1   1.0
```
Sort values ascending order (default behaviour)

```python
>>> s.sort_values(ascending=True)
  0   NaN
  1  1.0
  2  3.0
  3  5.0
  4 10.0
dtype: float64
```

Sort values descending order

```python
>>> s.sort_values(ascending=False)
  3 10.0
  4  5.0
  2  3.0
  1  1.0
  0   NaN
dtype: float64
```

Sort values inplace

```python
>>> s.sort_values(ascending=False, inplace=True)
```

Sort values putting NAs first

```python
>>> s.sort_values(na_position='first')
  0   NaN
  1  1.0
  2  3.0
  3  5.0
  4 10.0
dtype: float64
```

Sort a series of strings

```python
>>> s = pd.Series(['z', 'b', 'd', 'a', 'c'])
>>> s
0 z
1 b
2 d
3 a
4 c
dtype: object
```
```python
>>> s.sort_values()
3   a
1   b
4   c
2   d
0   z
dtype: object
```

**pandas.Series.sortlevel**

`Series.sortlevel(level=0, ascending=True, sort_remaining=True)`

Sort Series with MultiIndex by chosen level. Data will be lexicographically sorted by the chosen level followed by the other levels (in order).

Deprecated since version 0.20.0: Use `Series.sort_index()`.

**Parameters**

- `level` [int or level name, default None]
- `ascending` [bool, default True]

**Returns**

- `sorted` [Series]

**See also:**

`Series.sort_index`

**pandas.Series.squeeze**

`Series.squeeze(axis=None)`

Squeeze length 1 dimensions.

**Parameters**

- `axis` : None, integer or string axis name, optional
  
  The axis to squeeze if 1-sized.

**Returns**

- `scalar if 1-sized, else original object`

**pandas.Series.std**

`Series.std(axis=None, skipna=None, level=None, ddof=1, numeric_only=None, **kwargs)`

Return sample standard deviation over requested axis.

Normalized by N-1 by default. This can be changed using the `ddof` argument.

**Parameters**

- `axis` [{index (0)}]
- `skipna` : boolean, default True

  Exclude NA/null values. If an entire row/column is NA, the result will be NA.
level : int or level name, default None
    If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing
    into a scalar

ddf : int, default 1
    Delta Degrees of Freedom. The divisor used in calculations is N - ddf, where N
    represents the number of elements.

numeric_only : boolean, default None
    Include only float, int, boolean columns. If None, will attempt to use everything,
    then use only numeric data. Not implemented for Series.

Returns

std [scalar or Series (if level specified)]

pandas.Series.str

Series.str()
Vectorized string functions for Series and Index. NAs stay NA unless handled otherwise by a particular
method. Patterned after Python’s string methods, with some inspiration from R’s stringr package.

Examples

>>> s.str.split('_')
>>> s.str.replace('_', '')

pandas.Series.sub

Series.sub(other, level=None, fill_value=None, axis=0)
Subtraction of series and other, element-wise (binary operator sub).
Equivalent to series - other, but with support to substitute a fill_value for missing data in one of
the inputs.

Parameters

other [Series or scalar value]
fill_value : None or float value, default None (NaN)
    Fill existing missing (NaN) values, and any new element needed for successful
    Series alignment, with this value before computation. If data in both correspond-
    ing Series locations is missing the result will be missing
level : int or name
    Broadcast across a level, matching Index values on the passed MultiIndex level

Returns

result [Series]

See also:

Series.rsub
Examples

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a 1.0
b 1.0
c 1.0
d NaN
dtype: float64

>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])

>>> b
a 1.0
b NaN
d 1.0
e NaN
dtype: float64

>>> a.add(b, fill_value=0)
a 2.0
b 1.0
c 1.0
d 1.0
e NaN
dtype: float64
```

**pandas.Series.subtract**

Series.subtract(other, level=None, fill_value=None, axis=0)

Subtraction of `series` and `other`, element-wise (binary operator sub).

Equivalent to `series - other`, but with support to substitute a `fill_value` for missing data in one of the inputs.

**Parameters**

- **other** [Series or scalar value]
- **fill_value** : None or float value, default None (NaN)
  
  Fill existing missing (NaN) values, and any new element needed for successful Series alignment, with this value before computation. If data in both corresponding Series locations is missing the result will be missing

- **level** : int or name
  
  Broadcast across a level, matching Index values on the passed MultiIndex level

**Returns**

- **result** [Series]

**See also:**

Series.rsub

**Examples**
```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a  1.0
b  1.0
c  1.0
d  NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a  1.0
b  NaN
d  1.0
e  NaN
dtype: float64
>>> a.add(b, fill_value=0)
a  2.0
b  1.0
c  1.0
d  1.0
e  NaN
dtype: float64
```

**pandas.Series.sum**

`Series.sum (axis=None, skipna=None, level=None, numeric_only=None, min_count=0, **kwargs)`

Return the sum of the values for the requested axis

**Parameters**

- **axis**: [index (0)]
- **skipna**: boolean, default True
  
  Exclude NA/null values when computing the result.
- **level**: int or level name, default None
  
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a scalar.
- **numeric_only**: boolean, default None
  
  Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.
- **min_count**: int, default 0
  
  The required number of valid values to perform the operation. If fewer than `min_count` non-NA values are present the result will be NA.

**Returns**

- **sum**: [scalar or Series (if level specified)]
Examples

By default, the sum of an empty or all-NA Series is 0.

```python
>>> pd.Series([]).sum()  # min_count=0 is the default
0.0
```

This can be controlled with the `min_count` parameter. For example, if you’d like the sum of an empty series to be NaN, pass `min_count=1`.

```python
>>> pd.Series([]).sum(min_count=1)
nan
```

Thanks to the `skipna` parameter, `min_count` handles all-NA and empty series identically.

```python
>>> pd.Series([np.nan]).sum()
0.0
```

```python
>>> pd.Series([np.nan]).sum(min_count=1)
nan
```

**pandas.Series.swapaxes**

`Series.swapaxes(axis1, axis2, copy=True)`

Interchange axes and swap values axes appropriately

**Returns**

y [same as input]

**pandas.Series.swaplevel**

`Series.swaplevel(i=-2, j=-1, copy=True)`

Swap levels i and j in a MultiIndex

**Parameters** i, j : int, string (can be mixed)

Level of index to be swapped. Can pass level name as string.

**Returns**

swapped [Series]

.. versionchanged:: 0.18.1

The indexes i and j are now optional, and default to the two innermost levels of the index.

**pandas.Series.tail**

`Series.tail(n=5)`

Return the last n rows.

This function returns last n rows from the object based on position. It is useful for quickly verifying data, for example, after sorting or appending rows.
Parameters  

**n**: int, default 5

Number of rows to select.

Returns  

**type of caller**

The last \( n \) rows of the caller object.

See also:

**pandas.DataFrame.head** The first \( n \) rows of the caller object.

Examples

```python
>>> df = pd.DataFrame({'animal': ['alligator', 'bee', 'falcon', 'lion', ...
  'monkey', 'parrot', 'shark', 'whale', 'zebra']})
```

Viewing the last 5 lines

```python
>>> df.tail()
   animal
0  alligator
1     bee
2   falcon
3    lion
4  monkey
5  parrot
6   shark
7    whale
8  zebra
```

Viewing the last \( n \) lines (three in this case)

```python
>>> df.tail(3)
   animal
6   shark
7    whale
8  zebra
```

**pandas.Series.take**

**Series.take** (*indices*, *axis*=0, *convert*=None, *is_copy*=True, **kwargs*)

Return the elements in the given *positional* indices along an axis.

This means that we are not indexing according to actual values in the index attribute of the object. We are indexing according to the actual position of the element in the object.

Parameters  

**indices**: array-like

An array of ints indicating which positions to take.
axis : {0 or 'index', 1 or 'columns', None}, default 0

The axis on which to select elements. 0 means that we are selecting rows, 1
means that we are selecting columns.

call : bool, default True

Whether to convert negative indices into positive ones. For example, −1 would
map to the len(axis) − 1. The conversions are similar to the behavior of
indexing a regular Python list.

Deprecated since version 0.21.0: In the future, negative indices will always be
converted.

is_copy : bool, default True

Whether to return a copy of the original object or not.

**kwargs

For compatibility with numpy.take(). Has no effect on the output.

Returns taken : type of caller

An array-like containing the elements taken from the object.

See also:

DataFrame.loc Select a subset of a DataFrame by labels.

DataFrame.iloc Select a subset of a DataFrame by positions.

numpy.take Take elements from an array along an axis.

Examples

```python
>>> df = pd.DataFrame([('falcon', 'bird', 389.0),
...                    ('parrot', 'bird', 24.0),
...                    ('lion', 'mammal', 80.5),
...                    ('monkey', 'mammal', np.nan)],
...                   columns=['name', 'class', 'max_speed'],
...                   index=[0, 2, 3, 1])

>>> df
   name class  max_speed
0  falcon    bird     389.0
2  parrot    bird      24.0
3   lion  mammal      80.5
1 monkey  mammal        NaN

Take elements at positions 0 and 3 along the axis 0 (default).

Note how the actual indices selected (0 and 1) do not correspond to our selected indices 0 and 3. That’s
because we are selecting the 0th and 3rd rows, not rows whose indices equal 0 and 3.

>>> df.take([0, 3])
   name class  max_speed
0  falcon    bird     389.0
1 monkey  mammal        NaN

Take elements at indices 1 and 2 along the axis 1 (column selection).
We may take elements using negative integers for positive indices, starting from the end of the object, just like with Python lists.

```python
>>> df.take([-1, -2])
    name  class  max_speed
1  monkey  mammal        NaN
3     lion  mammal       80.5
```

### pandas.Series.to_clipboard

`Series.to_clipboard(excel=True, sep=None, **kwargs)`

Copy object to the system clipboard.

Write a text representation of object to the system clipboard. This can be pasted into Excel, for example.

**Parameters**

- **excel**: bool, default True
  
  - True, use the provided separator, writing in a csv format for allowing easy pasting into excel.
  
  - False, write a string representation of the object to the clipboard.
  
- **sep**: str, default `\t`
  
  Field delimiter.

**kwargs**

These parameters will be passed to DataFrame.to_csv.

**See also:**

- `DataFrame.to_csv` Write a DataFrame to a comma-separated values (csv) file.
- `read_clipboard` Read text from clipboard and pass to read_table.

### Notes

Requirements for your platform.

- Linux: xclip, or xsel (with gtk or PyQt4 modules)
- Windows: none
- OS X: none

### Examples

Copy the contents of a DataFrame to the clipboard.
We can omit the the index by passing the keyword `index` and setting it to false.

```python
>>> df.to_clipboard(sep=',', index=False)
... # Wrote the following to the system clipboard:
... # A, B, C
... # 1, 2, 3
... # 4, 5, 6
```

### pandas.Series.to_csv

`Series.to_csv(path=None, index=True, sep=',', na_rep='', float_format=None, header=False, index_label=None, mode='w', encoding=None, compression=None, date_format=None, decimal='.')`

Write Series to a comma-separated values (csv) file

**Parameters**

- **path**: string or file handle, default None
  - File path or object, if None is provided the result is returned as a string.
- **na_rep**: string, default “
  - Missing data representation
- **float_format**: string, default None
  - Format string for floating point numbers
- **header**: boolean, default False
  - Write out series name
- **index**: boolean, default True
  - Write row names (index)
- **index_label**: string or sequence, default None
  - Column label for index column(s) if desired. If None is given, and `header` and `index` are True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.
- **mode**: [Python write mode, default ‘w’]
- **sep**: character, default “,”
  - Field delimiter for the output file.
- **encoding**: string, optional
  - a string representing the encoding to use if the contents are non-ascii, for python versions prior to 3
- **compression**: string, optional
A string representing the compression to use in the output file. Allowed values are ‘gzip’, ‘bz2’, ‘zip’, ‘xz’. This input is only used when the first argument is a filename.

date_format: string, default None
Format string for datetime objects.
decimal: string, default ‘.’
Character recognized as decimal separator. E.g. use ‘,’ for European data

pandas.Series.to_dense

Series.to_dense()
Return dense representation of NDFrame (as opposed to sparse)

pandas.Series.to_dict

Series.to_dict(into=<class 'dict'>)
Convert Series to {label -> value} dict or dict-like object.

Parameters into: class, default dict
The collections.Mapping subclass to use as the return object. Can be the actual class or an empty instance of the mapping type you want. If you want a collections.defaultdict, you must pass it initialized.

Returns

value_dict [collections.Mapping]

Examples

>>> s = pd.Series([1, 2, 3, 4])
>>> s.to_dict()
{0: 1, 1: 2, 2: 3, 3: 4}
>>> from collections import OrderedDict, defaultdict
>>> s.to_dict(OrderedDict)
OrderedDict([(0, 1), (1, 2), (2, 3), (3, 4)])
>>> dd = defaultdict(list)
>>> s.to_dict(dd)
defaultdict(<type 'list'>, {0: 1, 1: 2, 2: 3, 3: 4})

pandas.Series.to_excel

Series.to_excel(excel_writer, sheet_name='Sheet1', na_rep='', float_format=None, columns=None, header=True, index=True, index_label=None, startrow=0, startcol=0, engine=None, merge_cells=True, encoding=None, inf_rep='inf', verbose=True)
Write Series to an excel sheet

New in version 0.20.0.
**Parameters**

**excel_writer**: string or ExcelWriter object

- File path or existing ExcelWriter

**sheet_name**: string, default ‘Sheet1’

- Name of sheet which will contain DataFrame

**na_rep**: string, default ‘’

- Missing data representation

**float_format**: string, default None

- Format string for floating point numbers

**columns**: sequence, optional

- Columns to write

**header**: boolean or list of string, default True

- Write out the column names. If a list of strings is given it is assumed to be aliases for the column names

**index**: boolean, default True

- Write row names (index)

**index_label**: string or sequence, default None

- Column label for index column(s) if desired. If None is given, and header and index are True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.

**startrow**: 

- upper left cell row to dump data frame

**startcol**: 

- upper left cell column to dump data frame

**engine**: string, default None

- write engine to use - you can also set this via the options io.excel.xlsx.writer, io.excel.xls.writer, and io.excel.xlsm.writer.

**merge_cells**: boolean, default True

- Write MultiIndex and Hierarchical Rows as merged cells.

**encoding**: string, default None

- encoding of the resulting excel file. Only necessary for xlwt, other writers support unicode natively.

**inf_rep**: string, default ‘inf’

- Representation for infinity (there is no native representation for infinity in Excel)

**freeze_panes**: tuple of integer (length 2), default None

- Specifies the one-based bottommost row and rightmost column that is to be frozen

New in version 0.20.0.
Notes

If passing an existing ExcelWriter object, then the sheet will be added to the existing workbook. This can be used to save different DataFrames to one workbook:

```python
>>> writer = pd.ExcelWriter('output.xlsx')
>>> df1.to_excel(writer,'Sheet1')
>>> df2.to_excel(writer,'Sheet2')
>>> writer.save()
```

For compatibility with to_csv, to_excel serializes lists and dicts to strings before writing.

**pandas.Series.to_frame**

Series.to_frame (name=None)

Convert Series to DataFrame

**Parameters**

name : object, default None

The passed name should substitute for the series name (if it has one).

**Returns**

data_frame [DataFrame]

**pandas.Series.to_hdf**

Series.to_hdf (path_or_buf, key, **kwargs)

Write the contained data to an HDF5 file using HDFStore.

Hierarchical Data Format (HDF) is self-describing, allowing an application to interpret the structure and contents of a file with no outside information. One HDF file can hold a mix of related objects which can be accessed as a group or as individual objects.

In order to add another DataFrame or Series to an existing HDF file please use append mode and a different a key.

For more information see the user guide.

**Parameters**

path_or_buf : str or pandas.HDFStore

File path or HDFStore object.

key : str

Identifier for the group in the store.

mode : {'a', 'w', 'r+'}, default ‘a’

Mode to open file:

• ‘w’: write, a new file is created (an existing file with the same name would be deleted).

• ‘a’: append, an existing file is opened for reading and writing, and if the file does not exist it is created.

• ‘r+’: similar to ‘a’, but the file must already exist.

format : {'fixed', 'table'}, default ‘fixed’
Possible values:

- ‘table’: Table format. Write as a PyTables Table structure which may perform worse but allow more flexible operations like searching / selecting subsets of the data.

**append**: bool, default False

For Table formats, append the input data to the existing.

**data_columns**: list of columns or True, optional

List of columns to create as indexed data columns for on-disk queries, or True to use all columns. By default only the axes of the object are indexed. See *Query via Data Columns*. Applicable only to format='table'.

**complevel**: {0-9}, optional

Specifies a compression level for data. A value of 0 disables compression.

**complib**: {'zlib', ‘lz4’, ‘bzip2’, ‘blosc’}, default ‘zlib’

Specifies the compression library to be used. As of v0.20.2 these additional compressors for Blosc are supported (default if no compressor specified: ‘blosc:blosclz’): {'blosc:blosclz', ‘blosc:lz4’, ‘blosc:lz4hc’, ‘blosc:snappy’, ‘blosc:zlib’, ‘blosc:zstd’}. Specifying a compression library which is not available issues a ValueError.

**fletcher32**: bool, default False

If applying compression use the fletcher32 checksum.

**dropna**: bool, default False

If true, ALL nan rows will not be written to store.

**errors**: str, default ‘strict’

Specifies how encoding and decoding errors are to be handled. See the errors argument for `open()` for a full list of options.

See also:

- `DataFrame.read_hdf` Read from HDF file.
- `DataFrame.to_parquet` Write a DataFrame to the binary parquet format.
- `DataFrame.to_sql` Write to a sql table.
- `DataFrame.to_feather` Write out feather-format for DataFrames.
- `DataFrame.to_csv` Write out to a csv file.

**Examples**

```python
>>> df = pd.DataFrame({'A': [1, 2, 3], 'B': [4, 5, 6]},
...                    index=['a', 'b', 'c'])
>>> df.to_hdf('data.h5', key='df', mode='w')
```

We can add another object to the same file:
```python
>>> s = pd.Series([1, 2, 3, 4])
>>> s.to_hdf('data.h5', key='s')

Reading from HDF file:
```n
```python
>>> pd.read_hdf('data.h5', 'df')
A  B
a 1  4
b 2  5
c 3  6
```n
```python
>>> pd.read_hdf('data.h5', 's')
0 1
1 2
2 3
3 4
dtype: int64
```

Deleting file with data:
```python
>>> import os
>>> os.remove('data.h5')
```

**pandas.Series.to_json**

**Series.to_json** *(path_or_buf=None, orient=None, date_format=None, double_precision=10, force_ascii=True, date_unit='ms', default_handler=None, lines=False, compression=None, index=True)*

Convert the object to a JSON string.

Note NaN's and None will be converted to null and datetime objects will be converted to UNIX timestamps.

**Parameters**

- **path_or_buf**: string or file handle, optional
  
  File path or object. If not specified, the result is returned as a string.

- **orient**: string
  
  Indication of expected JSON string format.
  
  - **Series**
    
    - default is ‘index’
    
    - allowed values are: {‘split’,’records’,’index’}
  
  - **DataFrame**
    
    - default is ‘columns’
    
    - allowed values are: {‘split’,’records’,’index’,’columns’,’values’}
  
  - The format of the JSON string
    
    - ‘split’ : dict like {‘index’ -> [index], ‘columns’ -> [columns], ‘data’ -> [values]}
    
    - ‘records’ : list like [{column -> value}, . . . , {column -> value}]
    
    - ‘index’ : dict like {index -> {column -> value}}
    
    - ‘columns’ : dict like {column -> {index -> value}}
```
- ‘values’ : just the values array
- ‘table’ : dict like {'schema': {schema}, 'data': {data}} describing the data, and the data component is like orient='records'.
  Changed in version 0.20.0.

date_format : {None, ‘epoch’, ‘iso’}
  Type of date conversion. ‘epoch’ = epoch milliseconds, ‘iso’ = ISO8601. The default depends on the orient. For orient='table', the default is ‘iso’. For all other orients, the default is ‘epoch’.

double_precision : int, default 10
  The number of decimal places to use when encoding floating point values.

force_ascii : boolean, default True
  Force encoded string to be ASCII.

date_unit : string, default ‘ms’ (milliseconds)
  The time unit to encode to, governs timestamp and ISO8601 precision. One of ‘s’, ‘ms’, ‘us’, ‘ns’ for second, millisecond, microsecond, and nanosecond respectively.

default_handler : callable, default None
  Handler to call if object cannot otherwise be converted to a suitable format for JSON. Should receive a single argument which is the object to convert and return a serialisable object.

lines : boolean, default False
  If ‘orient’ is ‘records’ write out line delimited json format. Will throw ValueError if incorrect ‘orient’ since others are not list like.
  New in version 0.19.0.

  A string representing the compression to use in the output file, only used when the first argument is a filename.
  New in version 0.21.0.

index : boolean, default True
  Whether to include the index values in the JSON string. Not including the index (index=False) is only supported when orient is ‘split’ or ‘table’.
  New in version 0.23.0.

See also:
pandas.read_json

Examples

```python
>>> df = pd.DataFrame([['a', 'b'], ['c', 'd']],
...                   index=['row 1', 'row 2'],
...                   columns=['col 1', 'col 2'])
>>> df.to_json(orient='split')
```
(continues on next page)
Encoding/decoding a Dataframe using 'records' formatted JSON. Note that index labels are not preserved with this encoding.

```python
>>> df.to_json(orient='records')
'[{"col 1":"a","col 2":"b"},{"col 1":"c","col 2":"d"}]
```

Encoding/decoding a Dataframe using 'index' formatted JSON:

```python
>>> df.to_json(orient='index')
'{"row 1":{"col 1":"a","col 2":"b"},"row 2":{"col 1":"c","col 2":"d"}}
```

Encoding/decoding a Dataframe using 'columns' formatted JSON:

```python
>>> df.to_json(orient='columns')
'{"col 1":{"row 1":"a","row 2":"c"},"col 2":{"row 1":"b","row 2":"d"}}
```

Encoding/decoding a Dataframe using 'values' formatted JSON:

```python
>>> df.to_json(orient='values')
'[["a","b"],["c","d"]]
```

Encoding with Table Schema

```python
>>> df.to_json(orient='table')
'{"schema": {"fields": [{"name": "index", "type": "string"},
                     {"name": "col 1", "type": "string"},
                     {"name": "col 2", "type": "string"}],
         "primaryKey": "index",
         "pandas_version": "0.20.0"},
     "data": [{"index": "row 1", "col 1": "a", "col 2": "b"},
           {"index": "row 2", "col 1": "c", "col 2": "d"}]}]
```

**pandas.Series.to_latex**

`Series.to_latex(buf=None, columns=None, col_space=None, header=True, index=True, na_rep='NaN', formatters=None, float_format=None, sparsify=None, index_names=True, bold_rows=False, column_format=None, longtable=None, escape=None, encoding=None, decimal='.', multicolumn=None, multicolumn_format=None, multirow=None)`

Render an object to a tabular environment table. You can splice this into a LaTeX document. Requires \usepackage{booktabs}.

Changed in version 0.20.2: Added to Series
to_latex-specific options:

- **bold_rows** [boolean, default False] Make the row labels bold in the output
- **column_format** [str, default None] The columns format as specified in LaTeX table format e.g 'rcl' for 3 columns
- **longtable** [boolean, default will be read from the pandas config module] Default: False. Use a longtable environment instead of tabular. Requires adding a \usepackage{longtable} to your LaTeX preamble.
escape [boolean, default will be read from the pandas config module] Default: True. When set to False prevents from escaping latex special characters in column names.

encoding [str, default None] A string representing the encoding to use in the output file, defaults to ‘ascii’ on Python 2 and ‘utf-8’ on Python 3.

decimal [string, default ‘.’] Character recognized as decimal separator, e.g. ‘,’ in Europe.

New in version 0.18.0.

multicolumn [boolean, default True] Use multicolumn to enhance MultiIndex columns. The default will be read from the config module.

New in version 0.20.0.

multicolumn_format [str, default ‘l’] The alignment for multicolumns, similar to column_format The default will be read from the config module.

New in version 0.20.0.

multirow [boolean, default False] Use multirow to enhance MultiIndex rows. Requires adding a \usepackage{multirow} to your LaTeX preamble. Will print centered labels (instead of top-aligned) across the contained rows, separating groups via clines. The default will be read from the pandas config module.

New in version 0.20.0.

**pandas.Series.to_msgpack**

Series.to_msgpack(path_or_buf=None, encoding='utf-8', **kwargs)

msgpack (serialize) object to input file path

THIS IS AN EXPERIMENTAL LIBRARY and the storage format may not be stable until a future release.

Parameters

- **path**: string File path, buffer-like, or None
  - if None, return generated string
  - default is False

- **append**: boolean whether to append to an existing msgpack
  - default is False

- **compress**: type of compressor (zlib or blosc), default to None (no compression)

**pandas.Series.to_period**

Series.to_period(freq=None, copy=True)

Convert Series from DatetimeIndex to PeriodIndex with desired frequency (inferred from index if not passed)

Parameters

- **freq**: string, default

Returns

- **ts**: Series with PeriodIndex
pandas.Series.to_pickle

Series.to_pickle(path, compression='infer', protocol=4)
Pickle (serialize) object to file.

Parameters

path : str
File path where the pickled object will be stored.

compression : {'infer', 'gzip', 'bz2', 'zip', 'xz', None}, default 'infer'
A string representing the compression to use in the output file. By default, infers from the file extension in specified path.
New in version 0.20.0.

protocol : int
Int which indicates which protocol should be used by the pickler, default HIGHEST_PROTOCOL (see [R27] paragraph 12.1.2). The possible values for this parameter depend on the version of Python. For Python 2.x, possible values are 0, 1, 2. For Python>=3.0, 3 is a valid value. For Python >= 3.4, 4 is a valid value. A negative value for the protocol parameter is equivalent to setting its value to HIGHEST_PROTOCOL.
New in version 0.21.0.

See also:

read_pickle Load pickled pandas object (or any object) from file.
DataFrame.to_hdf Write DataFrame to an HDF5 file.
DataFrame.to_sql Write DataFrame to a SQL database.
DataFrame.to_parquet Write a DataFrame to the binary parquet format.

Examples

>>> original_df = pd.DataFrame({'foo': range(5), 'bar': range(5, 10)})
>>> original_df
    foo  bar
0    0   5
1    1   6
2    2   7
3    3   8
4    4   9
>>> original_df.to_pickle('./dummy.pkl')

>>> unpickled_df = pd.read_pickle('./dummy.pkl')
>>> unpickled_df
    foo  bar
0    0   5
1    1   6
2    2   7
3    3   8
4    4   9
>>> import os
>>> os.remove("./dummy.pkl")

pandas.Series.to_sparse

Series.to_sparse(kind='block', fill_value=None)
Convert Series to SparseSeries

Parameters

kind [{‘block’, ‘integer’}]
fill_value [float, defaults to NaN (missing)]

Returns

sp [SparseSeries]

pandas.Series.to_sql

Series.to_sql(name, con, schema=None, if_exists='fail', index=True, index_label=None, chunksize=None, dtype=None)
Write records stored in a DataFrame to a SQL database.

Databases supported by SQLAlchemy [R28] are supported. Tables can be newly created, appended to, or overwritten.

Parameters

name : string
Name of SQL table.

con : sqlalchemy.engine.Engine or sqlite3.Connection
Using SQLAlchemy makes it possible to use any DB supported by that library.
Legacy support is provided for sqlite3.Connection objects.

schema : string, optional
Specify the schema (if database flavor supports this). If None, use default schema.

if_exists : {'fail', 'replace', 'append'}, default ‘fail’
How to behave if the table already exists.

• fail: Raise a ValueError.
• replace: Drop the table before inserting new values.
• append: Insert new values to the existing table.

index : boolean, default True
Write DataFrame index as a column. Uses index_label as the column name in the table.

index_label : string or sequence, default None
Column label for index column(s). If None is given (default) and index is True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.

chunksize : int, optional
Rows will be written in batches of this size at a time. By default, all rows will be written at once.

dtype : dict, optional

Specifying the datatype for columns. The keys should be the column names and the values should be the SQLAlchemy types or strings for the sqlite3 legacy mode.

Raises ValueError

When the table already exists and if_exists is ‘fail’ (the default).

See also:

pandas.read_sql read a DataFrame from a table

References

[R28], [R29]

Examples

Create an in-memory SQLite database.

```python
>>> from sqlalchemy import create_engine
>>> engine = create_engine('sqlite://', echo=False)
```

Create a table from scratch with 3 rows.

```python
>>> df = pd.DataFrame({'name' : ['User 1', 'User 2', 'User 3']})
```

```python
>>> df
     name
0   User 1
1   User 2
2   User 3
```

```python
>>> df.to_sql('users', con=engine)
```

```python
>>> engine.execute("SELECT * FROM users").fetchall()
[(0, 'User 1'), (1, 'User 2'), (2, 'User 3')]
```

```python
>>> df1 = pd.DataFrame({'name' : ['User 4', 'User 5']})
```

```python
>>> df1.to_sql('users', con=engine, if_exists='append')
```

```python
>>> engine.execute("SELECT * FROM users").fetchall()
[(0, 'User 1'), (1, 'User 2'), (2, 'User 3'),
 (0, 'User 4'), (1, 'User 5')]
```

Overwrite the table with just df1.

```python
>>> df1.to_sql('users', con=engine, if_exists='replace',
...            index_label='id')
```

```python
>>> engine.execute("SELECT * FROM users").fetchall()
[(0, 'User 4'), (1, 'User 5')]
```
Specify the dtype (especially useful for integers with missing values). Notice that while pandas is forced to store the data as floating point, the database supports nullable integers. When fetching the data with Python, we get back integer scalars.

```python
>>> df = pd.DataFrame({'A': [1, None, 2]})
>>> df
   A
0  1.0
1  NaN
2  2.0
```

```python
>>> from sqlalchemy.types import Integer
>>> df.to_sql('integers', con=engine, index=False, ...  dtype={'A': Integer()})
>>> engine.execute("SELECT * FROM integers").fetchall()
[(1,), (None,), (2,)]
```

### pandas.Series.to_string

`Series.to_string(buf=None, na_rep='NaN', float_format=None, header=True, index=True, length=False, dtype=False, name=False, max_rows=None)`

Render a string representation of the Series

**Parameters**

- **buf**: StringIO-like, optional
  - buffer to write to
- **na_rep**: string, optional
  - string representation of NAN to use, default 'NaN'
- **float_format**: one-parameter function, optional
  - formatter function to apply to columns’ elements if they are floats default None
- **header**: boolean, default True
  - Add the Series header (index name)
- **index**: bool, optional
  - Add index (row) labels, default True
- **length**: boolean, default False
  - Add the Series length
- **dtype**: boolean, default False
  - Add the Series dtype
- **name**: boolean, default False
  - Add the Series name if not None
- **max_rows**: int, optional
  - Maximum number of rows to show before truncating. If None, show all.

**Returns**

- **formatted** [string (if not buffer passed)]
pandas.Series.to_timestamp

```
Series.to_timestamp(freq=None, how='start', copy=True)
Cast to datetimeindex of timestamps, at beginning of period
```

**Parameters**
- `freq` : string, default frequency of PeriodIndex
  Desired frequency
- `how` : {'s', 'e', 'start', 'end'}
  Convention for converting period to timestamp; start of period vs. end

**Returns**
- `ts` [Series with DatetimeIndex]

pandas.Series.to_xarray

```
Series.to_xarray()
Return an xarray object from the pandas object.
```

**Returns**
- a DataArray for a Series
- a Dataset for a DataFrame
- a DataArray for higher dims

**Notes**

See the xarray docs

**Examples**

```python
>>> df = pd.DataFrame({'A' : [1, 2, 2],
                     'B' : ['foo', 'bar', 'foo'],
                     'C' : np.arange(4.,7))
>>> df
   A   B    C
0  1  foo  4.0
1  1  bar  5.0
2  2  foo  6.0
```

```python
>>> df.to_xarray()
<xarray.Dataset>
Dimensions: (index: 3)
Coordinates:
  * index (index) int64 0 1 2
Data variables:
    A (index) int64 1 1 2
    B (index) object 'foo' 'bar' 'foo'
    C (index) float64 4.0 5.0 6.0
```
```python
>>> df = pd.DataFrame({'A': [1, 1, 2],
                    'B': ['foo', 'bar', 'foo'],
                    'C': np.arange(4., 7))
                    ).set_index(['B', 'A'])
>>> df
    C
B  A
foo 1 4.0
bar 1 5.0
foo 2 6.0

>>> df.to_xarray()
<xarray.Dataset>
Dimensions: (A: 2, B: 2)
Coordinates:
  * B (B) object 'bar' 'foo'
  * A (A) int64 1 2
Data variables:
  C (B, A) float64 5.0 nan 4.0 6.0

>>> p = pd.Panel(np.arange(24).reshape(4, 3, 2),
                items=list('ABCD'),
                major_axis=pd.date_range('20130101', periods=3),
                minor_axis=['first', 'second'])
>>> p
<class 'pandas.core.panel.Panel'>
Dimensions: 4 (items) x 3 (major_axis) x 2 (minor_axis)
Items axis: A to D
Major_axis axis: 2013-01-01 00:00:00 to 2013-01-03 00:00:00
Minor_axis axis: first to second

>>> p.to_xarray()
<xarray.DataArray (items: 4, major_axis: 3, minor_axis: 2)>
array([[ 0,  1],
       [ 2,  3],
       [ 4,  5],
       [ 6,  7],
       [ 8,  9],
       [10, 11],
       [12, 13],
       [14, 15],
       [16, 17],
       [18, 19],
       [20, 21],
       [22, 23]])
Coordinates:
  * items (items) object 'A' 'B' 'C' 'D'
  * major_axis (major_axis) datetime64[ns] 2013-01-01 2013-01-02 2013-01-03
  * minor_axis (minor_axis) object 'first' 'second'

pandas.Series.tolist

Series.tolist()
Return a list of the values.
These are each a scalar type, which is a Python scalar (for str, int, float) or a pandas scalar (for Timestamp/Timedelta/Interval/Period)

See also:
numpy.ndarray.tolist

**pandas.Series.transform**

```
Series.transform(func, *args, **kwargs)
```

Call function producing a like-indexed NDFrame and return a NDFrame with the transformed values

New in version 0.20.0.

**Parameters**

- **func**: callable, string, dictionary, or list of string/callables

  To apply to column

  Accepted Combinations are:

  • string function name
  • function
  • list of functions
  • dict of column names -> functions (or list of functions)

**Returns**

- **transformed** [NDFrame]

See also:
pandas.NDFrame.aggregate, pandas.NDFrame.apply

**Examples**

```python
def = pd.DataFrame(np.random.randn(10, 3), columns=['A', 'B', 'C'],
                   index=pd.date_range('1/1/2000', periods=10))
df.iloc[3:7] = np.nan

>>> df.transform(lambda x: (x - x.mean()) / x.std())
```

<table>
<thead>
<tr>
<th>Date</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-01-01</td>
<td>0.579457</td>
<td>1.236184</td>
<td>0.123424</td>
</tr>
<tr>
<td>2000-01-02</td>
<td>0.370357</td>
<td>-0.605875</td>
<td>-1.231325</td>
</tr>
<tr>
<td>2000-01-03</td>
<td>1.455756</td>
<td>-0.277446</td>
<td>0.288967</td>
</tr>
<tr>
<td>2000-01-04</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>2000-01-05</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>2000-01-06</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>2000-01-07</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>2000-01-08</td>
<td>-0.498658</td>
<td>1.274522</td>
<td>1.642524</td>
</tr>
<tr>
<td>2000-01-09</td>
<td>-0.540524</td>
<td>-1.012676</td>
<td>-0.828968</td>
</tr>
<tr>
<td>2000-01-10</td>
<td>-1.366388</td>
<td>-0.614710</td>
<td>0.005378</td>
</tr>
</tbody>
</table>
pandas.Series.transpose

Series.transpose(*args, **kwargs)
return the transpose, which is by definition self

pandas.Series.truediv

Series.truediv(other, level=None, fill_value=None, axis=0)
Floating division of series and other, element-wise (binary operator truediv).
Equivalent to series / other, but with support to substitute a fill_value for missing data in one of
the inputs.

Parameters
other [Series or scalar value]
fill_value : None or float value, default None (NaN)
    Fill existing missing (NaN) values, and any new element needed for successful
    Series alignment, with this value before computation. If data in both correspond-
    ing Series locations is missing the result will be missing
level : int or name
    Broadcast across a level, matching Index values on the passed MultiIndex level

Returns
result [Series]

See also:
Series.rtruediv

Examples

```python
>>> a = pd.Series([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'])
>>> a
a    1.0
b    1.0
c    1.0
d    NaN
dtype: float64
>>> b = pd.Series([1, np.nan, 1, np.nan], index=['a', 'b', 'd', 'e'])
>>> b
a    1.0
b    NaN
d    1.0
e    NaN
dtype: float64
>>> a.add(b, fill_value=0)
a    2.0
b    1.0
c    1.0
d    1.0
e    NaN
dtype: float64
```
**pandas.Series.truncate**

Series.truncate(before=None, after=None, axis=None, copy=True)  
Truncate a Series or DataFrame before and after some index value.  
This is a useful shorthand for boolean indexing based on index values above or below certain thresholds.  

**Parameters**  
*before*: date, string, int  
Truncate all rows before this index value.  
*after*: date, string, int  
Truncate all rows after this index value.  
*axis*: {0 or ‘index’, 1 or ‘columns’}, optional  
Axis to truncate. Truncates the index (rows) by default.  
*copy*: boolean, default is True,  
Return a copy of the truncated section.  

**Returns** type of caller  
The truncated Series or DataFrame.  

**See also:**  
DataFrame.loc Select a subset of a DataFrame by label.  
DataFrame.iloc Select a subset of a DataFrame by position.  

**Notes**  
If the index being truncated contains only datetime values, before and after may be specified as strings instead of Timestamps.  

**Examples**

```python  
>>> df = pd.DataFrame({'A': ['a', 'b', 'c', 'd', 'e'],  
...                     'B': ['f', 'g', 'h', 'i', 'j'],  
...                     'C': ['k', 'l', 'm', 'n', 'o'],  
...                     'index': [1, 2, 3, 4, 5])  
>>> df  
   A  B  C
0  a  f  k
1  b  g  l
2  c  h  m
3  d  i  n
4  e  j  o

>>> df.truncate(before=2, after=4)  
   A  B  C
0  b  g  l
1  c  h  m
```

The columns of a DataFrame can be truncated.
>>> df.truncate(before="A", after="B", axis="columns")
   A  B
1  a  f
2  b  g
3  c  h
4  d  i
5  e  j

For Series, only rows can be truncated.

>>> df['A'].truncate(before=2, after=4)
2  b
3  c
4  d
Name: A, dtype: object

The index values in `truncate` can be datetimes or string dates.

>>> dates = pd.date_range('2016-01-01', '2016-02-01', freq='s')
>>> df = pd.DataFrame(index=dates, data={'A': 1})
>>> df.tail()
   A
2016-01-31 23:59:56  1
2016-01-31 23:59:57  1
2016-01-31 23:59:58  1
2016-01-31 23:59:59  1
2016-02-01 00:00:00  1

>>> df.truncate(before=pd.Timestamp('2016-01-05'),
... after=pd.Timestamp('2016-01-10')).tail()
   A
2016-01-09 23:59:56  1
2016-01-09 23:59:57  1
2016-01-09 23:59:58  1
2016-01-09 23:59:59  1
2016-01-10 00:00:00  1

Because the index is a DatetimeIndex containing only dates, we can specify `before` and `after` as strings. They will be coerced to Timestamps before truncation.

>>> df.truncate('2016-01-05', '2016-01-10').tail()
   A
2016-01-09 23:59:56  1
2016-01-09 23:59:57  1
2016-01-09 23:59:58  1
2016-01-09 23:59:59  1
2016-01-10 00:00:00  1

Note that `truncate` assumes a 0 value for any unspecified time component (midnight). This differs from partial string slicing, which returns any partially matching dates.

>>> df.loc['2016-01-05':'2016-01-10', :].tail()
   A
2016-01-10 23:59:55  1
2016-01-10 23:59:56  1
2016-01-10 23:59:57  1

(continues on next page)
pandas.Series.tshift

Series\texttt{.tshift} (\texttt{periods=1, freq=None, axis=0})
Shift the time index, using the index’s frequency if available.

**Parameters**

- \texttt{periods} : int
  Number of periods to move, can be positive or negative
- \texttt{freq} : DateOffset, timedelta, or time rule string, default None
  Increment to use from the tseries module or time rule (e.g. ‘EOM’)
- \texttt{axis} : int or basestring
  Corresponds to the axis that contains the Index

**Returns**

- \texttt{shifted} [NDFrame]

**Notes**

If freq is not specified then tries to use the freq or inferred_freq attributes of the index. If neither of those attributes exist, a ValueError is thrown

pandas.Series.tz_convert

Series\texttt{.tz_convert} (\texttt{tz}, \texttt{axis=0, level=None, copy=True})
Convert tz-aware axis to target time zone.

**Parameters**

- \texttt{tz} [string or pytz.timezone object]
- \texttt{axis} [the axis to convert]
- \texttt{level} : int, str, default None
  If axis ia a MultiIndex, convert a specific level. Otherwise must be None
- \texttt{copy} : boolean, default True
  Also make a copy of the underlying data

**Raises**

- **TypeError**
  If the axis is tz-naive.

pandas.Series.tz_localize

Series\texttt{.tz_localize} (\texttt{tz}, \texttt{axis=0, level=None, copy=True, ambiguous=’raise’})
Localize tz-naive TimeSeries to target time zone.
Parameters

tz [string or pytz.timezone object]
axis [the axis to localize]
level : int, str, default None
    If axis ia a MultiIndex, localize a specific level. Otherwise must be None
copy : boolean, default True
    Also make a copy of the underlying data
ambiguous : ‘infer’, bool-ndarray, ‘NaT’, default ‘raise’
    • ‘infer’ will attempt to infer fall dst-transition hours based on order
    • bool-ndarray where True signifies a DST time, False designates a non-DST time (note
      that this flag is only applicable for ambiguous times)
    • ‘NaT’ will return NaT where there are ambiguous times
    • ‘raise’ will raise an AmbiguousTimeError if there are ambiguous times

Raises TypeError
    If the TimeSeries is tz-aware and tz is not None.

pandas.Series.unique

Series.unique()
    Return unique values of Series object.
    Uniques are returned in order of appearance. Hash table-based unique, therefore does NOT sort.

Returns ndarray or Categorical
    The unique values returned as a NumPy array. In case of categorical data type,
    returned as a Categorical.

See also:

pandas.unique top-level unique method for any 1-d array-like object.
Index.unique return Index with unique values from an Index object.

Examples

```python
>>> pd.Series([2, 1, 3, 3], name='A').unique()
array([2, 1, 3])

>>> pd.Series([pd.Timestamp('2016-01-01') for _ in range(3)]).unique()
array(['2016-01-01T00:00:00.000000000'], dtype='datetime64[ns]')

>>> pd.Series([pd.Timestamp('2016-01-01', tz='US/Eastern') for _ in range(3)]).unique()
array([Timestamp('2016-01-01 00:00:00-0500', tz='US/Eastern')],
      dtype=object)
```

An unordered Categorical will return categories in the order of appearance.
An ordered Categorical preserves the category ordering.

```python
>>> pd.Series(pd.Categorical(list('baabc'))).unique()
[b, a, c]
Categories (3, object): [b, a, c]
```

```python
>>> pd.Series(pd.Categorical(list('baabc'), categories=list('abc'), ordered=True)).unique()
[b, a, c]
Categories (3, object): [a < b < c]
```

### pandas.Series.unstack

`Series.unstack(level=-1, fill_value=None)`

Unstack, a.k.a. pivot, Series with MultiIndex to produce DataFrame. The level involved will automatically get sorted.

**Parameters**

- **level**: int, string, or list of these, default last level
  
  Level(s) to unstack, can pass level name

- **fill_value**: replace NaN with this value if the unstack produces missing values

**Returns**

- **unstacked** [DataFrame]

**Examples**

```python
>>> s = pd.Series([1, 2, 3, 4],
                index=pd.MultiIndex.from_product([['one', 'two'], ['a', 'b']]))
>>> s
one a 1
   b 2
two a 3
   b 4
dtype: int64
```

```python
>>> s.unstack(level=-1)
    a  b
one 1  2
two 3  4
```

```python
>>> s.unstack(level=0)
    one  two
   a  1  3
   b  2  4
```
**pandas.Series.update**

Series.update(other)
Modify Series in place using non-NA values from passed Series. Aligns on index

**Parameters**
- **other** [Series]

**Examples**

```python
>>> s = pd.Series([1, 2, 3])
>>> s.update(pd.Series([4, 5, 6]))
>>> s
0  4
1  5
2  6
dtype: int64
```

```python
>>> s = pd.Series(['a', 'b', 'c'])
>>> s.update(pd.Series(['d', 'e'], index=[0, 2]))
>>> s
0  d
1  b
2  e
dtype: object
```

```python
>>> s = pd.Series([1, 2, 3])
>>> s.update(pd.Series([4, 5, 6, 7, 8]))
>>> s
0  4
1  5
2  6
dtype: int64
```

If **other** contains NaNs the corresponding values are not updated in the original Series.

```python
>>> s = pd.Series([1, 2, 3])
>>> s.update(pd.Series([4, np.nan, 6]))
>>> s
0  4
1  2
2  6
dtype: int64
```

**pandas.Series.valid**

Series.valid(inplace=False, **kwargs)
Return Series without null values.

Deprecated since version 0.23.0: Use `Series.dropna()` instead.
Series.value_counts

Series.value_counts(normalize=False, sort=True, ascending=False, bins=None, dropna=True)
Returns object containing counts of unique values.
The resulting object will be in descending order so that the first element is the most frequently-occurring
element. Excludes NA values by default.

Parameters

normalize : boolean, default False
If True then the object returned will contain the relative frequencies of the unique
values.

sort : boolean, default True
Sort by values

ascending : boolean, default False
Sort in ascending order

bins : integer, optional
Rather than count values, group them into half-open bins, a convenience for
pd.cut, only works with numeric data

dropna : boolean, default True
Don’t include counts of NaN.

Returns

counts [Series]

Series.var

Series.var(axis=None, skipna=None, level=None, ddof=1, numeric_only=None, **kwargs)
Return unbiased variance over requested axis.
Normalized by N-1 by default. This can be changed using the ddof argument

Parameters

axis [[index (0)]]

skipna : boolean, default True
Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None
If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing
into a scalar

ddof : int, default 1
Delta Degrees of Freedom. The divisor used in calculations is N - ddof, where N
represents the number of elements.

numeric_only : boolean, default None
Include only float, int, boolean columns. If None, will attempt to use everything,
then use only numeric data. Not implemented for Series.
Returns

var [scalar or Series (if level specified)]

pandas.Series.view

Series.view(dtype=None)
Create a new view of the Series.

This function will return a new Series with a view of the same underlying values in memory, optionally
reinterpreted with a new data type. The new data type must preserve the same size in bytes as to not cause
index misalignment.

Parameters dtype : data type
Data type object or one of their string representations.

Returns Series
A new Series object as a view of the same data in memory.

See also:
numpy.ndarray.view Equivalent numpy function to create a new view of the same data in memory.

Notes

Series are instantiated with dtype=float64 by default. While numpy.ndarray.view() will re-
turn a view with the same data type as the original array, Series.view() (without specified dtype)
will try using float64 and may fail if the original data type size in bytes is not the same.

Examples

```python
>>> s = pd.Series([-2, -1, 0, 1, 2], dtype='int8')
>>> s
0   -2
1   -1
2    0
3    1
4    2
dtype: int8
```

The 8 bit signed integer representation of -1 is 0b11111111, but the same bytes represent 255 if read as
an 8 bit unsigned integer:

```python
>>> us = s.view('uint8')
>>> us
0   254
1   255
2    0
3    1
4    2
dtype: uint8
```

The views share the same underlying values:
```python
>>> us[0] = 128
>>> s
0   -128
1     -1
2      0
3      1
4      2
dtype: int8
```

**pandas.Series.where**

Series.where(cond, other=nan, inplace=False, axis=None, level=None, errors='raise', try_cast=False, raise_on_error=None)

Return an object of same shape as self and whose corresponding entries are from self where cond is True and otherwise are from other.

**Parameters**

cond : boolean NDFrame, array-like, or callable

Where cond is True, keep the original value. Where False, replace with corresponding value from other. If cond is callable, it is computed on the NDFrame and should return boolean NDFrame or array. The callable must not change input NDFrame (though pandas doesn’t check it).

New in version 0.18.1: A callable can be used as cond.

other : scalar, NDFrame, or callable

Entries where cond is False are replaced with corresponding value from other. If other is callable, it is computed on the NDFrame and should return scalar or NDFrame. The callable must not change input NDFrame (though pandas doesn’t check it).

New in version 0.18.1: A callable can be used as other.

inplace : boolean, default False

Whether to perform the operation in place on the data

axis [alignment axis if needed, default None]

level [alignment level if needed, default None]

errors : str, {‘raise’, ‘ignore’}, default ‘raise’

• raise: allow exceptions to be raised
• ignore: suppress exceptions. On error return original object

Note that currently this parameter won’t affect the results and will always coerce to a suitable dtype.

try_cast : boolean, default False

try to cast the result back to the input type (if possible),

raise_on_error : boolean, default True

Whether to raise on invalid data types (e.g. trying to where on strings)

Deprecated since version 0.21.0.

**Returns**
wh [same type as caller]

See also:

DataFrame.mask()

Notes

The where method is an application of the if-then idiom. For each element in the calling DataFrame, if cond is True the element is used; otherwise the corresponding element from the DataFrame other is used.

The signature for DataFrame.where() differs from numpy.where(). Roughly df1.where(m, df2) is equivalent to np.where(m, df1, df2).

For further details and examples see the where documentation in indexing.

Examples

```python
>>> s = pd.Series(range(5))
>>> s.where(s > 0)
0   NaN
1   1.0
2   2.0
3   3.0
4   4.0

>>> s.mask(s > 0)
0    0.0
1   NaN
2   NaN
3   NaN
4   NaN

>>> s.where(s > 1, 10)
0  10.0
1  10.0
2   2.0
3   3.0
4   4.0

>>> df = pd.DataFrame(np.arange(10).reshape(-1, 2), columns=['A', 'B'])
>>> m = df % 3 == 0
>>> df.where(m, -df)
     A    B
0  -1   0
1   3  -2
2  -5   4
3  -7   6
4   9  -8

>>> df.where(m, -df) == np.where(m, df, -df)
     A   B
0  True True
1  True True
2  True True
(continues on next page)```
pandas: powerful Python data analysis toolkit, Release 0.23.2

3  True  True
4  True  True
>>> df.where(m, -df) == df.mask(~m, -df)
   A   B
0  True True
1  True True
2  True True
3  True True
4  True True

pandas.Series.xs

Series.xs (key, axis=0, level=None, drop_level=True)
Returns a cross-section (row(s) or column(s)) from the Series/DataFrame. Defaults to cross-section on the rows (axis=0).

Parameters

key : object
  Some label contained in the index, or partially in a MultiIndex

axis : int, default 0
  Axis to retrieve cross-section on

level : object, defaults to first n levels (n=1 or len(key))
  In case of a key partially contained in a MultiIndex, indicate which levels are used. Levels can be referred by label or position.

drop_level : boolean, default True
  If False, returns object with same levels as self.

Returns

xs [Series or DataFrame]

Notes

xs is only for getting, not setting values.

MultiIndex Slicers is a generic way to get/set values on any level or levels. It is a superset of xs functionality, see MultiIndex Slicers

Examples

>>> df
   A  B  C
a 4  5  2
b 4  0  9
c 9  7  3
>>> df.xs('a')
   A
A 4
B 5
C 2

(continues on next page)
Name: a
>>> df.xs('C', axis=1)
 a 2  
b 9  
c 3  
Name: C

>>> df
   A  B  C  D
first second third
    bar  one  1 4 1 8 9
         two  1 7 5 5 0
    baz  one  1 6 6 8 0
         three 2 5 3 5 3
>>> df.xs(('baz', 'three'))
   A  B  C  D
third
    2 5 3 5 3
>>> df.xs('one', level=1)
   A  B  C  D
first third
    bar  1 4 1 8 9
    baz  1 6 6 8 0
>>> df.xs(('baz', 2), level=[0, 'third'])
   A  B  C  D
second
    three 5 3 5 3

34.3.2 Attributes

Axes

Series.index The index (axis labels) of the Series.

Series.values Return Series as ndarray or ndarray-like depending on the dtype
Series.dtype return the dtype object of the underlying data
Series.itype return if the data is sparse|dense
Series.shape return a tuple of the shape of the underlying data
Series.nbytes return the number of bytes in the underlying data
Series.ndim return the number of dimensions of the underlying data, by definition 1
Series.size return the number of elements in the underlying data
Series.strides return the strides of the underlying data
Series.itemsize return the size of the dtype of the item of the underlying data
Series.base return the base object if the memory of the underlying data is shared
Series.T return the transpose, which is by definition self
Series.memory_usage([index, deep]) Return the memory usage of the Series.
Series.hasnans return if I have any nans; enables various perf speedups
### 34.3.2 pandas.Series.empty

Series.empty

### 34.3.2.2 pandas.Series.is_copy

Series.is_copy

### 34.3.2.3 pandas.Series.name

Series.name

### 34.3.3 Conversion

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>astype()</code></td>
<td>Cast a pandas object to a specified dtype.</td>
</tr>
<tr>
<td><code>infer_objects()</code></td>
<td>Attempt to infer better dtypes for object columns.</td>
</tr>
<tr>
<td><code>convert_objects</code></td>
<td>(DEPRECATED) Attempt to infer better dtype for object columns.</td>
</tr>
<tr>
<td><code>copy()</code></td>
<td>Make a copy of this object’s indices and data.</td>
</tr>
<tr>
<td><code>bool()</code></td>
<td>Return the bool of a single element PandasObject.</td>
</tr>
<tr>
<td><code>to_period()</code></td>
<td>Convert Series from DatetimeIndex to PeriodIndex with desired frequency (inferred from index if not passed).</td>
</tr>
<tr>
<td><code>to_timestamp()</code></td>
<td>Cast to datetimeindex of timestamps, at beginning of period.</td>
</tr>
<tr>
<td><code>tolist()</code></td>
<td>Return a list of the values.</td>
</tr>
<tr>
<td><code>get_values()</code></td>
<td>same as values (but handles sparseness conversions); is a view</td>
</tr>
</tbody>
</table>

### 34.3.4 Indexing, iteration

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>get()</code></td>
<td>Get item from object for given key (DataFrame column, Panel slice, etc.).</td>
</tr>
<tr>
<td><code>at</code></td>
<td>Access a single value for a row/column label pair.</td>
</tr>
<tr>
<td><code>iat</code></td>
<td>Access a single value for a row/column pair by integer position.</td>
</tr>
</tbody>
</table>

Continued on next page
Table 29 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.loc</code></td>
<td>Access a group of rows and columns by label(s) or a boolean array.</td>
</tr>
<tr>
<td><code>Series.iloc</code></td>
<td>Purely integer-location based indexing for selection by position.</td>
</tr>
<tr>
<td><code>Series.__iter__()</code></td>
<td>Return an iterator of the values.</td>
</tr>
<tr>
<td><code>Series.items()</code></td>
<td>Lazily iterate over (index, value) tuples</td>
</tr>
<tr>
<td><code>Series.keys()</code></td>
<td>Lazily iterate over (index, value) tuples</td>
</tr>
<tr>
<td><code>Series.pop(item)</code></td>
<td>Return item and drop from frame.</td>
</tr>
<tr>
<td><code>Series.item()</code></td>
<td>return the first element of the underlying data as a python scalar</td>
</tr>
<tr>
<td><code>Series.xs(key[, axis, level, drop_level])</code></td>
<td>Returns a cross-section (row(s) or column(s)) from the Series/DataFrame.</td>
</tr>
</tbody>
</table>

### 34.3.4.1 pandas.Series.__iter__

Series.__iter__()

Return an iterator of the values.

These are each a scalar type, which is a Python scalar (for str, int, float) or a pandas scalar (for Timestamp/Timedelta/Interval/Period)

For more information on `.at`, `.iat`, `.loc`, and `.iloc`, see the **indexing documentation**.

### 34.3.5 Binary operator functions

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.add(other[, level, fill_value, axis])</code></td>
<td>Addition of series and other, element-wise (binary operator <code>add</code>).</td>
</tr>
<tr>
<td><code>Series.sub(other[, level, fill_value, axis])</code></td>
<td>Subtraction of series and other, element-wise (binary operator <code>sub</code>).</td>
</tr>
<tr>
<td><code>Series.mul(other[, level, fill_value, axis])</code></td>
<td>Multiplication of series and other, element-wise (binary operator <code>mul</code>).</td>
</tr>
<tr>
<td><code>Series.div(other[, level, fill_value, axis])</code></td>
<td>Floating division of series and other, element-wise (binary operator <code>truediv</code>).</td>
</tr>
<tr>
<td><code>Series.truediv(other[, level, fill_value, axis])</code></td>
<td>Floating division of series and other, element-wise (binary operator <code>truediv</code>).</td>
</tr>
<tr>
<td><code>Series.floordiv(other[, level, fill_value, axis])</code></td>
<td>Integer division of series and other, element-wise (binary operator <code>floordiv</code>).</td>
</tr>
<tr>
<td><code>Series.mod(other[, level, fill_value, axis])</code></td>
<td>Modulo of series and other, element-wise (binary operator <code>mod</code>).</td>
</tr>
<tr>
<td><code>Series.pow(other[, level, fill_value, axis])</code></td>
<td>Exponential power of series and other, element-wise (binary operator <code>pow</code>).</td>
</tr>
<tr>
<td><code>Series.radd(other[, level, fill_value, axis])</code></td>
<td>Addition of series and other, element-wise (binary operator <code>radd</code>).</td>
</tr>
<tr>
<td><code>Series.rsub(other[, level, fill_value, axis])</code></td>
<td>Subtraction of series and other, element-wise (binary operator <code>rsub</code>).</td>
</tr>
<tr>
<td><code>Series.rmul(other[, level, fill_value, axis])</code></td>
<td>Multiplication of series and other, element-wise (binary operator <code>rmul</code>).</td>
</tr>
<tr>
<td><code>Series.rdiv(other[, level, fill_value, axis])</code></td>
<td>Floating division of series and other, element-wise (binary operator <code>rtruediv</code>).</td>
</tr>
</tbody>
</table>

Continued on next page
### Table 30 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.rtruediv(other[, level, fill_value, axis])</code></td>
<td>Floating division of series and other, element-wise (binary operator <code>rtruediv</code>).</td>
</tr>
<tr>
<td><code>Series.rfloordiv(other[, level, fill_value, ...])</code></td>
<td>Integer division of series and other, element-wise (binary operator <code>rfloordiv</code>).</td>
</tr>
<tr>
<td><code>Series.rmod(other[, level, fill_value, axis])</code></td>
<td>Modulo of series and other, element-wise (binary operator <code>rmod</code>).</td>
</tr>
<tr>
<td><code>Series.rpow(other[, level, fill_value, axis])</code></td>
<td>Exponential power of series and other, element-wise (binary operator <code>rpow</code>).</td>
</tr>
<tr>
<td><code>Series.combine(other, func[, fill_value])</code></td>
<td>Perform elementwise binary operation on two Series using given function with optional fill value when an index is missing from one Series or the other</td>
</tr>
<tr>
<td><code>Series.combine_first(other)</code></td>
<td>Combine Series values, choosing the calling Series’s values first.</td>
</tr>
<tr>
<td><code>Series.round([decimals])</code></td>
<td>Round each value in a Series to the given number of decimals.</td>
</tr>
<tr>
<td><code>Series.lt(other[, level, fill_value, axis])</code></td>
<td>Less than of series and other, element-wise (binary operator <code>lt</code>).</td>
</tr>
<tr>
<td><code>Series.gt(other[, level, fill_value, axis])</code></td>
<td>Greater than of series and other, element-wise (binary operator <code>gt</code>).</td>
</tr>
<tr>
<td><code>Series.le(other[, level, fill_value, axis])</code></td>
<td>Less than or equal to of series and other, element-wise (binary operator <code>le</code>).</td>
</tr>
<tr>
<td><code>Series.ge(other[, level, fill_value, axis])</code></td>
<td>Greater than or equal to of series and other, element-wise (binary operator <code>ge</code>).</td>
</tr>
<tr>
<td><code>Series.ne(other[, level, fill_value, axis])</code></td>
<td>Not equal to of series and other, element-wise (binary operator <code>ne</code>).</td>
</tr>
<tr>
<td><code>Series.eq(other[, level, fill_value, axis])</code></td>
<td>Equal to of series and other, element-wise (binary operator <code>eq</code>).</td>
</tr>
<tr>
<td><code>Series.product([axis, skipna, level, ...])</code></td>
<td>Return the product of the values for the requested axis</td>
</tr>
<tr>
<td><code>Series.dot(other)</code></td>
<td>Matrix multiplication with DataFrame or inner-product with Series objects.</td>
</tr>
</tbody>
</table>

#### 34.3.6 Function application, GroupBy & Window

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.apply(func[, convert_dtype, args])</code></td>
<td>Invoke function on values of Series.</td>
</tr>
<tr>
<td><code>Series.agg(func[, axis])</code></td>
<td>Aggregate using one or more operations over the specified axis.</td>
</tr>
<tr>
<td><code>Series.aggregate(func[, axis])</code></td>
<td>Aggregate using one or more operations over the specified axis.</td>
</tr>
<tr>
<td><code>Series.transform(func, *args, **kwargs)</code></td>
<td>Call function producing a like-indexed NDFrame and return a NDFrame with the transformed values</td>
</tr>
<tr>
<td><code>Series.map(arg[, na_action])</code></td>
<td>Map values of Series using input correspondence (a dict, Series, or function).</td>
</tr>
<tr>
<td><code>Series.groupby([by, axis, level, as_index, ...])</code></td>
<td>Group series using mapper (dict or key function, apply given function to group, return result as series) or by a series of columns.</td>
</tr>
<tr>
<td><code>Series.rolling(window[, min_periods, ...])</code></td>
<td>Provides rolling window calculations.</td>
</tr>
<tr>
<td><code>Series.exanding([min_periods, center, axis])</code></td>
<td>Provides expanding transformations.</td>
</tr>
<tr>
<td><code>Series.ewm([com, span, halflife, alpha, ...])</code></td>
<td>Provides exponential weighted functions</td>
</tr>
<tr>
<td><code>Series.pipe(func, *args, **kwargs)</code></td>
<td>Apply func(self, *args, **kwargs).</td>
</tr>
</tbody>
</table>
### 34.3.7 Computations / Descriptive Stats

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.abs()</code></td>
<td>Return a Series/DataFrame with absolute numeric value of each element.</td>
</tr>
<tr>
<td><code>Series.all()</code></td>
<td>Return whether all elements are True, potentially over an axis.</td>
</tr>
<tr>
<td><code>Series.any()</code></td>
<td>Return whether any element is True over requested axis.</td>
</tr>
<tr>
<td><code>Series.autocorr()</code></td>
<td>Lag-N autocorrelation</td>
</tr>
<tr>
<td><code>Series.between()</code></td>
<td>Return boolean Series equivalent to left &lt;= series &lt;= right.</td>
</tr>
<tr>
<td><code>Series.clip()</code></td>
<td>Trim values at input threshold(s).</td>
</tr>
<tr>
<td><code>Series.clip_lower()</code></td>
<td>Return copy of the input with values below a threshold truncated.</td>
</tr>
<tr>
<td><code>Series.clip_upper()</code></td>
<td>Return copy of input with values above given value(s) truncated.</td>
</tr>
<tr>
<td><code>Series.corr()</code></td>
<td>Compute correlation with other Series, excluding missing values</td>
</tr>
<tr>
<td><code>Series.count()</code></td>
<td>Return number of non-NA/null observations in the Series.</td>
</tr>
<tr>
<td><code>Series.cov()</code></td>
<td>Compute covariance with Series, excluding missing values</td>
</tr>
<tr>
<td><code>Series.cummax()</code></td>
<td>Return cumulative maximum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>Series.cummin()</code></td>
<td>Return cumulative minimum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>Series.cumprod()</code></td>
<td>Return cumulative product over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>Series.cumsum()</code></td>
<td>Return cumulative sum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>Series.describe()</code></td>
<td>Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset’s distribution, excluding NaN values.</td>
</tr>
<tr>
<td><code>Series.diff()</code></td>
<td>First discrete difference of element.</td>
</tr>
<tr>
<td><code>Series.factorize()</code></td>
<td>Encode the object as an enumerated type or categorical variable.</td>
</tr>
<tr>
<td><code>Series.kurt()</code></td>
<td>Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0).</td>
</tr>
<tr>
<td><code>Series.mad()</code></td>
<td>Return the mean absolute deviation of the values for the requested axis</td>
</tr>
<tr>
<td><code>Series.max()</code></td>
<td>This method returns the maximum of the values in the object.</td>
</tr>
<tr>
<td><code>Series.median()</code></td>
<td>Return the median of the values for the requested axis</td>
</tr>
<tr>
<td><code>Series.min()</code></td>
<td>This method returns the minimum of the values in the object.</td>
</tr>
<tr>
<td><code>Series.mode()</code></td>
<td>Return the mode(s) of the dataset.</td>
</tr>
<tr>
<td><code>Series.nlargest()</code></td>
<td>Return the largest n elements.</td>
</tr>
<tr>
<td><code>Series.nsmallest()</code></td>
<td>Return the smallest n elements.</td>
</tr>
<tr>
<td><code>Series.pct_change()</code></td>
<td>Percentage change between the current and a prior element.</td>
</tr>
<tr>
<td><code>Series.prod()</code></td>
<td>Return the product of the values for the requested axis</td>
</tr>
</tbody>
</table>

Continued on next page
### Series

**Series.quantile**([q, interpolation])
Return value at the given quantile, a la numpy.percentile.

**Series.rank**([axis, method, numeric_only, ...])
Compute numerical data ranks (1 through n) along axis.

**Series.sem**([axis, skipna, level, ddof, ...])
Return unbiased standard error of the mean over requested axis.

**Series.skew**([axis, skipna, level, numeric_only])
Return unbiased skew over requested axis Normalized by N-1

**Series.std**([axis, skipna, level, ddof, ...])
Return sample standard deviation over requested axis.

**Series.sum**([axis, skipna, level, ...])
Return the sum of the values for the requested axis.

**Series.var**([axis, skipna, level, ddof, ...])
Return unbiased variance over requested axis.

**Series.kurtosis**([axis, skipna, level, ...])
Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0).

**Series.unique**()
Return unique values of Series object.

**Series.nunique**([dropna])
Return number of unique elements in the object.

**Series.is_unique**
Return boolean if values in the object are unique.

**Series.is_monotonic**
Return boolean if values in the object are monotonic_increasing.

**Series.is_monotonic_increasing**
Return boolean if values in the object are monotonic_increasing.

**Series.is_monotonic_decreasing**
Return boolean if values in the object are monotonic_decreasing.

**Series.value_counts**([normalize, sort, ...])
Returns object containing counts of unique values.

**Series.compound**([axis, skipna, level])
Return the compound percentage of the values for the requested axis.

**Series.nonzero**()
Return the integer indices of the elements that are non-zero.

**Series.ptp**([axis, skipna, level, numeric_only])
Returns the difference between the maximum value and the minimum value in the object.

### 34.3.8 Reindexing / Selection / Label manipulation

**Series.align**(other[, join, axis, level, ...])
Align two objects on their axes with the specified join method for each axis Index.

**Series.drop**([labels, axis, index, columns, ...])
Return Series with specified index labels removed.

**Series.drop_duplicates**([keep, inplace])
Return Series with duplicate values removed.

**Series.duplicated**([keep])
Indicate duplicate Series values.

**Series.equals**(other)
Determines if two NDFrame objects contain the same elements.

**Series.first**(offset)
Convenience method for subsetting initial periods of time series data based on a date offset.

**Series.head**(n)
Return the first n rows.

**Series.idxmax**([axis, skipna])
Return the row label of the maximum value.

**Series.idxmin**([axis, skipna])
Return the row label of the minimum value.

**Series.isin**(values)
Check whether values are contained in Series.

**Series.last**(offset)
Convenience method for subsetting final periods of time series data based on a date offset.

**Series.reindex**(index)
Conform Series to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.

Continued on next page
### Table 33 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.reindex_like(other[, method, copy, ...])</code></td>
<td>Return an object with matching indices to myself.</td>
</tr>
<tr>
<td><code>Series.rename([index])</code></td>
<td>Alter Series index labels or name</td>
</tr>
<tr>
<td><code>Series.rename_axis(mapper[, axis, copy, inplace])</code></td>
<td>Alter the name of the index or columns.</td>
</tr>
<tr>
<td><code>Series.reset_index([level, drop, name, inplace])</code></td>
<td>Generate a new DataFrame or Series with the index reset.</td>
</tr>
<tr>
<td><code>Series.sample([n, frac, replace, weights, ...])</code></td>
<td>Return a random sample of items from an axis of object.</td>
</tr>
<tr>
<td><code>Series.select(crit[, axis])</code></td>
<td>(DEPRECATED) Return data corresponding to axis labels matching criteria</td>
</tr>
<tr>
<td><code>Series.set_axis(labels[, axis, inplace])</code></td>
<td>Assign desired index to given axis.</td>
</tr>
<tr>
<td><code>Series.take(indices[, axis, convert, is_copy])</code></td>
<td>Return the elements in the given positional indices along an axis.</td>
</tr>
<tr>
<td><code>Series.tail([n])</code></td>
<td>Return the last n rows.</td>
</tr>
<tr>
<td><code>Series.truncate([before, after, axis, copy])</code></td>
<td>Truncate a Series or DataFrame before and after some index value.</td>
</tr>
<tr>
<td><code>Series.where(cond[, other, inplace, axis, ...])</code></td>
<td>Return an object of same shape as self and whose corresponding entries are from self where cond is True and otherwise are from other.</td>
</tr>
<tr>
<td><code>Series.mask(cond[, other, inplace, axis, ...])</code></td>
<td>Return an object of same shape as self and whose corresponding entries are from self where cond is False and otherwise are from other.</td>
</tr>
<tr>
<td><code>Series.add_prefix(prefix)</code></td>
<td>Prefix labels with string prefix.</td>
</tr>
<tr>
<td><code>Series.add_suffix(suffix)</code></td>
<td>Suffix labels with string suffix.</td>
</tr>
<tr>
<td><code>Series.filter([items, like, regex, axis])</code></td>
<td>Subset rows or columns of dataframe according to labels in the specified index.</td>
</tr>
</tbody>
</table>

### 34.3.9 Missing data handling

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.isna()</code></td>
<td>Detect missing values.</td>
</tr>
<tr>
<td><code>Series.notna()</code></td>
<td>Detect existing (non-missing) values.</td>
</tr>
<tr>
<td><code>Series.dropna([axis, inplace])</code></td>
<td>Return a new Series with missing values removed.</td>
</tr>
<tr>
<td><code>Series.fillna([value, method, axis, ...])</code></td>
<td>Fill NA/NaN values using the specified method</td>
</tr>
<tr>
<td><code>Series.interpolate([method, axis, limit, ...])</code></td>
<td>Interpolate values according to different methods.</td>
</tr>
</tbody>
</table>

### 34.3.10 Reshaping, sorting

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.argsort([axis, kind, order])</code></td>
<td>Overrides ndarray.argsort.</td>
</tr>
<tr>
<td><code>Series.argmin([axis, skipna])</code></td>
<td>(DEPRECATED) ..</td>
</tr>
<tr>
<td><code>Series.argmax([axis, skipna])</code></td>
<td>(DEPRECATED) ..</td>
</tr>
<tr>
<td><code>Series.reorder_levels(order)</code></td>
<td>Rearrange index levels using input order.</td>
</tr>
<tr>
<td><code>Series.sort_values([axis, ascending, ...])</code></td>
<td>Sort by the values.</td>
</tr>
<tr>
<td><code>Series.sort_index([axis, level, ascending, ...])</code></td>
<td>Sort Series by index labels.</td>
</tr>
<tr>
<td><code>Series.swaplevel([i, j, copy])</code></td>
<td>Swap levels i and j in a MultiIndex</td>
</tr>
<tr>
<td><code>Series.unstack([level, fill_value])</code></td>
<td>Unstack, a.k.a.</td>
</tr>
<tr>
<td><code>Series.searchsorted(value[, side, sorter])</code></td>
<td>Find indices where elements should be inserted to maintain order.</td>
</tr>
<tr>
<td><code>Series.ravel([order])</code></td>
<td>Return the flattened underlying data as an ndarray</td>
</tr>
<tr>
<td><code>Series.repeat(repeats, *args, **kwargs)</code></td>
<td>Repeat elements of an Series.</td>
</tr>
<tr>
<td><code>Series.squeeze([axis])</code></td>
<td>Squeeze length 1 dimensions.</td>
</tr>
</tbody>
</table>

Continued on next page
Table 35 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.view</code> ([dtype])</td>
<td>Create a new view of the Series.</td>
</tr>
<tr>
<td><code>Series.sortlevel</code> ([level, ascending,...])</td>
<td>(DEPRECATED) Sort Series with MultiIndex by chosen level.</td>
</tr>
</tbody>
</table>

### 34.3.11 Combining / joining / merging

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.append</code> (to_append[, ignore_index,...])</td>
<td>Concatenate two or more Series.</td>
</tr>
<tr>
<td><code>Series.replace</code> ([to_replace, value, inplace,...])</td>
<td>Replace values given in to_replace with value.</td>
</tr>
<tr>
<td><code>Series.update</code> (other)</td>
<td>Modify Series in place using non-NA values from passed Series.</td>
</tr>
</tbody>
</table>

### 34.3.12 Time series-related

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.asfreq</code> (freq[, method, how,...])</td>
<td>Convert TimeSeries to specified frequency.</td>
</tr>
<tr>
<td><code>Series.asof</code> (where[, subset])</td>
<td>The last row without any NaN is taken (or the last row without NaN considering only the subset of columns in the case of a DataFrame)</td>
</tr>
<tr>
<td><code>Series.shift</code> ([periods, freq, axis])</td>
<td>Shift index by desired number of periods with an optional time freq.</td>
</tr>
<tr>
<td><code>Series.first_valid_index()</code></td>
<td>Return index for first non-NA/null value.</td>
</tr>
<tr>
<td><code>Series.last_valid_index()</code></td>
<td>Return index for last non-NA/null value.</td>
</tr>
<tr>
<td><code>Series.resample</code> (rule[, how, axis,...])</td>
<td>Convenience method for frequency conversion and resampling of time series.</td>
</tr>
<tr>
<td><code>Series.tz_convert</code> (tz[, axis, level, copy])</td>
<td>Convert tz-aware axis to target time zone.</td>
</tr>
<tr>
<td><code>Series.tz_localize</code> (tz[, axis, level, copy,...])</td>
<td>Localize tz-naive TimeSeries to target time zone.</td>
</tr>
<tr>
<td><code>Series.at_time</code> (time[, asof])</td>
<td>Select values at particular time of day (e.g., 9:00-9:30 AM).</td>
</tr>
<tr>
<td><code>Series.between_time</code> (start_time, end_time[, ...])</td>
<td>Select values between particular times of the day (e.g., 9:00-9:30 AM).</td>
</tr>
<tr>
<td><code>Series.tshift</code> ([periods, freq, axis])</td>
<td>Shift the time index, using the index’s frequency if available.</td>
</tr>
<tr>
<td><code>Series.slice_shift</code> ([periods, axis])</td>
<td>Equivalent to shift without copying data.</td>
</tr>
</tbody>
</table>

### 34.3.13 Datetimelike Properties

Series.dt can be used to access the values of the series as datetimelike and return several properties. These can be accessed like `Series.dt.<property>`.

**Datetime Properties**

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.dt.date</code></td>
<td>Returns numpy array of python datetime.date objects (namely, the date part of Timestamps without timezone information).</td>
</tr>
<tr>
<td><code>Series.dt.time</code></td>
<td>Returns numpy array of datetime.time.</td>
</tr>
<tr>
<td><code>Series.dt.year</code></td>
<td>The year of the datetime</td>
</tr>
<tr>
<td><code>Series.dt.month</code></td>
<td>The month as January=1, December=12</td>
</tr>
<tr>
<td><code>Series.dt.day</code></td>
<td>The days of the datetime</td>
</tr>
<tr>
<td><code>Series.dt.hour</code></td>
<td>The hours of the datetime</td>
</tr>
<tr>
<td><code>Series.dt.minute</code></td>
<td>The minutes of the datetime</td>
</tr>
<tr>
<td><code>Series.dt.second</code></td>
<td>The seconds of the datetime</td>
</tr>
</tbody>
</table>

Continued on next page
Table 38 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series.dt.microsecond</td>
<td>The microseconds of the datetime</td>
</tr>
<tr>
<td>Series.dt.nanosecond</td>
<td>The nanoseconds of the datetime</td>
</tr>
<tr>
<td>Series.dt.week</td>
<td>The week ordinal of the year</td>
</tr>
<tr>
<td>Series.dt.weekofyear</td>
<td>The week ordinal of the year</td>
</tr>
<tr>
<td>Series.dt.dayofweek</td>
<td>The day of the week with Monday=0, Sunday=6</td>
</tr>
<tr>
<td>Series.dt.weekday</td>
<td>The day of the week with Monday=0, Sunday=6</td>
</tr>
<tr>
<td>Series.dt.dayofyear</td>
<td>The ordinal day of the year</td>
</tr>
<tr>
<td>Series.dt.quarter</td>
<td>The quarter of the date</td>
</tr>
<tr>
<td>Series.dt.is_month_start</td>
<td>Logical indicating if first day of month (defined by frequency)</td>
</tr>
<tr>
<td>Series.dt.is_month_end</td>
<td>Indicator for whether the date is the last day of the month.</td>
</tr>
<tr>
<td>Series.dt.is_quarter_start</td>
<td>Indicator for whether the date is the first day of a quarter.</td>
</tr>
<tr>
<td>Series.dt.is_quarter_end</td>
<td>Indicator for whether the date is the last day of a quarter.</td>
</tr>
<tr>
<td>Series.dt.is_year_start</td>
<td>Indicate whether the date is the first day of a year.</td>
</tr>
<tr>
<td>Series.dt.is_year_end</td>
<td>Indicate whether the date is the last day of the year.</td>
</tr>
<tr>
<td>Series.dt.is_leap_year</td>
<td>Boolean indicator if the date belongs to a leap year.</td>
</tr>
<tr>
<td>Series.dt.daysinmonth</td>
<td>The number of days in the month</td>
</tr>
<tr>
<td>Series.dt.days_in_month</td>
<td>The number of days in the month</td>
</tr>
<tr>
<td>Series.dt.tz</td>
<td></td>
</tr>
<tr>
<td>Series.dt.freq</td>
<td></td>
</tr>
</tbody>
</table>

34.3.13.1 pandas.Series.dt.date

Series.dt.date

Returns numpy array of python datetime.date objects (namely, the date part of Timestamps without timezone information).

34.3.13.2 pandas.Series.dt.time

Series.dt.time

Returns numpy array of datetime.time. The time part of the Timestamps.

34.3.13.3 pandas.Series.dt.year

Series.dt.year

The year of the datetime

34.3.13.4 pandas.Series.dt.month

Series.dt.month

The month as January=1, December=12

34.3.13.5 pandas.Series.dt.day

Series.dt.day

The days of the datetime
34.3.13.6 pandas.Series.dt.hour

Series.dt.hour
The hours of the datetime

34.3.13.7 pandas.Series.dt.minute

Series.dt.minute
The minutes of the datetime

34.3.13.8 pandas.Series.dt.second

Series.dt.second
The seconds of the datetime

34.3.13.9 pandas.Series.dt.microsecond

Series.dt.microsecond
The microseconds of the datetime

34.3.13.10 pandas.Series.dt.nanosecond

Series.dt.nanosecond
The nanoseconds of the datetime

34.3.13.11 pandas.Series.dt.week

Series.dt.week
The week ordinal of the year

34.3.13.12 pandas.Series.dt.weekofyear

Series.dt.weekofyear
The week ordinal of the year

34.3.13.13 pandas.Series.dt.dayofweek

Series.dt.dayofweek
The day of the week with Monday=0, Sunday=6

34.3.13.14 pandas.Series.dt.weekday

Series.dt.weekday
The day of the week with Monday=0, Sunday=6
### pandas.Series.dt.dayofyear

**Series.dt.dayofyear**

The ordinal day of the year

### pandas.Series.dt.quarter

**Series.dt.quarter**

The quarter of the date

### pandas.Series.dt.is_month_start

**Series.dt.is_month_start**

Logical indicating if first day of month (defined by frequency)

### pandas.Series.dt.is_month_end

**Series.dt.is_month_end**

Indicator for whether the date is the last day of the month.

**Returns** Series or array

For Series, returns a Series with boolean values. For DatetimeIndex, returns a boolean array.

**See also:**

*is_month_start* Indicator for whether the date is the first day of the month.

**Examples**

This method is available on Series with datetime values under the `.dt` accessor, and directly on DatetimeIndex.

```python
>>> dates = pd.Series(pd.date_range("2018-02-27", periods=3))
>>> dates
0  2018-02-27
1  2018-02-28
2  2018-03-01
dtype: datetime64[ns]
>>> dates.dt.is_month_end
0   False
1    True
2   False
dtype: bool

>>> idx = pd.date_range("2018-02-27", periods=3)
>>> idx.is_month_end
array([False, True, False], dtype=bool)
```
34.3.13.19 pandas.Series.dt.is_quarter_start

Series.dt.is_quarter_start
Indicator for whether the date is the first day of a quarter.

Returns is_quarter_start : Series or DatetimeIndex
The same type as the original data with boolean values. Series will have the same
name and index. DatetimeIndex will have the same name.

See also:

quarter Return the quarter of the date.

is_quarter_end Similar property for indicating the quarter start.

Examples

This method is available on Series with datetime values under the .dt accessor, and directly on DatetimeIndex.

```python
>>> df = pd.DataFrame({'dates': pd.date_range("2017-03-30", ... periods=4))
>>> df.assign(quarter=df.dates.dt.quarter, ...
... is_quarter_start=df.dates.dt.is_quarter_start)
   dates      quarter  is_quarter_start
0 2017-03-30          1         False
1 2017-03-31          1         False
2 2017-04-01          2          True
3 2017-04-02          2         False
```

```python
>>> idx = pd.date_range('2017-03-30', periods=4)
>>> idx
DatetimeIndex(['2017-03-30', '2017-03-31', '2017-04-01', '2017-04-02'],
              dtype='datetime64[ns]', freq='D')

>>> idx.is_quarter_start
array([False, False,  True, False])
```

34.3.13.20 pandas.Series.dt.is_quarter_end

Series.dt.is_quarter_end
Indicator for whether the date is the last day of a quarter.

Returns is_quarter_end : Series or DatetimeIndex
The same type as the original data with boolean values. Series will have the same
name and index. DatetimeIndex will have the same name.

See also:

quarter Return the quarter of the date.

is_quarter_start Similar property indicating the quarter start.
Examples

This method is available on Series with datetime values under the .dt accessor, and directly on DatetimeIndex.

```python
df = pd.DataFrame({'dates': pd.date_range("2017-03-30", periods=4)})
df.assign(quarter=df.dates.dt.quarter, is_quarter_end=df.dates.dt.is_quarter_end)
```

<table>
<thead>
<tr>
<th>dates</th>
<th>quarter</th>
<th>is_quarter_end</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017-03-30</td>
<td>1</td>
<td>False</td>
</tr>
<tr>
<td>2017-03-31</td>
<td>1</td>
<td>True</td>
</tr>
<tr>
<td>2017-04-01</td>
<td>2</td>
<td>False</td>
</tr>
<tr>
<td>2017-04-02</td>
<td>2</td>
<td>False</td>
</tr>
</tbody>
</table>

```python
idx = pd.date_range('2017-03-30', periods=4)
idx.is_quarter_end
```

```
array([False, True, False, False])
```

34.3.13.21 pandas.Series.dt.is_year_start

Series.dt.is_year_start

Indicate whether the date is the first day of a year.

Returns Series or DatetimeIndex

The same type as the original data with boolean values. Series will have the same name and index. DatetimeIndex will have the same name.

See also:

is_year_end Similar property indicating the last day of the year.

Examples

This method is available on Series with datetime values under the .dt accessor, and directly on DatetimeIndex.

```python
dates = pd.Series(pd.date_range("2017-12-30", periods=3))
dates.dt.is_year_start
```

```
0   False
1   False
2    True
dtype: bool
```
>>> idx = pd.date_range("2017-12-30", periods=3)
>>> idx
DatetimeIndex(['2017-12-30', '2017-12-31', '2018-01-01'],
dtype='datetime64[ns]', freq='D')

>>> idx.is_year_start
array([False, False, True])

34.3.13.22 pandas.Series.dt.is_year_end

Series.dt.is_year_end
Indicate whether the date is the last day of the year.

Returns Series or DatetimeIndex
The same type as the original data with boolean values. Series will have the same
name and index. DatetimeIndex will have the same name.

See also:

is_year_start Similar property indicating the start of the year.

Examples

This method is available on Series with datetime values under the .dt accessor, and directly on DatetimeIndex.

>>> dates = pd.Series(pd.date_range("2017-12-30", periods=3))
>>> dates
0    2017-12-30
1    2017-12-31
2    2018-01-01
dtype: datetime64[ns]

>>> dates.dt.is_year_end
0    False
1    True
2    False
dtype: bool

>>> idx = pd.date_range("2017-12-30", periods=3)
>>> idx
DatetimeIndex(['2017-12-30', '2017-12-31', '2018-01-01'],
dtype='datetime64[ns]', freq='D')

>>> idx.is_year_end
array([False, True, False])

34.3.13.23 pandas.Series.dt.is_leap_year

Series.dt.is_leap_year
Boolean indicator if the date belongs to a leap year.
A leap year is a year, which has 366 days (instead of 365) including 29th of February as an intercalary day. Leap years are years which are multiples of four with the exception of years divisible by 100 but not by 400.

**Returns** Series or ndarray

Booleans indicating if dates belong to a leap year.

**Examples**

This method is available on Series with datetime values under the .dt accessor, and directly on DatetimeIndex.

```python
>>> idx = pd.date_range("2012-01-01", "2015-01-01", freq="Y")
>>> idx
DatetimeIndex(['2012-12-31', '2013-12-31', '2014-12-31'],
dtype='datetime64[ns]', freq='A-DEC')
>>> idx.is_leap_year
array([ True, False, False], dtype=bool)
```

```python
>>> dates = pd.Series(idx)
>>> dates_series
0 2012-12-31
1 2013-12-31
2 2014-12-31
dtype: datetime64[ns]
>>> dates_series.dt.is_leap_year
0  True
1  False
2  False
dtype: bool
```

### 34.3.13.24 pandas.Series.dt.daysinmonth

**Series.dt.daysinmonth**

The number of days in the month

### 34.3.13.25 pandas.Series.dt.days_in_month

**Series.dt.days_in_month**

The number of days in the month

### 34.3.13.26 pandas.Series.dt.tz

**Series.dt.tz**

### 34.3.13.27 pandas.Series.dt.freq

**Series.dt.freq**

**Datetime Methods**

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series.dt.to_period(*args, **kwargs)</td>
<td>Cast to PeriodIndex at a particular frequency.</td>
</tr>
</tbody>
</table>

Continued on next page
Table 39 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.dt.to_pydatetime()</code></td>
<td>Return the data as an array of native Python datetime objects</td>
</tr>
<tr>
<td><code>Series.dt.tz_localize(*args, **kwargs)</code></td>
<td>Localize tz-naive DatetimeIndex to tz-aware DatetimeIndex.</td>
</tr>
<tr>
<td><code>Series.dt.tz_convert(*args, **kwargs)</code></td>
<td>Convert tz-aware DatetimeIndex from one time zone to another.</td>
</tr>
<tr>
<td><code>Series.dt.normalize(*args, **kwargs)</code></td>
<td>Convert times to midnight.</td>
</tr>
<tr>
<td><code>Series.dt.strftime(*args, **kwargs)</code></td>
<td>Convert to Index using specified date_format.</td>
</tr>
<tr>
<td><code>Series.dt.floor(*args, **kwargs)</code></td>
<td>Round the data to the specified freq.</td>
</tr>
<tr>
<td><code>Series.dt.ceil(*args, **kwargs)</code></td>
<td>Round the data to the specified freq.</td>
</tr>
<tr>
<td><code>Series.dt.month_name(*args, **kwargs)</code></td>
<td>Return the month names of the DateTimeIndex with specified locale.</td>
</tr>
<tr>
<td><code>Series.dt.day_name(*args, **kwargs)</code></td>
<td>Return the day names of the DateTimeIndex with specified locale.</td>
</tr>
</tbody>
</table>

34.3.13.28 pandas.Series.dt.to_period

`Series.dt.to_period(*args, **kwargs)`

Cast to PeriodIndex at a particular frequency.

Converts DatetimeIndex to PeriodIndex.

**Parameters**

- `freq`: string or Offset, optional
  One of pandas' *offset strings* or an Offset object. Will be inferred by default.

**Returns**

- `PeriodIndex`

**Raises**

- `ValueError`
  When converting a DatetimeIndex with non-regular values, so that a frequency cannot be inferred.

**See also:**

- `pandas.PeriodIndex` Immutable ndarray holding ordinal values
- `pandas.DatetimeIndex.to_pydatetime` Return DatetimeIndex as object

**Examples**

```python
>>> df = pd.DataFrame({"y": [1,2,3]})
...     index=pd.to_datetime(['2000-03-31 00:00:00',
...                           '2000-05-31 00:00:00',
...                           '2000-08-31 00:00:00'])
... >>> df.index.to_period("M")
PeriodIndex(["2000-03", '2000-05', '2000-08'],
            dtype='period[M]', freq='M')
```

Infer the daily frequency

---

34.3. Series 1645
>>> idx = pd.date_range("2017-01-01", periods=2)
>>> idx.to_period()
PeriodIndex(['2017-01-01', '2017-01-02'],
            dtype='period[D]', freq='D')

34.3.13.29 pandas.Series.dt.to_pydatetime

Series.dt.to_pydatetime()

Return the data as an array of native Python datetime objects

Timezone information is retained if present.

**Warning:** Python’s datetime uses microsecond resolution, which is lower than pandas (nanosecond). The values are truncated.

**Returns** numpy.ndarray

object dtype array containing native Python datetime objects.

See also:

datetime.datetime Standard library value for a datetime.

**Examples**

```python
>>> s = pd.Series(pd.date_range('20180310', periods=2))
>>> s
\n0 2018-03-10
1 2018-03-11
\ndtype: datetime64[ns]

>>> s.dt.to_pydatetime()
array([\ndatetime.datetime(2018, 3, 10, 0, 0),
       datetime.datetime(2018, 3, 11, 0, 0)], dtype=object)
```

Pandas' nanosecond precision is truncated to microseconds.

```python
>>> s = pd.Series(pd.date_range('20180310', periods=2, freq='ns'))
>>> s
\n0 2018-03-10 00:00:00.000000000
1 2018-03-10 00:00:00.000000001
\ndtype: datetime64[ns]

>>> s.dt.to_pydatetime()
array([\ndatetime.datetime(2018, 3, 10, 0, 0),
       datetime.datetime(2018, 3, 11, 0, 0)], dtype=object)
```

34.3.13.30 pandas.Series.dt.tz_localize

Series.dt.tz_localize(*args, **kwargs)

Localize tz-naive DatetimeIndex to tz-aware DatetimeIndex.
This method takes a time zone (tz) naive DatetimeIndex object and makes this time zone aware. It does not move the time to another time zone. Time zone localization helps to switch from time zone aware to time zone unaware objects.

**Parameters**

- **tz**: string, pytz.timezone, dateutil.tz.tzfile or None
  
  Time zone to convert timestamps to. Passing None will remove the time zone information preserving local time.

- **ambiguous**: str {'infer', 'NaT', 'raise'} or bool array, default 'raise'
  
  - 'infer' will attempt to infer fall dst-transition hours based on order
  - bool-ndarray where True signifies a DST time, False signifies a non-DST time (note that this flag is only applicable for ambiguous times)
  - 'NaT' will return NaT where there are ambiguous times
  - 'raise' will raise an AmbiguousTimeError if there are ambiguous times

- **errors**: {'raise', 'coerce'}, default 'raise'
  
  - 'raise' will raise a NonExistentTimeError if a timestamp is not valid in the specified time zone (e.g. due to a transition from or to DST time)
  - 'coerce' will return NaT if the timestamp can not be converted to the specified time zone

New in version 0.19.0.

**Returns**

DatetimeIndex

Index converted to the specified time zone.

**Raises**

TypeError

If the DatetimeIndex is tz-aware and tz is not None.

**See also:**

DatetimeIndex.tz_convert  Convert tz-aware DatetimeIndex from one time zone to another.

**Examples**

```python
>>> tz_naive = pd.date_range('2018-03-01 09:00', periods=3)
>>> tz_naive
DatetimeIndex(['2018-03-01 09:00:00', '2018-03-02 09:00:00',
               '2018-03-03 09:00:00'],
              dtype='datetime64[ns]', freq='D')

>>> tz_aware = tz_naive.tz_localize(tz='US/Eastern')
>>> tz_aware
DatetimeIndex(['2018-03-01 09:00:00-05:00',
                '2018-03-02 09:00:00-05:00',
                '2018-03-03 09:00:00-05:00'],
               dtype='datetime64[ns, US/Eastern]', freq='D')
```

With the tz=None, we can remove the time zone information while keeping the local time (not converted to UTC):
>>> tz_aware.tz_localize(None)
DatetimeIndex(['2018-03-01 09:00:00', '2018-03-02 09:00:00',
               '2018-03-03 09:00:00'],
               dtype='datetime64[ns]', freq='D')

34.3.13.31 pandas.Series.dt.tz_convert

Series.dt.tz_convert(*args, **kwargs)
Convert tz-aware DatetimeIndex from one time zone to another.

Parameters tz : string, pytz.timezone, dateutil.tz.tzfile or None
Time zone for time. Corresponding timestamps would be converted to this time zone
of the DatetimeIndex. A tz of None will convert to UTC and remove the timezone
information.

Returns
normalized [DatetimeIndex]

Raises TypeError
If DatetimeIndex is tz-naive.

See also:
DatetimeIndex.tz A timezone that has a variable offset from UTC
DatetimeIndex.tz_localize Localize tz-naive DatetimeIndex to a given time zone, or remove time-
zone from a tz-aware DatetimeIndex.

Examples

With the tz parameter, we can change the DatetimeIndex to other time zones:

>>> dti = pd.DatetimeIndex(start='2014-08-01 09:00',
                          freq='H', periods=3, tz='Europe/Berlin')

>>> dti
DatetimeIndex(['2014-08-01 09:00:00+02:00',
               '2014-08-01 10:00:00+02:00',
               '2014-08-01 11:00:00+02:00'],
               dtype='datetime64[ns, Europe/Berlin]', freq='H')

>>> dti.tz_convert('US/Central')
DatetimeIndex(['2014-08-01 02:00:00-05:00',
               '2014-08-01 03:00:00-05:00',
               '2014-08-01 04:00:00-05:00'],
               dtype='datetime64[ns, US/Central]', freq='H')

With the tz=None, we can remove the timezone (after converting to UTC if necessary):

>>> dti = pd.DatetimeIndex(start='2014-08-01 09:00', freq='H',
                          periods=3, tz='Europe/Berlin')

>>> dti
DatetimeIndex(['2014-08-01 09:00:00', '2014-08-01 10:00:00',
               '2014-08-01 11:00:00'],
               dtype='datetime64[ns]', freq='H')

>>> dti.tz_convert(None)
DatetimeIndex(['2014-08-01 02:00:00-05:00',
               '2014-08-01 03:00:00-05:00',
               '2014-08-01 04:00:00-05:00'],
               dtype='datetime64[ns, US/Central]', freq='H')
```py
>>> dti
DatetimeIndex(['2014-08-01 09:00:00+02:00',
               '2014-08-01 10:00:00+02:00',
               '2014-08-01 11:00:00+02:00'],
              dtype='datetime64[ns, Europe/Berlin]', freq='H')
```

```py
>>> dti.tz_convert(None)
DatetimeIndex(['2014-08-01 07:00:00',
               '2014-08-01 08:00:00',
               '2014-08-01 09:00:00'],
              dtype='datetime64[ns]', freq='H')
```

### 34.3.13.32 pandas.Series.dt.normalize

`Series.dt.normalize(*args, **kwargs)`

Convert times to midnight.

The time component of the date-time is converted to midnight i.e. 00:00:00. This is useful in cases, when the time does not matter. Length is unaltered. The timezones are unaffected.

This method is available on Series with datetime values under the `.dt` accessor, and directly on DatetimeIndex.

**Returns** DatetimeIndex or Series

The same type as the original data. Series will have the same name and index. DatetimeIndex will have the same name.

**See also:**

*floor* Floor the datetimes to the specified freq.

*ceil* Ceiling the datetimes to the specified freq.

*round* Round the datetimes to the specified freq.

**Examples**

```py
>>> idx = pd.DatetimeIndex(start='2014-08-01 10:00', freq='H',
                         ... periods=3, tz='Asia/Calcutta')
```

```py
>>> idx
DatetimeIndex(['2014-08-01 10:00:00+05:30',
               '2014-08-01 11:00:00+05:30',
               '2014-08-01 12:00:00+05:30'],
              dtype='datetime64[ns, Asia/Calcutta]', freq='H')
```

```py
>>> idx.normalize()
DatetimeIndex(['2014-08-01 00:00:00+05:30',
               '2014-08-01 00:00:00+05:30',
               '2014-08-01 00:00:00+05:30'],
              dtype='datetime64[ns, Asia/Calcutta]', freq=None)
```

### 34.3.13.33 pandas.Series.dt.strftime

`Series.dt.strftime(*args, **kwargs)`

Convert to Index using specified date_format.
Return an Index of formatted strings specified by date_format, which supports the same string format as the python standard library. Details of the string format can be found in python string format doc

**Parameters**

date_format : str

Date format string (e.g. “%Y-%m-%d”).

**Returns**

Index

Index of formatted strings

**See also:**

- pandas.to_datetime: Convert the given argument to datetime
- DatetimeIndex.normalize: Return DatetimeIndex with times to midnight.
- DatetimeIndex.round: Round the DatetimeIndex to the specified freq.
- DatetimeIndex.floor: Floor the DatetimeIndex to the specified freq.

**Examples**

```python
def date_range_example():
    rng = pd.date_range(pd.Timestamp("2018-03-10 09:00"),
                        periods=3, freq='s')
    return rng

rng = date_range_example()
print(rng.strftime('%B %d, %Y, %r'))
```

**34.3.13.34 pandas.Series.dt.round**

Series.dt.round(*args, **kwargs)

round the data to the specified freq.

**Parameters**

freq : str or Offset

The frequency level to round the index to. Must be a fixed frequency like ‘S’ (second) not ‘ME’ (month end). See frequency aliases for a list of possible freq values.

**Returns**

DatetimeIndex, TimedeltaIndex, or Series

Index of the same type for a DatetimeIndex or TimedeltaIndex, or a Series with the same index for a Series.

**Raises**

ValueError if the ‘freq‘ cannot be converted.

**Examples**

```python
def round_example():
    rng = pd.date_range('1/1/2018 11:59:00', periods=3, freq='min')
    return rng

rng = round_example()
print(rng)
```

(continues on next page)
Series

```python
>>> pd.Series(rng).dt.round("H")
0    2018-01-01 12:00:00
1    2018-01-01 12:00:00
2    2018-01-01 12:00:00
dtype: datetime64[ns]
```

34.3.13.35 pandas.Series.dt.floor

Series.dt.floor(*args, **kwargs)

floor the data to the specified freq.

**Parameters**

- freq : str or Offset
  
The frequency level to floor the index to. Must be a fixed frequency like ‘S’ (second) not ‘ME’ (month end). See frequency aliases for a list of possible freq values.

**Returns**

- DatetimeIndex, TimedeltaIndex, or Series
  
  Index of the same type for a DatetimeIndex or TimedeltaIndex, or a Series with the same index for a Series.

**Raises**

- ValueError if the ‘freq’ cannot be converted.

**Examples**

**DatetimeIndex**

```python
>>> rng = pd.date_range('1/1/2018 11:59:00', periods=3, freq='min')
>>> rng
DatetimeIndex(['2018-01-01 11:59:00', '2018-01-01 12:00:00', '2018-01-01 12:00:00'],
               dtype='datetime64[ns]', freq='T')
>>> rng.floor("H")
DatetimeIndex(['2018-01-01 11:00:00', '2018-01-01 12:00:00', '2018-01-01 12:00:00'],
               dtype='datetime64[ns]', freq=None)
```

**Series**

```python
>>> pd.Series(rng).dt.floor("H")
0    2018-01-01 11:00:00
1    2018-01-01 12:00:00
2    2018-01-01 12:00:00
dtype: datetime64[ns]
```
34.3.13.36 pandas.Series.dt.ceil

Series.dt.ceil(*args, **kwargs)

ceil the data to the specified freq.

Parameters
freq : str or Offset

The frequency level to ceil the index to. Must be a fixed frequency like ‘S’ (second) not ‘ME’ (month end). See frequency aliases for a list of possible freq values.

Returns
DatetimeIndex, TimedeltaIndex, or Series

Index of the same type for a DatetimeIndex or TimedeltaIndex, or a Series with the same index for a Series.

Raises

ValueError if the ‘freq‘ cannot be converted.

Examples

DatetimeIndex

```python
>>> rng = pd.date_range('1/1/2018 11:59:00', periods=3, freq='min')
>>> rng
 DatetimeIndex(['2018-01-01 11:59:00', '2018-01-01 12:00:00',
                 '2018-01-01 12:01:00'],
               dtype='datetime64[ns]', freq='T')
```

```python
>>> rng.ceil('H')
 DatetimeIndex(['2018-01-01 12:00:00', '2018-01-01 12:00:00',
                 '2018-01-01 13:00:00'],
               dtype='datetime64[ns]', freq=None)
```

Series

```python
>>> pd.Series(rng).dt.ceil("H")
0 2018-01-01 12:00:00
1 2018-01-01 12:00:00
2 2018-01-01 13:00:00
dtype: datetime64[ns]
```

34.3.13.37 pandas.Series.dt.month_name

Series.dt.month_name(*args, **kwargs)

Return the month names of the DateTimeIndex with specified locale.

Parameters
locale : string, default None (English locale)

locale determining the language in which to return the month name

Returns
month_names : Index

Index of month names

.. versionadded:: 0.23.0
34.3.13.38 pandas.Series.dt.day_name

Series.dt.day_name(*args, **kwargs)

Return the day names of the DateTimeIndex with specified locale.

**Parameters**

- **locale**: string, default None (English locale)
  locale determining the language in which to return the day name

**Returns**

- **month_names**: Index
  Index of day names

.. versionadded:: 0.23.0

Timedelta Properties

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series.dt.days</td>
<td>Number of days for each element.</td>
</tr>
<tr>
<td>Series.dt.seconds</td>
<td>Number of seconds (&gt;= 0 and less than 1 day) for each element.</td>
</tr>
<tr>
<td>Series.dt.microseconds</td>
<td>Number of microseconds (&gt;= 0 and less than 1 second) for each element.</td>
</tr>
<tr>
<td>Series.dt.nanoseconds</td>
<td>Number of nanoseconds (&gt;= 0 and less than 1 microsecond) for each element.</td>
</tr>
<tr>
<td>Series.dt.components</td>
<td>Return a dataframe of the components (days, hours, minutes, seconds, milliseconds, microseconds, nanoseconds) of the Timedeltas.</td>
</tr>
</tbody>
</table>

34.3.13.39 pandas.Series.dt.days

Series.dt.days

Number of days for each element.

34.3.13.40 pandas.Series.dt.seconds

Series.dt.seconds

Number of seconds (>= 0 and less than 1 day) for each element.

34.3.13.41 pandas.Series.dt.microseconds

Series.dt.microseconds

Number of microseconds (>= 0 and less than 1 second) for each element.

34.3.13.42 pandas.Series.dt.nanoseconds

Series.dt.nanoseconds

Number of nanoseconds (>= 0 and less than 1 microsecond) for each element.

34.3.13.43 pandas.Series.dt.components

Series.dt.components

Return a dataframe of the components (days, hours, minutes, seconds, milliseconds, microseconds, nanoseconds) of the Timedeltas.
onds) of the Timedeltas.

Returns

a DataFrame

Timedelta Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.dt.to_pytimedelta()</code></td>
<td>Return an array of native <code>datetime.timedelta</code> objects.</td>
</tr>
<tr>
<td><code>Series.dt.total_seconds(*args, **kwargs)</code></td>
<td>Return total duration of each element expressed in seconds.</td>
</tr>
</tbody>
</table>

### 34.3.13.44 pandas.Series.dt.to_pytimedelta

`Series.dt.to_pytimedelta()`  
Return an array of native `datetime.timedelta` objects.

Python’s standard `datetime` library uses a different representation timedelta’s. This method converts a Series of pandas Timedeltas to `datetime.timedelta` format with the same length as the original Series.

Returns a : numpy.ndarray  
1D array containing data with `datetime.timedelta` type.

See also:  
datetime.timedelta

Examples

```python  
>>> s = pd.Series(pd.to_timedelta(np.arange(5), unit='d'))  
>>> s  
0  0 days  
1  1 days  
2  2 days  
3  3 days  
4  4 days  
dtype: timedelta64[ns]

>>> s.dt.to_pytimedelta()  
array([datetime.timedelta(0), datetime.timedelta(1),
       datetime.timedelta(2), datetime.timedelta(3),
       datetime.timedelta(4)], dtype=object)
```

### 34.3.13.45 pandas.Series.dt.total_seconds

`Series.dt.total_seconds(*args, **kwargs)`  
Return total duration of each element expressed in seconds.

This method is available directly on TimedeltaIndex and on Series containing timedelta values under the .dt namespace.

Returns seconds : Float64Index or Series
When the calling object is a TimedeltaIndex, the return type is a Float64Index. When
the calling object is a Series, the return type is Series of type float64 whose index is
the same as the original.

See also:

datetime.timedelta.total_seconds  Standard library version of this method.
TimedeltaIndex.components  Return a DataFrame with components of each Timedelta.

Examples

Series

>>> s = pd.Series(pd.to_timedelta(np.arange(5), unit='d'))
      0   1   2   3   4
s 0 days 1 days 2 days 3 days 4 days
>>> s.dt.total_seconds()
          0  0.0  86400.0  172800.0  259200.0  345600.0
Index: [0.0, 86400.0, 172800.0, 259200.00000000003, 345600.0]

TimedeltaIndex

>>> idx = pd.to_timedelta(np.arange(5), unit='d')
      TimedeltaIndex(['0 days', '1 days', '2 days', '3 days', '4 days'],
       dtype='timedelta64[ns]', freq=None)
>>> idx.total_seconds()
Float64Index([0.0, 86400.0, 172800.0, 259200.00000000003, 345600.0],
       dtype='float64')

34.3.14 String handling

Series.str can be used to access the values of the series as strings and apply several methods to it. These can be
accessed like Series.str.<function/property>.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series.str.capitalize()</td>
<td>Convert strings in the Series/Index to be capitalized.</td>
</tr>
<tr>
<td>Series.str.cat([others, sep, na_rep, join])</td>
<td>Concatenate strings in the Series/Index with given separator.</td>
</tr>
<tr>
<td>Series.str.center(width[, fillchar])</td>
<td>Filling left and right side of strings in the Series/Index with an additional character.</td>
</tr>
</tbody>
</table>

Continued on next page
**Table 42 – continued from previous page**

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series.str.contains(pat[, case, flags, na, ...])</td>
<td>Test if pattern or regex is contained within a string of a Series or Index.</td>
</tr>
<tr>
<td>Series.str.count(pat[, flags])</td>
<td>Count occurrences of pattern in each string of the Series/Index.</td>
</tr>
<tr>
<td>Series.str.decode(encoding[, errors])</td>
<td>Decode character string in the Series/Index using indicated encoding.</td>
</tr>
<tr>
<td>Series.str.encode(encoding[, errors])</td>
<td>Encode character string in the Series/Index using indicated encoding.</td>
</tr>
<tr>
<td>Series.str.endswith(pat[, na])</td>
<td>Test if the end of each string element matches a pattern.</td>
</tr>
<tr>
<td>Series.str.extract(pat[, flags, expand])</td>
<td>For each subject string in the Series, extract groups from the first match of regular expression pat.</td>
</tr>
<tr>
<td>Series.str.extractall(pat[, flags])</td>
<td>For each subject string in the Series, extract groups from all matches of regular expression pat.</td>
</tr>
<tr>
<td>Series.str.find(sub[, start, end])</td>
<td>Return lowest indexes in each strings in the Series/Index where the substring is fully contained between [start:end].</td>
</tr>
<tr>
<td>Series.str.findall(pat[, flags])</td>
<td>Find all occurrences of pattern or regular expression in the Series/Index.</td>
</tr>
<tr>
<td>Series.str.get(i)</td>
<td>Extract element from each component at specified position.</td>
</tr>
<tr>
<td>Series.str.index(sub[, start, end])</td>
<td>Return lowest indexes in each strings where the substring is fully contained between [start:end].</td>
</tr>
<tr>
<td>Series.str.join(sep)</td>
<td>Join lists contained as elements in the Series/Index with passed delimiter.</td>
</tr>
<tr>
<td>Series.str.len()</td>
<td>Compute length of each string in the Series/Index.</td>
</tr>
<tr>
<td>Series.str.ljust(width[, fillchar])</td>
<td>Filling right side of strings in the Series/Index with an additional character.</td>
</tr>
<tr>
<td>Series.str.lower()</td>
<td>Convert strings in the Series/Index to lowercase.</td>
</tr>
<tr>
<td>Series.str.lstrip([to Strip])</td>
<td>Strip whitespace (including newlines) from each string in the Series/Index from left side.</td>
</tr>
<tr>
<td>Series.str.match(pat[, case, flags, na, ...])</td>
<td>Determine if each string matches a regular expression.</td>
</tr>
<tr>
<td>Series.str.normalize(form)</td>
<td>Return the Unicode normal form for the strings in the Series/Index.</td>
</tr>
<tr>
<td>Series.str.pad(width[, side, fillchar])</td>
<td>Pad strings in the Series/Index with an additional character to specified side.</td>
</tr>
<tr>
<td>Series.str.partition([pat, expand])</td>
<td>Split the string at the first occurrence of sep, and return 3 elements containing the part before the separator, the separator itself, and the part after the separator.</td>
</tr>
<tr>
<td>Series.str.repeat(repeats)</td>
<td>Duplicate each string in the Series/Index by indicated number of times.</td>
</tr>
<tr>
<td>Series.str.replace(pat, repl[, n, case, ...])</td>
<td>Replace occurrences of pattern/regex in the Series/Index with some other string.</td>
</tr>
<tr>
<td>Series.str.rfind(sub[, start, end])</td>
<td>Return highest indexes in each strings in the Series/Index where the substring is fully contained between [start:end].</td>
</tr>
<tr>
<td>Series.str.rindex(sub[, start, end])</td>
<td>Return highest indexes in each strings where the substring is fully contained between [start:end].</td>
</tr>
<tr>
<td>Series.str.rjust(width[, fillchar])</td>
<td>Filling left side of strings in the Series/Index with an additional character.</td>
</tr>
</tbody>
</table>

**Continued on next page**
Table 42 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.str.rpartition</code></td>
<td>Split the string at the last occurrence of <code>sep</code>, and return 3 elements containing the part before the separator, the separator itself, and the part after the separator.</td>
</tr>
<tr>
<td><code>Series.str.rstrip</code></td>
<td>Strip whitespace (including newlines) from each string in the Series/Index from right side.</td>
</tr>
<tr>
<td><code>Series.str.slice</code></td>
<td>Slice substrings from each element in the Series/Index.</td>
</tr>
<tr>
<td><code>Series.str.slice_replace</code></td>
<td>Replace a positional slice of a string with another value.</td>
</tr>
<tr>
<td><code>Series.str.split</code></td>
<td>Split strings around given separator/delimiter.</td>
</tr>
<tr>
<td><code>Series.str.rsplit</code></td>
<td>Split each string in the Series/Index by the given delimiter string, starting at the end of the string and working to the front.</td>
</tr>
<tr>
<td><code>Series.str.startswith</code></td>
<td>Test if the start of each string element matches a pattern.</td>
</tr>
<tr>
<td><code>Series.str.strip</code></td>
<td>Strip whitespace (including newlines) from each string in the Series/Index from left and right sides.</td>
</tr>
<tr>
<td><code>Series.str.swapcase</code></td>
<td>Convert strings in the Series/Index to be swapcased.</td>
</tr>
<tr>
<td><code>Series.str.title</code></td>
<td>Convert strings in the Series/Index to titlecase.</td>
</tr>
<tr>
<td><code>Series.str.translate</code></td>
<td>Map all characters in the string through the given mapping table.</td>
</tr>
<tr>
<td><code>Series.str.upper</code></td>
<td>Convert strings in the Series/Index to uppercase.</td>
</tr>
<tr>
<td><code>Series.str.wrap</code></td>
<td>Wrap long strings in the Series/Index to be formatted in paragraphs with length less than a given width.</td>
</tr>
<tr>
<td><code>Series.str.zfill</code></td>
<td>Filling left side of strings in the Series/Index with 0.</td>
</tr>
<tr>
<td><code>Series.str.isalnum</code></td>
<td>Check whether all characters in each string in the Series/Index are alphanumeric.</td>
</tr>
<tr>
<td><code>Series.str.isalpha</code></td>
<td>Check whether all characters in each string in the Series/Index are alphabetic.</td>
</tr>
<tr>
<td><code>Series.str.isdigit</code></td>
<td>Check whether all characters in each string in the Series/Index are digits.</td>
</tr>
<tr>
<td><code>Series.str.isspace</code></td>
<td>Check whether all characters in each string in the Series/Index are whitespace.</td>
</tr>
<tr>
<td><code>Series.str.islower</code></td>
<td>Check whether all characters in each string in the Series/Index are lowercase.</td>
</tr>
<tr>
<td><code>Series.str.isupper</code></td>
<td>Check whether all characters in each string in the Series/Index are uppercase.</td>
</tr>
<tr>
<td><code>Series.str.istitle</code></td>
<td>Check whether all characters in each string in the Series/Index are titlecase.</td>
</tr>
<tr>
<td><code>Series.str.isnumeric</code></td>
<td>Check whether all characters in each string in the Series/Index are numeric.</td>
</tr>
<tr>
<td><code>Series.str.isdecimal</code></td>
<td>Check whether all characters in each string in the Series/Index are decimal.</td>
</tr>
<tr>
<td><code>Series.str.get_dummies</code></td>
<td>Split each string in the Series by sep and return a frame of dummy/indicator variables.</td>
</tr>
</tbody>
</table>

34.3.14.1 pandas.Series.str.capitalize

`Series.str.capitalize()`  
Convert strings in the Series/Index to be capitalized.  
Equivalent to `str.capitalize()`.

Returns  
Series/Index of objects
See also:

**Series.str.lower** Converts all characters to lowercase.

**Series.str.upper** Converts all characters to uppercase.

**Series.str.title** Converts first character of each word to uppercase and remaining to lowercase.

**Series.str.capitalize** Converts first character to uppercase and remaining to lowercase.

**Series.str.swapcase** Converts uppercase to lowercase and lowercase to uppercase.

Examples

```python
>>> s = pd.Series(['lower', 'CAPITALS', 'this is a sentence', 'SwApCaSe'])
>>> s
0    lower
1    CAPITALS
2    this is a sentence
3    SwApCaSe
dtype: object

>>> s.str.lower()
0    lower
1    capitals
2    this is a sentence
3    swapcase
dtype: object

>>> s.str.upper()
0    LOWER
1    CAPITALS
2    THIS IS A SENTENCE
3    SWAPCASE

dtype: object

>>> s.str.title()
0    Lower
1    Capitals
2    This Is A Sentence
3    Swapcase

dtype: object

>>> s.str.capitalize()
0    Lower
1    Capitals
2    This is a sentence
3    Swapcase

dtype: object

>>> s.str.swapcase()
0    LOWER
1    capitals
2    THIS IS A SENTENCE
3    sWaPcAsE

dtype: object
```
34.3.14.2 pandas.Series.str.cat

Series.str.cat (others=None, sep=None, na_rep=None, join=None)

Concatenate strings in the Series/Index with given separator.

If others is specified, this function concatenates the Series/Index and elements of others element-wise. If others is not passed, then all values in the Series/Index are concatenated into a single string with a given sep.

**Parameters**

- **others**: Series, Index, DataFrame, np.ndarray or list-like

  Series, Index, DataFrame, np.ndarray (one- or two-dimensional) and other list-likes of strings must have the same length as the calling Series/Index, with the exception of indexed objects (i.e. Series/Index/DataFrame) if join is not None.

  If others is a list-like that contains a combination of Series, np.ndarray (1-dim) or list-like, then all elements will be unpacked and must satisfy the above criteria individually.

  If others is None, the method returns the concatenation of all strings in the calling Series/Index.

- **sep**: string or None, default None

  If None, concatenates without any separator.

- **na_rep**: string or None, default None

  Representation that is inserted for all missing values:

  - If na_rep is None, and others is None, missing values in the Series/Index are omitted from the result.

  - If na_rep is None, and others is not None, a row containing a missing value in any of the columns (before concatenation) will have a missing value in the result.

- **join**: {'left', 'right', 'outer', 'inner'}, default None

  Determines the join-style between the calling Series/Index and any Series/Index/DataFrame in others (objects without an index need to match the length of the calling Series/Index). If None, alignment is disabled, but this option will be removed in a future version of pandas and replaced with a default of 'left'. To disable alignment, use .values on any Series/Index/DataFrame in others.

  New in version 0.23.0.

**Returns**

- **concat**: str or Series/Index of objects

  If others is None, str is returned, otherwise a Series/Index (same type as caller) of objects is returned.

**See also**

- **split** Split each string in the Series/Index

**Examples**

When not passing others, all values are concatenated into a single string:
By default, NA values in the Series are ignored. Using `na_rep`, they can be given a representation:

```python
>>> s.str.cat(sep=' ', na_rep='?')
'a b ? d'
```

If `others` is specified, corresponding values are concatenated with the separator. Result will be a Series of strings.

```python
>>> s.str.cat(['A', 'B', 'C', 'D'], sep=',')
0    a,A
1    b,B
2    NaN
3    d,D
dtype: object
```

Missing values will remain missing in the result, but can again be represented using `na_rep`.

```python
>>> s.str.cat(['A', 'B', 'C', 'D'], sep=':', na_rep='-')
0    a:A
1    b:B
2    -,C
3    d:D
```

If `sep` is not specified, the values are concatenated without separation.

```python
>>> s.str.cat(['A', 'B', 'C', 'D'], na_rep='-')
0    aA
1    bB
2    -C
3    dD
```

Series with different indexes can be aligned before concatenation. The `join`-keyword works as in other methods.

```python
>>> t = pd.Series(['d', 'a', 'e', 'c'], index=[3, 0, 4, 2])
>>> s.str.cat(t, join=None, na_rep='-')
0    ad
1    ba
2    -e
3    dc
```

```python
>>> s.str.cat(t, join='left', na_rep='-')
0    aa
1    b-
2    -c
3    dd
```

```python
>>> s.str.cat(t, join='outer', na_rep='-')
0    aa
1    b-
2    -c
```

(continues on next page)
```
3   dd
dtype: object
```
```python
>>> s.str.cat(t, join='inner', na_rep='-')
0   aa
2   -c
3   dd
dtype: object
```
```python
>>> s.str.cat(t, join='right', na_rep='-')
3   dd
0   aa
4   -e
2   -c
dtype: object
```
Fill value for missing values.

`regex` : bool, default True

If True, assumes the pat is a regular expression.
If False, treats the pat as a literal string.

**Returns** Series or Index of boolean values

A Series or Index of boolean values indicating whether the given pattern is contained within the string of each element of the Series or Index.

**See also:**

`match` analogous, but stricter, relying on re.match instead of re.search

**Examples**

Returning a Series of booleans using only a literal pattern.

```python
>>> s1 = pd.Series(['Mouse', 'dog', 'house and parrot', '23', np.NaN])
>>> s1.str.contains('og', regex=False)
0    False
1    True
2    False
3    False
4      NaN
dtype: object
```

Returning an Index of booleans using only a literal pattern.

```python
>>> ind = pd.Index(['Mouse', 'dog', 'house and parrot', '23.0', np.NaN])
>>> ind.str.contains('23', regex=False)
Index([False, False, False, True, nan], dtype='object')
```

Specifying case sensitivity using `case`.

```python
>>> s1.str.contains('oG', case=True, regex=True)
0    False
1    False
2    False
3    False
4      NaN
dtype: object
```

Specifying `na` to be `False` instead of `NaN` replaces NaN values with `False`. If Series or Index does not contain NaN values the resultant dtype will be `bool`, otherwise, an `object` dtype.

```python
>>> s1.str.contains('og', na=False, regex=True)
0    False
1    True
2    False
3    False
4    False
dtype: bool
```

Returning ‘house’ and ‘parrot’ within same string.
>>> s1.str.contains('house|parrot', regex=True)
0    False
1    False
2     True
3    False
4     NaN
dtype: object

Ignoring case sensitivity using flags with regex.

>>> import re

>>> s1.str.contains('PARROT', flags=re.IGNORECASE, regex=True)
0    False
1    False
2     True
3    False
4     NaN
dtype: object

Returning any digit using regular expression.

>>> s1.str.contains('\d', regex=True)
0    False
1    False
2    False
3     True
4     NaN
dtype: object

Ensure pat is a not a literal pattern when regex is set to True. Note in the following example one might expect only s2[1] and s2[3] to return True. However, '.0' as a regex matches any character followed by a 0.

>>> s2 = pd.Series(['40', '40.0', '41', '41.0', '35'])

>>> s2.str.contains('.0', regex=True)
0     True
1     True
2    False
3     True
4    False
dtype: bool

34.3.14.5 pandas.Series.str.count

Series.str.count(pat, flags=0, **kwargs)

Count occurrences of pattern in each string of the Series/Index.

This function is used to count the number of times a particular regex pattern is repeated in each of the string elements of the Series.

Parameters pat : str

Valid regular expression.

flags : int, default 0, meaning no flags

Flags for the re module. For a complete list, see here.

**kwargs
For compatibility with other string methods. Not used.

**Returns** counts : Series or Index

Same type as the calling object containing the integer counts.

**See also:**

re Standard library module for regular expressions.

str.count Standard library version, without regular expression support.

**Notes**

Some characters need to be escaped when passing in *pat*. eg. '\$' has a special meaning in regex and must be escaped when finding this literal character.

**Examples**

```python
>>> s = pd.Series(["A", "B", "Aaba", "Baca", np.nan, "CABA", "cat"])
>>> s.str.count("a")
0    0.0
1    0.0
2    2.0
3    2.0
4    NaN
5    0.0
6    1.0
dtype: float64

Escape '\$' to find the literal dollar sign.

```python
>>> s = pd.Series(["$", "B", "Aab$", "$ca", "C$B$", "cat"])
>>> s.str.count("\$")
0    1
1    0
2    1
3    2
4    2
5    0
dtype: int64
```

This is also available on Index

```python
>>> pd.Index(["A", "A", "Aaba", "cat"]).str.count("a")
Int64Index([0, 0, 2, 1], dtype='int64')
```

34.3.14.6 **pandas.Series.str.decode**

Series.str.decode(*encoding*, *errors=’strict’)*

Decode character string in the Series/Index using indicated encoding. Equivalent to str.decode() in python2 and bytes.decode() in python3.

**Parameters**

encoding [str]
errors [str, optional]

Returns

decoded [Series/Index of objects]

34.3.14.7 pandas.Series.str.encode

Series.str.encode (encoding, errors='strict')
    Encode character string in the Series/Index using indicated encoding. Equivalent to str.encode().

Parameters
    encoding [str]
    errors [str, optional]

Returns
    encoded [Series/Index of objects]

34.3.14.8 pandas.Series.str.endswith

Series.str.endswith (pat, na=nan)
    Test if the end of each string element matches a pattern.
    Equivalent to str.endswith().

Parameters pat : str
    Character sequence. Regular expressions are not accepted.
    na : object, default NaN
        Object shown if element tested is not a string.

Returns Series or Index of bool
    A Series of booleans indicating whether the given pattern matches the end of each
    string element.

See also:

str.endswith Python standard library string method.
Series.str.startswith Same as endswith, but tests the start of string.
Series.str.contains Tests if string element contains a pattern.

Examples

```python
>>> s = pd.Series(['bat', 'bear', 'caT', np.nan])
>>> s
0    bat
1    bear
2    caT
3    NaN
dtype: object
```
>>> s.str.endswith('t')
0   True
1   False
2   False
3   NaN
dtype: object

Specifying na to be False instead of NaN.

>>> s.str.endswith('t', na=False)
0   True
1   False
2   False
3   False
dtype: bool

34.3.14.9 pandas.Series.str.extract

Series.str.extract(pat, flags=0, expand=True)

For each subject string in the Series, extract groups from the first match of regular expression pat.

Parameters

pat : string
    Regular expression pattern with capturing groups

flags : int, default 0 (no flags)
    re module flags, e.g. re.IGNORECASE

expand : bool, default True
    • If True, return DataFrame.
    • If False, return Series/Index/DataFrame.

New in version 0.18.0.

Returns

DataFrame with one row for each subject string, and one column for each group. Any capture group names in regular expression pat will be used for column names; otherwise capture group numbers will be used. The dtype of each result column is always object, even when no match is found. If expand=False and pat has only one capture group, then return a Series (if subject is a Series) or Index (if subject is an Index).

See also:

effectall returns all matches (not just the first match)

Examples

A pattern with two groups will return a DataFrame with two columns. Non-matches will be NaN.
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
>>> s = Series(['a1', 'b2', 'c3'])
>>> s.str.extract(r'([ab])\d')
      0  1  2
   0 a b NaN
   1 b a NaN
   2 NaN NaN NaN

A pattern may contain optional groups.

```python
>>> s.str.extract(r'([ab])?\d')
      0  1  2
   0 a b NaN
   1 b a 3
   2 NaN NaN NaN

Named groups will become column names in the result.

```python
>>> s.str.extract(r'(\d)(?P<letter>[ab])(?P<digit>\d)')
    letter digit
   0   a    1
   1   b    2
   2 NaN   NaN

A pattern with one group will return a DataFrame with one column if expand=True.

```python
>>> s.str.extract(r'[ab]\d', expand=True)
   0  1
  0 a 1
  1 b 2
  2 NaN

A pattern with one group will return a Series if expand=False.

```python
>>> s.str.extract(r'[ab]\d', expand=False)
0  1
1  2
2 NaN
dtype: object
```

34.3.14.10 pandas.Series.str.extractall

Series.str.extractall(pat, flags=0)

For each subject string in the Series, extract groups from all matches of regular expression pat. When each subject string in the Series has exactly one match, extractall(pat).xs(0, level='match') is the same as extract(pat).

New in version 0.18.0.

**Parameters**

- **pat**: string
  
  Regular expression pattern with capturing groups

- **flags**: int, default 0 (no flags)
  
  re module flags, e.g. re.IGNORECASE

**Returns**

A DataFrame with one row for each match, and one column for each
group. Its rows have a MultiIndex with first levels that come from the subject Series. The last level is named ‘match’ and indicates the order in the subject. Any capture group names in regular expression pat will be used for column names; otherwise capture group numbers will be used.

See also:

*extract* returns first match only (not all matches)

**Examples**

A pattern with one group will return a DataFrame with one column. Indices with no matches will not appear in the result.

```python
>>> s = Series(["a1a2", "b1", "c1"], index=["A", "B", "C"])
>>> s.str.extractall(r"[ab](\d)"

<table>
<thead>
<tr>
<th>match</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 0 1</td>
</tr>
<tr>
<td>1 2</td>
</tr>
<tr>
<td>B 0 1</td>
</tr>
</tbody>
</table>
```

Capture group names are used for column names of the result.

```python
>>> s.str.extractall(r"[ab](?P<digit>\d)"

<table>
<thead>
<tr>
<th>digit</th>
</tr>
</thead>
<tbody>
<tr>
<td>match</td>
</tr>
<tr>
<td>A 0 1</td>
</tr>
<tr>
<td>1 2</td>
</tr>
<tr>
<td>B 0 1</td>
</tr>
</tbody>
</table>
```

A pattern with two groups will return a DataFrame with two columns.

```python
>>> s.str.extractall(r"(?P<letter>[ab]) (?P<digit>\d)"

<table>
<thead>
<tr>
<th>letter</th>
<th>digit</th>
</tr>
</thead>
<tbody>
<tr>
<td>match</td>
<td></td>
</tr>
<tr>
<td>A 0 a 1</td>
<td></td>
</tr>
<tr>
<td>1 a 2</td>
<td></td>
</tr>
<tr>
<td>B 0 b 1</td>
<td></td>
</tr>
</tbody>
</table>
```

Optional groups that do not match are NaN in the result.

```python
>>> s.str.extractall(r"(?P<letter>[ab])?(?P<digit>\d)"

<table>
<thead>
<tr>
<th>letter</th>
<th>digit</th>
</tr>
</thead>
<tbody>
<tr>
<td>match</td>
<td></td>
</tr>
<tr>
<td>A 0 a 1</td>
<td></td>
</tr>
<tr>
<td>1 a 2</td>
<td></td>
</tr>
<tr>
<td>B 0 b 1</td>
<td></td>
</tr>
<tr>
<td>C 0 NaN 1</td>
<td></td>
</tr>
</tbody>
</table>
34.3.14.11 pandas.Series.str.find

Series.str.find(sub, start=0, end=None)
Return lowest indexes in each strings in the Series/Index where the substring is fully contained between [start:end]. Return -1 on failure. Equivalent to standard str.find().

Parameters

- **sub**: str
  Substring being searched
- **start**: int
  Left edge index
- **end**: int
  Right edge index

Returns

- **found**: [Series/Index of integer values]

See also:

rfind Return highest indexes in each strings

34.3.14.12 pandas.Series.str.findall

Series.str.findall(pat, flags=0, **kwargs)
Find all occurrences of pattern or regular expression in the Series/Index.
Equivalent to applying re.findall() to all the elements in the Series/Index.

Parameters

- **pat**: string
  Pattern or regular expression.
- **flags**: int, default 0
  re module flags, e.g. re.IGNORECASE (default is 0, which means no flags).

Returns

Series/Index of lists of strings
All non-overlapping matches of pattern or regular expression in each string of this Series/Index.

See also:

count Count occurrences of pattern or regular expression in each string of the Series/Index.
extractall For each string in the Series, extract groups from all matches of regular expression and return a DataFrame with one row for each match and one column for each group.
re.findall The equivalent re function to all non-overlapping matches of pattern or regular expression in string, as a list of strings.

Examples

```python
>>> s = pd.Series(['Lion', 'Monkey', 'Rabbit'])
```
The search for the pattern ‘Monkey’ returns one match:
On the other hand, the search for the pattern ‘MONKEY’ doesn’t return any match:

```python
>>> s.str.findall('MONKEY')
0    []
1    []
2    []
dtype: object
```

Flags can be added to the pattern or regular expression. For instance, to find the pattern ‘MONKEY’ ignoring the case:

```python
>>> import re
>>> s.str.findall('MONKEY', flags=re.IGNORECASE)
0    []
1    [Monkey]
2    []
dtype: object
```

When the pattern matches more than one string in the Series, all matches are returned:

```python
>>> s.str.findall('on')
0    [on]
1    [on]
2    []
dtype: object
```

Regular expressions are supported too. For instance, the search for all the strings ending with the word ‘on’ is shown next:

```python
>>> s.str.findall('on$')
0    [on]
1    []
2    []
dtype: object
```

If the pattern is found more than once in the same string, then a list of multiple strings is returned:

```python
>>> s.str.findall('b')
0    []
1    []
2    [b, b]
dtype: object
```

### 34.3.14.13 pandas.Series.str.get

`Series.str.get(i)`

- Extract element from each component at specified position.
- Extract element from lists, tuples, or strings in each element in the Series/Index.

**Parameters**

- `i : int`
Position of element to extract.

Returns

items [Series/Index of objects]

Examples

```python
>>> s = pd.Series(["String",
                (1, 2, 3),
                ["a", "b", "c"],
                123, -456,
                {1:"Hello", "2":"World"}])
```

```python
>>> s
0     String
1    (1, 2, 3)
2      [a, b, c]
3       123
4      -456
5    {1: 'Hello', '2': 'World'}
dtype: object
```

```python
>>> s.str.get(1)
0    t
1    2
2    b
3  NaN
4  NaN
5  Hello
dtype: object
```

```python
>>> s.str.get(-1)
0    g
1    3
2    c
3  NaN
4  NaN
5  NaN
dtype: object
```

### 34.3.14.14 pandas.Series.str.index

Series.str.index(sub, start=0, end=None)

Return lowest indexes in each strings where the substring is fully contained between [start:end]. This is the same as str.find except instead of returning -1, it raises a ValueError when the substring is not found. Equivalent to standard str.index.

Parameters  

- **sub** : str  
  Substring being searched
- **start** : int  
  Left edge index
- **end** : int
Right edge index

Returns

found [Series/Index of objects]

See also:

rindex Return highest indexes in each strings

34.3.14.15 pandas.Series.str.join

Series.str.join(sep)

Join lists contained as elements in the Series/Index with passed delimiter.

If the elements of a Series are lists themselves, join the content of these lists using the delimiter passed to the function. This function is an equivalent to str.join().

Parameters sep : str

Delimiter to use between list entries.

Returns

Series/Index: object

See also:

str.join Standard library version of this method.

Series.str.split Split strings around given separator/delimiter.

Notes

If any of the lists does not contain string objects the result of the join will be NaN.

Examples

Example with a list that contains non-string elements.

```python
>>> s = pd.Series([['lion', 'elephant', 'zebra'],
...                 [1.1, 2.2, 3.3],
...                 ['cat', np.nan, 'dog'],
...                 ['cow', 4.5, 'goat'],
...                 ['duck', ['swan', 'fish'], 'guppy']])
>>> s
0    [lion, elephant, zebra]
1    [1.1, 2.2, 3.3]
2    [cat, nan, dog]
3    [cow, 4.5, goat]
4    [duck, [swan, 'fish'], 'guppy']
dtype: object
```

Join all lists using an ‘-‘; the lists containing object(s) of types other than str will become a NaN.
```python
>>> s.str.join('-')
0    lion-elephant-zebra
1          NaN
2          NaN
3          NaN
4          NaN
dtype: object
```

### 34.3.14.16 pandas.Series.str.len

`Series.str.len()`
Compute length of each string in the Series/Index.

**Returns**

`lengths` [Series/Index of integer values]

### 34.3.14.17 pandas.Series.str.ljust

`Series.str.ljust(width, fillchar='')`
Filling right side of strings in the Series/Index with an additional character. Equivalent to `str.ljust()`.

**Parameters**

- `width` : int
  Minimum width of resulting string; additional characters will be filled with `fillchar`
- `fillchar` : str
  Additional character for filling, default is whitespace

**Returns**

`filled` [Series/Index of objects]

### 34.3.14.18 pandas.Series.str.lower

`Series.str.lower()`
Convert strings in the Series/Index to lowercase.
Equivalent to `str.lower()`.

**Returns**

Series/Index of objects

See also:

- `Series.str.lower` Converts all characters to lowercase.
- `Series.str.upper` Converts all characters to uppercase.
- `Series.str.title` Converts first character of each word to uppercase and remaining to lowercase.
- `Series.str.capitalize` Converts first character to uppercase and remaining to lowercase.
- `Series.str.swapcase` Converts uppercase to lowercase and lowercase to uppercase.
Examples

```python
>>> s = pd.Series(['lower', 'CAPITALS', 'this is a sentence', 'SwApCaSe'])
>>> s
0    lower
1    CAPITALS
2  this is a sentence
3        SwApCaSe
dtype: object

>>> s.str.lower()
0    lower
1    capitals
2  this is a sentence
3      swapcase
dtype: object

>>> s.str.upper()
0   LOWER
1  CAPITALS
2  THIS IS A SENTENCE
3      SWAPCASE
dtype: object

>>> s.str.title()
0      Lower
1      Capitals
2  This Is A Sentence
3      Swapcase
dtype: object

>>> s.str.capitalize()
0     Lower
1     Capitals
2  This is a sentence
3     Swapcase
dtype: object

>>> s.str.swapcase()
0   LOWER
1  capitals
2 THIS IS A SENTENCE
3    sWaPcAsE
dtype: object
```

34.3.14.19 pandas.Series.str.lstrip

Series.str.lstrip(to_strip=None)

Strip whitespace (including newlines) from each string in the Series/Index from left side. Equivalent to str.lstrip().

Returns

stripped [Series/Index of objects]
34.3.14.20 pandas.Series.str.match

Series.str.match(pat, case=True, flags=0, na=nan, as_indexer=None)

Determine if each string matches a regular expression.

**Parameters**

- **pat**: string
  - Character sequence or regular expression
- **case**: boolean, default True
  - If True, case sensitive
- **flags**: int, default 0 (no flags)
  - re module flags, e.g. re.IGNORECASE
- **na**: [default NaN, fill value for missing values.]
- **as_indexer**: Deprecated since version 0.21.0.

**Returns**

Series/array of boolean values

**See also:**

- `contains`: analogous, but less strict, relying on re.search instead of re.match
- `extract`: extract matched groups

34.3.14.21 pandas.Series.str.normalize

Series.str.normalize(form)

Return the Unicode normal form for the strings in the Series/Index. For more information on the forms, see the `unicodedata.normalize()`.

**Parameters**

- **form**: {'NFC', 'NFKC', 'NFD', 'NFKD'}
  - Unicode form

**Returns**

normalized [Series/Index of objects]

34.3.14.22 pandas.Series.str.pad

Series.str.pad(width, side='left', fillchar=' ')

Pad strings in the Series/Index with an additional character to specified side.

**Parameters**

- **width**: int
  - Minimum width of resulting string; additional characters will be filled with spaces
- **side**: ['left', 'right', 'both'], default ‘left’
- **fillchar**: str
  - Additional character for filling, default is whitespace
Returns

**padded** [Series/Index of objects]

### 34.3.14.23 pandas.Series.str.partition

**Series.str.partition**( `pat=' '`, `expand=True`)  
Split the string at the first occurrence of `sep`, and return 3 elements containing the part before the separator, the separator itself, and the part after the separator. If the separator is not found, return 3 elements containing the string itself, followed by two empty strings.

**Parameters**

- **pat**: string, default whitespace
  
  String to split on.

- **expand**: bool, default True
  
  - If True, return DataFrame/MultiIndex expanding dimensionality.
  
  - If False, return Series/Index.

**Returns**

**split** [DataFrame/MultiIndex or Series/Index of objects]

See also:

- **rpartition** Split the string at the last occurrence of `sep`

**Examples**

```python
>>> s = Series(['A_B_C', 'D_E_F', 'X'])
0    A_B_C
1    D_E_F
2     X
dtype: object

>>> s.str.partition('_')
      0  1  2
0   A _ B_C
1   D _ E_F
2     X

>>> s.str.rpartition('_')
      0  1  2
0  A_B _ C
1  D_E _ F
2     X
```

### 34.3.14.24 pandas.Series.str.repeat

**Series.str.repeat**( `repeats`)  
Duplicate each string in the Series/Index by indicated number of times.

**Parameters**

- **repeats**: int or array
  
  Same value for all (int) or different value per (array)
34.3.14.25 pandas.Series.str.replace

Series.str.replace (pat, repl, n=-1, case=None, flags=0, regex=True)
Replace occurrences of pattern/regex in the Series/Index with some other string. Equivalent to str.replace() or re.sub().

Parameters
- **pat**: string or compiled regex
  - String can be a character sequence or regular expression.
  - New in version 0.20.0: pat also accepts a compiled regex.
- **repl**: string or callable
  - Replacement string or a callable. The callable is passed the regex match object and must return a replacement string to be used. See re.sub().
  - New in version 0.20.0: repl also accepts a callable.
- **n**: int, default -1 (all)
  - Number of replacements to make from start
- **case**: boolean, default None
  - If True, case sensitive (the default if pat is a string)
  - Set to False for case insensitive
  - Cannot be set if pat is a compiled regex
- **flags**: int, default 0 (no flags)
  - re module flags, e.g. re.IGNORECASE
  - Cannot be set if pat is a compiled regex
- **regex**: boolean, default True
  - If True, assumes the passed-in pattern is a regular expression.
  - If False, treats the pattern as a literal string
  - Cannot be set to False if pat is a compiled regex or repl is a callable.

Returns
- **replaced**: [Series/Index of objects]

Raises
- ValueError
  - if regex is False and repl is a callable or pat is a compiled regex
  - if pat is a compiled regex and case or flags is set

Notes

When pat is a compiled regex, all flags should be included in the compiled regex. Use of case, flags, or regex=False with a compiled regex will raise an error.
Examples

When `pat` is a string and `regex` is True (the default), the given `pat` is compiled as a regex. When `repl` is a string, it replaces matching regex patterns as with `re.sub()`. NaN value(s) in the Series are left as is:

```python
>>> pd.Series(['foo', 'fuz', np.nan]).str.replace('f\.', 'ba', regex=True)
0  bao
1  baz
2  NaN
dtype: object
```

When `pat` is a string and `regex` is False, every `pat` is replaced with `repl` as with `str.replace()`:

```python
>>> pd.Series(['f.o', 'fuz', np.nan]).str.replace('f\.', 'ba', regex=False)
0  bao
1  fuz
2  NaN
dtype: object
```

When `repl` is a callable, it is called on every `pat` using `re.sub()`. The callable should expect one positional argument (a regex object) and return a string.

To get the idea:

```python
>>> pd.Series(['foo', 'fuz', np.nan]).str.replace('f', repr)
0  <_sre.SRE_Match object; span=(0, 1), match='f'>oo
1  <_sre.SRE_Match object; span=(0, 1), match='f'>uz
2  NaN
dtype: object
```

Reverse every lowercase alphabetic word:

```python
>>> repl = lambda m: m.group(0)[::-1]
>>> pd.Series(['foo 123', 'bar baz', np.nan]).str.replace(r'[a-z]+', repl)
0  oof 123
1  rab zab
2  NaN
dtype: object
```

Using regex groups (extract second group and swap case):

```python
>>> pat = r"(?P<one>\w+)\s(?P<two>\w+)\s(?P<three>\w+)"
>>> repl = lambda m: m.group('two').swapcase()
>>> pd.Series(['One Two Three', 'Foo Bar Baz']).str.replace(pat, repl)
0  tWO
1  bAR
dtype: object
```

Using a compiled regex with flags

```python
>>> regex_pat = re.compile(r'FUZ', flags=re.IGNORECASE)
>>> pd.Series(['foo', 'fuz', np.nan]).str.replace(regex_pat, 'bar')
0  foo
1  bar
2  NaN
dtype: object
```
34.3.14.26 pandas.Series.str.rfind

Series.str.rfind(sub, start=0, end=None)
Return highest indexes in each strings in the Series/Index where the substring is fully contained between [start:end]. Return -1 on failure. Equivalent to standard str.rfind().

Parameters
- sub : str
  Substring being searched
- start : int
  Left edge index
- end : int
  Right edge index

Returns
- found [Series/Index of integer values]

See also:
- find  Return lowest indexes in each strings

34.3.14.27 pandas.Series.str.rindex

Series.str.rindex(sub, start=0, end=None)
Return highest indexes in each strings where the substring is fully contained between [start:end]. This is the same as str.rfind except instead of returning -1, it raises a ValueError when the substring is not found. Equivalent to standard str.rindex.

Parameters
- sub : str
  Substring being searched
- start : int
  Left edge index
- end : int
  Right edge index

Returns
- found [Series/Index of objects]

See also:
- index  Return lowest indexes in each strings

34.3.14.28 pandas.Series.str.rjust

Series.str.rjust(width, fillchar=' ‘)
Filling left side of strings in the Series/Index with an additional character. Equivalent to str.rjust().

Parameters
- width : int
  Minimum width of resulting string; additional characters will be filled with fillchar
fillchar : str

Additional character for filling, default is whitespace

Returns

filled [Series/Index of objects]

34.3.14.29 pandas.Series.str.rpartition

Series.str.rpartition(\texttt{\textit{pat}=\textquotesingle{}, \textit{expand}=\texttt{True}})

Split the string at the last occurrence of \textit{sep}, and return 3 elements containing the part before the separator, the separator itself, and the part after the separator. If the separator is not found, return 3 elements containing two empty strings, followed by the string itself.

Parameters \textit{pat} : string, default whitespace

String to split on.

\textit{expand} : bool, default \texttt{True}

• If \texttt{True}, return DataFrame/MultiIndex expanding dimensionality.
• If \texttt{False}, return Series/Index.

Returns

\textit{split} [DataFrame/MultiIndex or Series/Index of objects]

See also:

\textit{partition} Split the string at the first occurrence of \textit{sep}

Examples

```python
>>> s = Series(['A_B_C', 'D_E_F', 'X'])
0   A_B_C
1   D_E_F
2     X
dtype: object

>>> s.str.partition('_')
   0   1   2
0  A  _  B_C
1  D  _  E_F
2    X

>>> s.str.rpartition('_')
   0   1   2
0  A_B  _  C
1  D_E  _  F
2    X
```
34.3.14.30 pandas.Series.str.rstrip

Series.str.rstrip(to_strip=None)
Strip whitespace (including newlines) from each string in the Series/Index from right side. Equivalent to str.rstrip().

Returns
stripped [Series/Index of objects]

34.3.14.31 pandas.Series.str.slice

Series.str.slice(start=None, stop=None, step=None)
Slice substrings from each element in the Series/Index

Parameters

- **start** [int or None]
- **stop** [int or None]
- **step** [int or None]

Returns
sliced [Series/Index of objects]

34.3.14.32 pandas.Series.str.slice_replace

Series.str.slice_replace(start=None, stop=None, repl=None)
Replace a positional slice of a string with another value.

Parameters **start** : int, optional

Left index position to use for the slice. If not specified (None), the slice is unbounded on the left, i.e. slice from the start of the string.

**stop** : int, optional

Right index position to use for the slice. If not specified (None), the slice is unbounded on the right, i.e. slice until the end of the string.

**repl** : str, optional

String for replacement. If not specified (None), the sliced region is replaced with an empty string.

Returns **replaced** : Series or Index

Same type as the original object.

See also:

- **Series.str.slice** Just slicing without replacement.

Examples
>>> s = pd.Series(['a', 'ab', 'abc', 'abdc', 'abcde'])
>>> s
 0   a
 1   ab
 2   abc
 3  abdc
 4  abcde
dtype: object

Specify just `start`, meaning replace `start` until the end of the string with `repl`.

```python
>>> s.str.slice_replace(1, repl='X')
 0   aX
 1   aX
 2   aX
 3   aX
 4   aX
dtype: object
```

Specify just `stop`, meaning the start of the string to `stop` is replaced with `repl`, and the rest of the string is included.

```python
>>> s.str.slice_replace(stop=2, repl='X')
 0   X
 1   Xc
 2   Xdc
 3   Xdc
 4   Xcde
dtype: object
```

Specify `start` and `stop`, meaning the slice from `start` to `stop` is replaced with `repl`. Everything before or after `start` and `stop` is included as is.

```python
>>> s.str.slice_replace(start=1, stop=3, repl='X')
 0   aX
 1   aX
 2   aX
 3   aXc
 4   aXde
dtype: object
```

### 34.3.14.33 pandas.Series.str.split

`Series.str.split(pat=None, n=-1, expand=False)`

Split strings around given separator/delimiter.

Split each string in the caller’s values by given pattern, propagating NaN values. Equivalent to `str.split()`.

**Parameters**

- **pat**: str, optional
  - String or regular expression to split on. If not specified, split on whitespace.

- **n**: int, default -1 (all)
  - Limit number of splits in output. `None`, `0` and `-1` will be interpreted as return all splits.

- **expand**: bool, default False
  - Expand the splitted strings into separate columns.
• If True, return DataFrame/MultiIndex expanding dimensionality.
• If False, return Series/Index, containing lists of strings.

Returns Series, Index, DataFrame or MultiIndex
Type matches caller unless expand=True (see Notes).

See also:

str.split Standard library version of this method.
Series.str.get_dummies Split each string into dummy variables.
Series.str.partition Split string on a separator, returning the before, separator, and after components.

Notes

The handling of the n keyword depends on the number of found splits:
  • If found splits > n, make first n splits only
  • If found splits <= n, make all splits
  • If for a certain row the number of found splits < n, append None for padding up to n if expand=True

If using expand=True, Series and Index callers return DataFrame and MultiIndex objects, respectively.

Examples

```python
>>> s = pd.Series(["this is good text", "but this is even better"])

By default, split will return an object of the same size having lists containing the split elements

```python
>>> s.str.split()
0  [this, is, good, text]
1  [but, this, is, even, better]
dtype: object
>>> s.str.split("random")
0  [this is good text]
1  [but this is even better]
dtype: object
```n

When using expand=True, the split elements will expand out into separate columns.

For Series object, output return type is DataFrame.

```python
>>> s.str.split(expand=True)
  0  1  2  3  4
0  this is good text None
1  but this is even better
```n

For Index object, output return type is MultiIndex.
>>> i = pd.Index(['ba 100 001', 'ba 101 002', 'ba 102 003'])
>>> i.str.split(expand=True)
MultiIndex(levels=[['ba'], ['100', '101', '102'], ['001', '002', '003']],
       labels=[[0, 0, 0], [0, 1, 2], [0, 1, 2]])

Parameter \( n \) can be used to limit the number of splits in the output.

```python
>>> s.str.split("is", n=1)
0    [th, is good text]
1    [but th, is even better]
```

```python
dtype: object
>>> s.str.split("is", n=1, expand=True)
   0   1
0 th is good text
1 but th is even better
```

If NaN is present, it is propagated throughout the columns during the split.

```python
>>> s = pd.Series(['this is good text', 'but this is even better', np.nan])
>>> s.str.split(n=3, expand=True)
   0  1  2  3
0 this is good text
1 but this is even better
2 NaN NaN NaN NaN
```

### 34.3.14.34 pandas.Series.str.rsplit

**Series.str.rsplit** (\( \text{pat} = \text{None}, \ n = -1, \ \text{expand} = \text{False} \))

Split each string in the Series/Index by the given delimiter string, starting at the end of the string and working to the front. Equivalent to \text{str.rsplit}().

**Parameters**

- \( \text{pat} \) : string, default None
  
  Separator to split on. If None, splits on whitespace

- \( n \) : int, default -1 (all)
  
  None, 0 and -1 will be interpreted as return all splits

- \( \text{expand} \) : bool, default False
  
  - If True, return DataFrame/MultiIndex expanding dimensionality.
  
  - If False, return Series/Index.

**Returns**

- \( \text{split} \) [Series/Index or DataFrame/MultiIndex of objects]

### 34.3.14.35 pandas.Series.str.startswith

**Series.str.startswith** (\( \text{pat}, \ \text{na} = \text{nan} \))

Test if the start of each string element matches a pattern.

Equivalent to \text{str.startswith}().

**Parameters**

- \( \text{pat} \) : str
  
  Character sequence. Regular expressions are not accepted.
na : object, default NaN
Object shown if element tested is not a string.

Returns Series or Index of bool
A Series of booleans indicating whether the given pattern matches the start of each string element.

See also:

str.startswith Python standard library string method.

Series.str.endswith Same as startswith, but tests the end of string.

Series.str.contains Tests if string element contains a pattern.

Examples

```python
>>> s = pd.Series(['bat', 'Bear', 'cat', np.nan])
>>>
>>> s
0    bat
1    Bear
2    cat
3   NaN
dtype: object

>>> s.str.startswith('b')
0    True
1   False
2   False
3   NaN
dtype: object

Specifying na to be False instead of NaN.

>>> s.str.startswith('b', na=False)
0    True
1   False
2   False
3   False
dtype: bool
```

34.3.14.36 pandas.Series.str.strip

Series.str.strip(to_strip=None)
Strip whitespace (including newlines) from each string in the Series/Index from left and right sides. Equivalent to str.strip().

Returns

stripped [Series/Index of objects]
34.3.14.37 pandas.Series.str.swapcase

Series.str.swapcase()
Convert strings in the Series/Index to be swapcased.
Equivalent to str.swapcase().

Returns
Series/Index of objects

See also:

Series.str.lower Converts all characters to lowercase.
Series.str.upper Converts all characters to uppercase.
Series.str.title Converts first character of each word to uppercase and remaining to lowercase.
Series.str.capitalize Converts first character to uppercase and remaining to lowercase.
Series.str.swapcase Converts uppercase to lowercase and lowercase to uppercase.

Examples

```python
>>> s = pd.Series(['lower', 'CAPITALS', 'this is a sentence', 'SwApCaSe'])
```
```python
>>> s
0    lower
1   CAPITALS
2  this is a sentence
3     SwApCaSe
dtype: object
```
```python
>>> s.str.lower()
```
```python
0    lower
1   capitals
2  this is a sentence
3     swapcase
dtype: object
```
```python
>>> s.str.upper()
```
```python
0    LOWER
1   CAPITALS
2  THIS IS A SENTENCE
3     SWAPCASE
dtype: object
```
```python
>>> s.str.title()
```
```python
0    Lower
1   Capitals
2  This Is A Sentence
3     Swapcase
dtype: object
```
```python
>>> s.str.capitalize()
```
```python
0    Lower
1   Capitals
```
```python
(continues on next page)```
This is a sentence

dtype: object

```
>>> s.str.swapcase()
0   LOWER
1  capitals
2  THIS IS A SENTENCE
3    sWApCaSe
dtype: object
```

### 34.3.14.38 pandas.Series.str.title

```
Series.str.title()
```

Convert strings in the Series/Index to titlecase.

Equivalent to `str.title()`.

**Returns**

Series/Index of objects

**See also:**

- `Series.str.lower` Converts all characters to lowercase.
- `Series.str.upper` Converts all characters to uppercase.
- `Series.str.title` Converts first character of each word to uppercase and remaining to lowercase.
- `Series.str.capitalize` Converts first character to uppercase and remaining to lowercase.
- `Series.str.swapcase` Converts uppercase to lowercase and lowercase to uppercase.

**Examples**

```
>>> s = pd.Series(['lower', 'CAPITALS', 'this is a sentence', 'SwApCaSe'])
```

```
>>> s
0    lower
1  CAPITALS
2  this is a sentence
3    SwApCaSe
dtype: object
```

```
>>> s.str.lower()
0    lower
1  capitals
2  this is a sentence
3    swapcase
dtype: object
```

```
>>> s.str.upper()
0    LOWER
1  CAPITALS
2  THIS IS A SENTENCE
```
3 SWAPCASE

dtype: object

```python
>>> s.str.title()
0    Lower
1   Capitals
2  This Is A Sentence
3   Swapcase
dtype: object
```

```python
>>> s.str.capitalize()
0    Lower
1   Capitals
2  This is a sentence
3   Swapcase
dtype: object
```

```python
>>> s.str.swapcase()
0    LOWER
1   capitals
2  THIS IS A SENTENCE
3   sWaPcAsE
dtype: object
```

### 34.3.14.39 pandas.Series.str.translate

`Series.str.translate(table, deletechars=None)`

Map all characters in the string through the given mapping table. Equivalent to standard `str.translate()`. Note that the optional argument `deletechars` is only valid if you are using python 2. For python 3, character deletion should be specified via the table argument.

**Parameters**

- `table` : `dict` (python 3), `str` or `None` (python 2)
  
  In python 3, `table` is a mapping of Unicode ordinals to Unicode ordinals, strings, or `None`. Unmapped characters are left untouched. Characters mapped to `None` are deleted. `str.maketrans()` is a helper function for making translation tables. In python 2, `table` is either a string of length 256 or `None`. If the `table` argument is `None`, no translation is applied and the operation simply removes the characters in `deletechars`. `string.maketrans()` is a helper function for making translation tables.

- `deletechars` : `str`, optional (python 2)

  A string of characters to delete. This argument is only valid in python 2.

**Returns**

- `translated` : `[Series/Index of objects]`

### 34.3.14.40 pandas.Series.str.upper

`Series.str.upper()`

Convert strings in the `Series/Index` to uppercase.

Equivalent to `str.upper()`.
Returns

Series/Index of objects

See also:

*Series.str.lower* Converts all characters to lowercase.
*Series.str.upper* Converts all characters to uppercase.
*Series.str.title* Converts first character of each word to uppercase and remaining to lowercase.
*Series.str.capitalize* Converts first character to uppercase and remaining to lowercase.
*Series.str.swapcase* Converts uppercase to lowercase and lowercase to uppercase.

Examples

```python
>>> s = pd.Series(['lower', 'CAPITALS', 'this is a sentence', 'SwApCaSe'])
>>> s
0    lower
1  CAPITALS
2  this is a sentence
3    SwApCaSe
dtype: object

>>> s.str.lower()
0      lower
1    capitals
2  this is a sentence
3     swapcase
dtype: object

>>> s.str.upper()
0      LOWER
1  CAPITALS
2 THIS IS A SENTENCE
3    SWAPCASE
dtype: object

>>> s.str.title()
0   Lower
1  Capitals
2  This Is A Sentence
3    Swapcase
dtype: object

>>> s.str.capitalize()
0      Lower
1    Capitals
2  This is a sentence
3    Swapcase
dtype: object

>>> s.str.swapcase()
```

(continues on next page)
34.3.14.41 pandas.Series.str.wrap

Series.str.wrap(width, **kwargs)

Wrap long strings in the Series/Index to be formatted in paragraphs with length less than a given width.

This method has the same keyword parameters and defaults as `textwrap.TextWrapper`.

Parameters

- **width**: int
  - Maximum line-width

- **expand_tabs**: bool, optional
  - If true, tab characters will be expanded to spaces (default: True)

- **replace_whitespace**: bool, optional
  - If true, each whitespace character (as defined by `string.whitespace`) remaining after tab expansion will be replaced by a single space (default: True)

- **drop_whitespace**: bool, optional
  - If true, whitespace that, after wrapping, happens to end up at the beginning or end of a line is dropped (default: True)

- **break_long_words**: bool, optional
  - If true, then words longer than width will be broken in order to ensure that no lines are longer than width. If it is false, long words will not be broken, and some lines may be longer than width. (default: True)

- **break_on_hyphens**: bool, optional
  - If true, wrapping will occur preferably on whitespace and right after hyphens in compound words, as it is customary in English. If false, only whitespaces will be considered as potentially good places for line breaks, but you need to set `break_long_words` to false if you want truly insecable words. (default: True)

Returns

- **wrapped** [Series/Index of objects]

Notes

Internally, this method uses a `textwrap.TextWrapper` instance with default settings. To achieve behavior matching R’s stringr library `str_wrap` function, use the arguments:

- `expand_tabs = False`
- `replace_whitespace = True`
- `drop_whitespace = True`
- `break_long_words = False`
- `break_on_hyphens = False`
Examples

```python
>>> s = pd.Series(['line to be wrapped', 'another line to be wrapped'])
>>> s.str.wrap(12)
0    line to be
      wrapped
1    another line
      nto be
      wrapped
```

34.3.14.42 pandas.Series.str.zfill

`Series.str.zfill(width)`

Filling left side of strings in the Series/Index with 0. Equivalent to `str.zfill()`.

**Parameters**

- `width`: int
  
  Minimum width of resulting string; additional characters will be filled with 0

**Returns**

- `filled`: [Series/Index of objects]

34.3.14.43 pandas.Series.str.isalnum

`Series.str.isalnum()`

Check whether all characters in each string in the Series/Index are alphanumeric. Equivalent to `str.isalnum()`.

**Returns**

- `is`: [Series/array of boolean values]

34.3.14.44 pandas.Series.str.isalpha

`Series.str.isalpha()`

Check whether all characters in each string in the Series/Index are alphabetic. Equivalent to `str.isalpha()`.

**Returns**

- `is`: [Series/array of boolean values]

34.3.14.45 pandas.Series.str.isdigit

`Series.str.isdigit()`

Check whether all characters in each string in the Series/Index are digits. Equivalent to `str.isdigit()`.

**Returns**

- `is`: [Series/array of boolean values]

34.3.14.46 pandas.Series.str.isspace

`Series.str.isspace()`

Check whether all characters in each string in the Series/Index are whitespace. Equivalent to `str.isspace()`.

**Returns**

-
is  [Series/array of boolean values]

34.3.14.47 pandas.Series.str.islower

Series.str.islower()
Check whether all characters in each string in the Series/Index are lowercase. Equivalent to str.islower().
Returns
is  [Series/array of boolean values]

34.3.14.48 pandas.Series.str.isupper

Series.str.isupper()
Check whether all characters in each string in the Series/Index are uppercase. Equivalent to str.isupper().
Returns
is  [Series/array of boolean values]

34.3.14.49 pandas.Series.str.istitle

Series.str.istitle()
Check whether all characters in each string in the Series/Index are titlecase. Equivalent to str.istitle().
Returns
is  [Series/array of boolean values]

34.3.14.50 pandas.Series.str.isnumeric

Series.str.isnumeric()
Check whether all characters in each string in the Series/Index are numeric. Equivalent to str.isnumeric().
Returns
is  [Series/array of boolean values]

34.3.14.51 pandas.Series.str.isdecimal

Series.str.isdecimal()
Check whether all characters in each string in the Series/Index are decimal. Equivalent to str.isdecimal().
Returns
is  [Series/array of boolean values]

34.3.14.52 pandas.Series.str.get_dummies

Series.str.get_dummies(sep='|')
Split each string in the Series by sep and return a frame of dummy/indicator variables.
Parameters sep : string, default “|”
String to split on.
Returns

dummies [DataFrame]

See also:
pandas.get_dummies

Examples

```python
>>> Series(['a|b', 'a', 'a|c']).str.get_dummies()
   a  b  c
0  1  1  0
1  1  0  0
2  1  0  1

>>> Series(['a|b', np.nan, 'a|c']).str.get_dummies()
   a  b  c
0  1  1  0
1  0  0  0
2  1  0  1
```

34.3.15 Categorical

Pandas defines a custom data type for representing data that can take only a limited, fixed set of values. The dtype of a Categorical can be described by a `pandas.api.types.CategoricalDtype`.

```python
api.types.CategoricalDtype(categories, ordered=None)
```

Type for categorical data with the categories and orderedness

Changed in version 0.21.0.

Parameters
categories : sequence, optional

Must be unique, and must not contain any nulls.

ordered [bool, default False]

See also:
pandas.Categorical

Notes

This class is useful for specifying the type of a Categorical independent of the values. See `CategoricalDtype` for more.
pandas: powerful Python data analysis toolkit, Release 0.23.2

Examples

```python
>>> t = CategoricalDtype(categories=['b', 'a'], ordered=True)
>>> pd.Series(['a', 'b', 'a', 'c'], dtype=t)
0   a
1   b
2   a
3  NaN
dtype: category
Categories (2, object): [b < a]
```

Attributes

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>categories</strong></td>
<td>An Index containing the unique categories allowed.</td>
</tr>
<tr>
<td><strong>ordered</strong></td>
<td>Whether the categories have an ordered relationship</td>
</tr>
</tbody>
</table>

**pandas.api.types.CategoricalDtype.categories**

`CategoricalDtype.categories`

An Index containing the unique categories allowed.

**pandas.api.types.CategoricalDtype.ordered**

`CategoricalDtype.ordered`

Whether the categories have an ordered relationship

Methods

None

**api.types.CategoricalDtype.categories**

An Index containing the unique categories allowed.

**api.types.CategoricalDtype.ordered**

Whether the categories have an ordered relationship

Categorical data can be stored in a `pandas.Categorical`

```
Categorical(values[, categories, ordered, ...])
```

Represents a categorical variable in classic R / S-plus fashion

34.3.15.2 pandas.Categorical

**class pandas.Categorical(values, categories=None, ordered=None, dtype=None, fastpath=False)**

Represents a categorical variable in classic R / S-plus fashion

*Categoricals* can only take on only a limited, and usually fixed, number of possible values (*categories*). In contrast to statistical categorical variables, a *Categorical* might have an order, but numerical operations (additions, divisions, ...) are not possible.
All values of the `Categorical` are either in `categories` or `np.nan`. Assigning values outside of `categories` will raise a `ValueError`. Order is defined by the order of the `categories`, not lexical order of the values.

**Parameters**

`values` : list-like

The values of the categorical. If categories are given, values not in categories will be replaced with NaN.

`categories` : Index-like (unique), optional

The unique categories for this categorical. If not given, the categories are assumed to be the unique values of values.

`ordered` : boolean, (default False)

Whether or not this categorical is treated as a ordered categorical. If not given, the resulting categorical will not be ordered.

`dtype` : CategoricalDtype

An instance of `CategoricalDtype` to use for this categorical

New in version 0.21.0.

**Raises**

`ValueError`

If the categories do not validate.

`TypeError`

If an explicit `ordered=True` is given but no `categories` and the `values` are not sortable.

**See also:**

`pandas.api.types.CategoricalDtype` Type for categorical data

`CategoricalIndex` An Index with an underlying `Categorical`

**Notes**

See the user guide for more.

**Examples**

```python
>>> pd.Categorical([1, 2, 3, 1, 2, 3])
[1, 2, 3, 1, 2, 3]
Categories (3, int64): [1, 2, 3]

>>> pd.Categorical(['a', 'b', 'c', 'a', 'b', 'c'])
[a, b, c, a, b, c]
Categories (3, object): [a, b, c]
```

Ordered `Categoricals` can be sorted according to the custom order of the categories and can have a min and max value.
```python
>>> c = pd.Categorical(['a','b','c','a','b','c'], ordered=True,
... categories=['c', 'b', 'a'])
... c
[a, b, c, a, b, c]
Categories (3, object): [c < b < a]
>>> c.min()
'c'
```

**Attributes**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>categories</td>
<td>The categories of this categorical.</td>
</tr>
<tr>
<td>codes</td>
<td>The category codes of this categorical.</td>
</tr>
<tr>
<td>ordered</td>
<td>Whether the categories have an ordered relationship</td>
</tr>
<tr>
<td>dtype</td>
<td>The <code>CategoricalDtype</code> for this instance</td>
</tr>
</tbody>
</table>

**pandas.Categorical.categories**

The categories of this categorical.

Setting assigns new values to each category (effectively a rename of each individual category).

The assigned value has to be a list-like object. All items must be unique and the number of items in the new categories must be the same as the number of items in the old categories.

Assigning to categories is an inplace operation!

**Raises** ValueError

If the new categories do not validate as categories or if the number of new categories is unequal the number of old categories

**See also:**

rename_categories, reorder_categories, add_categories, remove_categories, remove_unused_categories, set_categories

**pandas.Categorical.codes**

The category codes of this categorical.

Level codes are an array if integer which are the positions of the real values in the categories array.

There is not setter, use the other categorical methods and the normal item setter to change values in the categorical.

**pandas.Categorical.ordered**

Whether the categories have an ordered relationship
pandas.Categorical.dtype

Categorical.dtype

The CategoricalDtype for this instance

Methods

from_codes(codes, categories[, ordered])

Make a Categorical type from codes and categories arrays.

__array__((dtype))

The numpy array interface.

pandas.Categorical.from_codes

classmethod Categorical.from_codes(codes, categories, ordered=False)

Make a Categorical type from codes and categories arrays.

This constructor is useful if you already have codes and categories and so do not need the (computation intensive) factorization step, which is usually done on the constructor.

If your data does not follow this convention, please use the normal constructor.

Parameters

codes : array-like, integers

An integer array, where each integer points to a category in categories or -1 for NaN

categories : index-like

The categories for the categorical. Items need to be unique.

ordered : boolean, (default False)

Whether or not this categorical is treated as a ordered categorical. If not given, the resulting categorical will be unordered.

pandas.Categorical.__array__

Categorical.__array__((dtype=None)

The numpy array interface.

Returns

values : numpy array

A numpy array of either the specified dtype or, if dtype==None (default), the same dtype as categorical.categories.dtype

The alternative Categorical.from_codes() constructor can be used when you have the categories and integer codes already:

from_codes(codes, categories[, ...])

Make a Categorical type from codes and categories arrays.

The dtype information is available on the Categorical
Categorical.dtype
The CategoricalDtype for this instance

Categorical.categories
The categories of this categorical.

Categorical.ordered
Whether the categories have an ordered relationship

Categorical.codes
The category codes of this categorical.

np.asarray(categorical) works by implementing the array interface. Be aware, that this converts the Categorical back to a NumPy array, so categories and order information is not preserved!

Categorical.__array__((dtype)) The numpy array interface.

A Categorical can be stored in a Series or DataFrame. To create a Series of dtype category, use cat = s.astype(dtype) or Series(..., dtype=dtype) where dtype is either

- the string 'category'
- an instance of CategoricalDtype.

If the Series is of dtype CategoricalDtype, Series.cat can be used to change the categorical data. This accessor is similar to the Series.dt or Series.str and has the following usable methods and properties:

Series.cat.categories
The categories of this categorical.

Series.cat.ordered
Whether the categories have an ordered relationship

Series.cat.codes

34.3.15.3 pandas.Series.cat.categories

Series.cat.categories
The categories of this categorical.

Setting assigns new values to each category (effectively a rename of each individual category).

The assigned value has to be a list-like object. All items must be unique and the number of items in the new categories must be the same as the number of items in the old categories.

Assigning to categories is a inplace operation!

Raises ValueError
If the new categories do not validate as categories or if the number of new categories is unequal the number of old categories

See also:

rename_categories, reorder_categories, add_categories, remove_categories, remove_unused_categories, set_categories

34.3.15.4 pandas.Series.cat.ordered

Series.cat.ordered
Whether the categories have an ordered relationship

34.3.15.5 pandas.Series.cat.codes

Series.cat.codes
### Series.cat.rename_categories(*args, **kwargs)

Renames categories.

**Parameters**

- **new_categories**: list-like, dict-like or callable
  - list-like: all items must be unique and the number of items in the new categories must match the existing number of categories.
  - dict-like: specifies a mapping from old categories to new. Categories not contained in the mapping are passed through and extra categories in the mapping are ignored.
    
    New in version 0.21.0.
  - callable: a callable that is called on all items in the old categories and whose return values comprise the new categories.
    
    New in version 0.23.0.

**Warning:** Currently, Series are considered list like. In a future version of pandas they’ll be considered dict-like.

- **inplace**: boolean (default: False)
  
  Whether or not to rename the categories inplace or return a copy of this categorical with renamed categories.

**Returns**

- **cat**: Categorical or None
  
  With `inplace=False`, the new categorical is returned. With `inplace=True`, there is no return value.

**Raises**

- **ValueError**
  
  If new categories are list-like and do not have the same number of items than the current categories or do not validate as categories.

**See also:**

- `reorder_categories`
- `add_categories`
- `remove_categories`
- `remove_unused_categories`
- `set_categories`
Examples

```python
>>> c = Categorical(['a', 'a', 'b'])
>>> c.rename_categories([0, 1])
[0, 0, 1]
Categories (2, int64): [0, 1]
```

For dict-like `new_categories`, extra keys are ignored and categories not in the dictionary are passed through

```python
>>> c.rename_categories({'a': 'A', 'c': 'C'})
[A, A, b]
Categories (2, object): [A, b]
```

You may also provide a callable to create the new categories

```python
>>> c.rename_categories(lambda x: x.upper())
[A, A, B]
Categories (2, object): [A, B]
```

### 34.3.15.7 pandas.Series.cat.reorder_categories

**Series.cat.reorder_categories(**`*args`, **`**kwargs`**)

Reorders categories as specified in `new_categories`.

`new_categories` need to include all old categories and no new category items.

**Parameters**

- `new_categories` : Index-like
  The categories in new order.
- `ordered` : boolean, optional
  Whether or not the categorical is treated as a ordered categorical. If not given, do not change the ordered information.
- `inplace` : boolean (default: False)
  Whether or not to reorder the categories inplace or return a copy of this categorical with reordered categories.

**Returns**

- `cat` : [Categorical with reordered categories or None if inplace.]

**Raises**

- ValueError
  If the new categories do not contain all old category items or any new ones

**See also**

- rename_categories, add_categories, remove_categories, remove_unused_categories, set_categories

### 34.3.15.8 pandas.Series.cat.add_categories

**Series.cat.add_categories(**`*args`, **`**kwargs`**)

Add new categories.

`new_categories` will be included at the last/highest place in the categories and will be unused directly after this call.
Parameters **new_categories** : category or list-like of category

The new categories to be included.

**inplace** : boolean (default: False)

Whether or not to add the categories inplace or return a copy of this categorical with added categories.

Returns

**cat**  [Categorical with new categories added or None if inplace.]

**Raises** ValueError

If the new categories include old categories or do not validate as categories

See also:

rename_categories, reorder_categories, remove_categories, remove_unused_categories, set_categories

34.3.15.9 pandas.Series.cat.remove_categories

Series.cat.remove_categories(*args, **kwargs)

Removes the specified categories.

removals must be included in the old categories. Values which were in the removed categories will be set to NaN

**Parameters** **removals** : category or list of categories

The categories which should be removed.

**inplace** : boolean (default: False)

Whether or not to remove the categories inplace or return a copy of this categorical with removed categories.

Returns

**cat**  [Categorical with removed categories or None if inplace.]

**Raises** ValueError

If the removals are not contained in the categories

See also:

rename_categories, reorder_categories, add_categories, remove_unused_categories, set_categories

34.3.15.10 pandas.Series.cat.remove_unused_categories

Series.cat.remove_unused_categories(*args, **kwargs)

Removes categories which are not used.

**Parameters** **inplace** : boolean (default: False)

Whether or not to drop unused categories inplace or return a copy of this categorical with unused categories dropped.

Returns

**cat**  [Categorical with unused categories dropped or None if inplace.]
See also:

rename_categories, reorder_categories, add_categories, remove_categories, set_categories

### 34.3.15.11 pandas.Series.cat.set_categories

**Series.cat.set_categories** (*args, **kwargs*)

Sets the categories to the specified new_categories.

*new_categories* can include new categories (which will result in unused categories) or remove old categories (which results in values set to NaN). If *rename==True*, the categories will simple be renamed (less or more items than in old categories will result in values set to NaN or in unused categories respectively).

This method can be used to perform more than one action of adding, removing, and reordering simultaneously and is therefore faster than performing the individual steps via the more specialised methods.

On the other hand this method does not do checks (e.g., whether the old categories are included in the new categories on a reorder), which can result in surprising changes, for example when using special string dtypes on python3, which does not considers a S1 string equal to a single char python string.

**Parameters**

new_categories : Index-like

The categories in new order.

ordered : boolean, (default: False)

Whether or not the categorical is treated as a ordered categorical. If not given, do not change the ordered information.

rename : boolean (default: False)

Whether or not the new_categories should be considered as a rename of the old categories or as reordered categories.

inplace : boolean (default: False)

Whether or not to reorder the categories inplace or return a copy of this categorical with reordered categories.

**Returns**

cat [Categorical with reordered categories or None if inplace.]

**Raises**

ValueError

If new_categories does not validate as categories

See also:

rename_categories, reorder_categories, add_categories, remove_categories, remove_unused_categories

### 34.3.15.12 pandas.Series.cat.as_ordered

**Series.cat.as_ordered** (*args, **kwargs*)

Sets the Categorical to be ordered.

**Parameters**

inplace : boolean (default: False)

Whether or not to set the ordered attribute inplace or return a copy of this categorical with ordered set to True
34.3.15.13 pandas.Series.cat.as_unordered

Series.cat.as_unordered(*args, **kwargs)
Sets the Categorical to be unordered

Parameters inplace : boolean (default: False)
Whether or not to set the ordered attribute inplace or return a copy of this categorical
with ordered set to False

34.3.16 Plotting

Series.plot is both a callable method and a namespace attribute for specific plotting methods of the form
Series.plot.<kind>.

<table>
<thead>
<tr>
<th>Series.plot([kind, ax, figsize, ...])</th>
<th>Series plotting accessor and method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series.plot.area(**kwds)</td>
<td>Area plot</td>
</tr>
<tr>
<td>Series.plot.bar(**kwds)</td>
<td>Vertical bar plot</td>
</tr>
<tr>
<td>Series.plot.barh(**kwds)</td>
<td>Horizontal bar plot</td>
</tr>
<tr>
<td>Series.plot.box(**kwds)</td>
<td>Boxplot</td>
</tr>
<tr>
<td>Series.plot.boxplot(**kwds)</td>
<td>Boxplot</td>
</tr>
<tr>
<td>Series.plot.boxplot(**kwds)</td>
<td>Boxplot</td>
</tr>
<tr>
<td>Series.plot.density([bw_method, ind])</td>
<td>Generate Kernel Density Estimate plot using Gaussian kernels.</td>
</tr>
<tr>
<td>Series.plot.hist([bins])</td>
<td>Histogram</td>
</tr>
<tr>
<td>Series.plot.kde([bw_method, ind])</td>
<td>Generate Kernel Density Estimate plot using Gaussian kernels.</td>
</tr>
<tr>
<td>Series.plot.line(**kwds)</td>
<td>Line plot</td>
</tr>
<tr>
<td>Series.plot.pie(**kwds)</td>
<td>Pie chart</td>
</tr>
</tbody>
</table>

34.3.16.1 pandas.Series.plot.area

Series.plot.area(**kwds)
Area plot

Parameters **kwds : optional
Additional keyword arguments are documented in pandas.Series.plot().

Returns
axes [matplotlib.axes.Axes or numpy.ndarray of them]

34.3.16.2 pandas.Series.plot.bar

Series.plot.bar(**kwds)
Vertical bar plot

Parameters **kwds : optional
Additional keyword arguments are documented in pandas.Series.plot().

Returns
axes [matplotlib.axes.Axes or numpy.ndarray of them]
34.3.16.3 pandas.Series.plot.barh

Series.plot.barh(**kwds)
Horizontal bar plot

Parameters `**kwds`: optional
Additional keyword arguments are documented in `pandas.Series.plot()`.

Returns
axes [matplotlib.axes.Axes or numpy.ndarray of them]

34.3.16.4 pandas.Series.plot.box

Series.plot.box(**kwds)
Boxplot

Parameters `**kwds`: optional
Additional keyword arguments are documented in `pandas.Series.plot()`.

Returns
axes [matplotlib.axes.Axes or numpy.ndarray of them]

34.3.16.5 pandas.Series.plot.density

Series.plot.density(bw_method=None, ind=None, **kwds)
Generate Kernel Density Estimate plot using Gaussian kernels.

In statistics, kernel density estimation (KDE) is a non-parametric way to estimate the probability density function (PDF) of a random variable. This function uses Gaussian kernels and includes automatic bandwith determination.

Parameters `bw_method`: str, scalar or callable, optional
The method used to calculate the estimator bandwidth. This can be ‘scott’, ‘silverman’, a scalar constant or a callable. If None (default), ‘scott’ is used. See `scipy.stats.gaussian_kde` for more information.

`ind`: NumPy array or integer, optional
Evaluation points for the estimated PDF. If None (default), 1000 equally spaced points are used. If `ind` is a NumPy array, the KDE is evaluated at the points passed. If `ind` is an integer, `ind` number of equally spaced points are used.

`**kwds`: optional
Additional keyword arguments are documented in `pandas.Series.plot()`.

Returns
axes [matplotlib.axes.Axes or numpy.ndarray of them]

See also:

`scipy.stats.gaussian_kde` Representation of a kernel-density estimate using Gaussian kernels. This is the function used internally to estimate the PDF.

`DataFrame.plot.kde` Generate a KDE plot for a DataFrame.
Examples

Given a Series of points randomly sampled from an unknown distribution, estimate its PDF using KDE with automatic bandwidth determination and plot the results, evaluating them at 1000 equally spaced points (default):

```python
>>> s = pd.Series([1, 2, 2.5, 3, 3.5, 4, 5])
>>> ax = s.plot.kde()
```

A scalar bandwidth can be specified. Using a small bandwidth value can lead to overfitting, while using a large bandwidth value may result in underfitting:

```python
>>> ax = s.plot.kde(bw_method=0.3)
>>> ax = s.plot.kde(bw_method=3)
```

Finally, the `ind` parameter determines the evaluation points for the plot of the estimated PDF:

```python
>>> ax = s.plot.kde(ind=[1, 2, 3, 4, 5])
```

### 34.3.16.6 pandas.Series.plot.hist

Series.plot.hist(bins=10, **kwds)

Histogram

**Parameters**

- **bins**: integer, default 10
  
  Number of histogram bins to be used

- '**kwds'**: optional
  
  Additional keyword arguments are documented in `pandas.Series.plot()`.

**Returns**

- axes [matplotlib.axes.Axes or numpy.ndarray of them]

### 34.3.16.7 pandas.Series.plot.kde

Series.plot.kde(bw_method=None, ind=None, **kwds)

Generate Kernel Density Estimate plot using Gaussian kernels.

In statistics, kernel density estimation (KDE) is a non-parametric way to estimate the probability density function (PDF) of a random variable. This function uses Gaussian kernels and includes automatic bandwidth determination.

**Parameters**

- **bw_method**: str, scalar or callable, optional
  
  The method used to calculate the estimator bandwidth. This can be 'scott', 'silverman', a scalar constant or a callable. If None (default), 'scott' is used. See `scipy.stats.gaussian_kde` for more information.

- **ind**: NumPy array or integer, optional
  
  Evaluation points for the estimated PDF. If None (default), 1000 equally spaced points are used. If `ind` is a NumPy array, the KDE is evaluated at the points passed. If `ind` is an integer, `ind` number of equally spaced points are used.

- '**kwds'**: optional
Additional keyword arguments are documented in `pandas.Series.plot()`.

**Returns**

- **axes**: [matplotlib.axes.Axes or numpy.ndarray of them]

**See also:**

- `scipy.stats.gaussian_kde`: Representation of a kernel-density estimate using Gaussian kernels. This is the function used internally to estimate the PDF.
- `DataFrame.plot.kde`: Generate a KDE plot for a DataFrame.

**Examples**

Given a Series of points randomly sampled from an unknown distribution, estimate its PDF using KDE with automatic bandwidth determination and plot the results, evaluating them at 1000 equally spaced points (default):

```python
>>> s = pd.Series([1, 2, 2.5, 3, 3.5, 4, 5])
>>> ax = s.plot.kde()
```

A scalar bandwidth can be specified. Using a small bandwidth value can lead to overfitting, while using a large bandwidth value may result in underfitting:

```python
>>> ax = s.plot.kde(bw_method=0.3)
```

```python
>>> ax = s.plot.kde(bw_method=3)
```

Finally, the `ind` parameter determines the evaluation points for the plot of the estimated PDF:

```python
>>> ax = s.plot.kde(ind=[1, 2, 3, 4, 5])
```

**34.3.16.8 pandas.Series.plot.line**

`Series.plot.line(**kwds)`

Line plot

**Parameters** `**kwds` : optional

Additional keyword arguments are documented in `pandas.Series.plot()`.

**Returns**

- **axes**: [matplotlib.axes.Axes or numpy.ndarray of them]

**Examples**

```python
>>> s = pd.Series([1, 3, 2])
>>> s.plot.line()
```

**34.3.16.9 pandas.Series.plot.pie**

`Series.plot.pie(**kwds)`

Pie chart
Parameters `**kwds` : optional

Additional keyword arguments are documented in `pandas.Series.plot()`.

Returns

`axes` [matplotlib.axes.Axes or numpy.ndarray of them]

\[\text{Series.hist}([by, ax, grid, xlabels, ...])\] Draw histogram of the input series using matplotlib

### 34.3.17 Serialization / IO / Conversion

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Series.to_pickle(path[, compression, protocol])</code></td>
<td>Pickle (serialize) object to file.</td>
</tr>
<tr>
<td><code>Series.to_csv([path, index, sep, na_rep, ...])</code></td>
<td>Write Series to a comma-separated values (csv) file</td>
</tr>
<tr>
<td><code>Series.to_dict([into])</code></td>
<td>Convert Series to <code>{label -&gt; value}</code> dict or dict-like object.</td>
</tr>
<tr>
<td><code>Series.to_excel(excel_writer[, sheet_name, ...])</code></td>
<td>Write the contained data to an HDF5 file using HDFStore.</td>
</tr>
<tr>
<td><code>Series.to_frame([name])</code></td>
<td>Convert Series to DataFrame</td>
</tr>
<tr>
<td><code>Series.to_hdf(path_or_buf, key, **kwargs)</code></td>
<td>Return an xarray object from the pandas object.</td>
</tr>
<tr>
<td><code>Series.to_json([path_or_buf, orient, ...])</code></td>
<td>Convert the object to a JSON string.</td>
</tr>
<tr>
<td><code>Series.to_pickle(path[, compression, protocol])</code></td>
<td>Pickle (serialize) object to file.</td>
</tr>
<tr>
<td><code>Series.to_csv([path, index, sep, na_rep, ...])</code></td>
<td>Write Series to a comma-separated values (csv) file</td>
</tr>
<tr>
<td><code>Series.to_dict([into])</code></td>
<td>Convert Series to <code>{label -&gt; value}</code> dict or dict-like object.</td>
</tr>
<tr>
<td><code>Series.to_excel(excel_writer[, sheet_name, ...])</code></td>
<td>Write the contained data to an HDF5 file using HDFStore.</td>
</tr>
<tr>
<td><code>Series.to_frame([name])</code></td>
<td>Convert Series to DataFrame</td>
</tr>
<tr>
<td><code>Series.to_hdf(path_or_buf, key, **kwargs)</code></td>
<td>Return an xarray object from the pandas object.</td>
</tr>
<tr>
<td><code>Series.to_json([path_or_buf, orient, ...])</code></td>
<td>Convert the object to a JSON string.</td>
</tr>
<tr>
<td><code>Series.to_pickle(path[, compression, protocol])</code></td>
<td>Pickle (serialize) object to file.</td>
</tr>
<tr>
<td><code>Series.to_csv([path, index, sep, na_rep, ...])</code></td>
<td>Write Series to a comma-separated values (csv) file</td>
</tr>
<tr>
<td><code>Series.to_dict([into])</code></td>
<td>Convert Series to <code>{label -&gt; value}</code> dict or dict-like object.</td>
</tr>
<tr>
<td><code>Series.to_excel(excel_writer[, sheet_name, ...])</code></td>
<td>Write the contained data to an HDF5 file using HDFStore.</td>
</tr>
<tr>
<td><code>Series.to_frame([name])</code></td>
<td>Convert Series to DataFrame</td>
</tr>
<tr>
<td><code>Series.to_hdf(path_or_buf, key, **kwargs)</code></td>
<td>Return an xarray object from the pandas object.</td>
</tr>
<tr>
<td><code>Series.to_json([path_or_buf, orient, ...])</code></td>
<td>Convert the object to a JSON string.</td>
</tr>
</tbody>
</table>

### 34.3.18 Sparse

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>SparseSeries.to_coo([row_levels, ...])</code></td>
<td>Create a scipy.sparse.coo_matrix from a SparseSeries with MultiIndex.</td>
</tr>
<tr>
<td><code>SparseSeries.from_coo(A[, dense_index])</code></td>
<td>Create a SparseSeries from a scipy.sparse.coo_matrix.</td>
</tr>
</tbody>
</table>

#### 34.3.18.1 pandas.SparseSeries.to_coo

`SparseSeries.to_coo(row_levels=(0,), column_levels=(1,), sort_labels=False)`

Create a scipy.sparse.coo_matrix from a SparseSeries with MultiIndex.

Use `row_levels` and `column_levels` to determine the row and column coordinates respectively. `row_levels` and `column_levels` are the names (labels) or numbers of the levels. `{row_levels, column_levels}` must be a partition of the MultiIndex level names (or numbers).

Parameters

- `row_levels` [tuple/list]
- `column_levels` [tuple/list]
- `sort_labels` : bool, default False
Sort the row and column labels before forming the sparse matrix.

Returns

- `y` [scipy.sparse.coo_matrix]
- `rows` [list (row labels)]
- `columns` [list (column labels)]

Examples

```python
>>> from numpy import nan

>>> s = Series([3.0, nan, 1.0, 3.0, nan, nan])

>>> s.index = MultiIndex.from_tuples([(1, 2, 'a', 0),
                                      (1, 2, 'a', 1),
                                      (1, 1, 'b', 0),
                                      (1, 1, 'b', 1),
                                      (2, 1, 'b', 0),
                                      (2, 1, 'b', 1)],
                                      names=['A', 'B', 'C', 'D'])

>>> ss = s.to_sparse()

>>> A, rows, columns = ss.to_coo(row_levels=['A', 'B'],
                                column_levels=['C', 'D'],
                                sort_labels=True)

>>> A
<3x4 sparse matrix of type '<class 'numpy.float64'>'
    with 3 stored elements in COOrdinate format>

>>> A.todense()
matrix([[ 0., 0., 1., 3.],
        [ 3., 0., 0., 0.],
        [ 0., 0., 0., 0.]])

>>> rows
[(1, 1), (1, 2), (2, 1)]

>>> columns
[('a', 0), ('a', 1), ('b', 0), ('b', 1)]
```

### 34.3.18.2 pandas.SparseSeries.from_coo

classmethod SparseSeries.from_coo(A, dense_index=False)

Create a SparseSeries from a scipy.sparse.coo_matrix.

Parameters

- `A` [scipy.sparse.coo_matrix]
- `dense_index` : bool, default False

  If False (default), the SparseSeries index consists of only the coords of the non-null entries of the original coo_matrix. If True, the SparseSeries index consists of the full sorted (row, col) coordinates of the coo_matrix.

Returns

- `s` [SparseSeries]
Examples

```python
>>> from scipy import sparse
>>> A = sparse.coo_matrix(((3.0, 1.0, 2.0), ([1, 0, 0], [0, 2, 3])),
                          shape=(3, 4))
>>> A
<3x4 sparse matrix of type '<class 'numpy.float64'>'
    with 3 stored elements in COOrdinate format>
>>> A.todense()
matrix([[ 0., 0., 1., 2.],
        [ 3., 0., 0., 0.],
        [ 0., 0., 0., 0.]])
>>> ss = SparseSeries.from_coo(A)
>>> ss
0 2 1
  3 2
1 0 3
dtype: float64
```

34.4 DataFrame

34.4.1 Constructor

```ruby
DataFrame([data, index, columns, dtype, copy])
```

Two-dimensional size-mutable, potentially heterogeneous tabular data structure with labeled axes (rows and columns).

34.4.1.1 pandas.DataFrame
class pandas.DataFrame(data=None, index=None, columns=None, dtype=None, copy=False)

Two-dimensional size-mutable, potentially heterogeneous tabular data structure with labeled axes (rows and columns). Arithmetic operations align on both row and column labels. Can be thought of as a dict-like container for Series objects. The primary pandas data structure.

Parameters data: numpy ndarray (structured or homogeneous), dict, or DataFrame

Dict can contain Series, arrays, constants, or list-like objects

Changed in version 0.23.0: If data is a dict, argument order is maintained for Python 3.6 and later.

index: Index or array-like

Index to use for resulting frame. Will default to RangeIndex if no indexing information part of input data and no index provided

columns: Index or array-like

Column labels to use for resulting frame. Will default to RangeIndex (0, 1, 2, ..., n) if no column labels are provided

dtype: dtype, default None
Data type to force. Only a single dtypes is allowed. If None, infer

`copy`: boolean, default False

Copy data from inputs. Only affects DataFrame / 2d ndarray input

**See also:**

- `DataFrame.from_records` constructor from tuples, also record arrays
- `DataFrame.from_dict` from dicts of Series, arrays, or dicts
- `DataFrame.from_items` from sequence of (key, value) pairs

`pandas.read_csv`, `pandas.read_table`, `pandas.read_clipboard`

### Examples

**Constructing DataFrame from a dictionary.**

```python
>>> d = {'col1': [1, 2], 'col2': [3, 4]}
>>> df = pd.DataFrame(data=d)
```

```plaintext
    col1 col2
0    1    3
1    2    4
```

Notice that the inferred dtypes is int64.

```python
>>> df.dtypes
    col1     col2
dtype: int64, int64
```

To enforce a single dtype:

```python
>>> df = pd.DataFrame(data=d, dtype=np.int8)
```

```plaintext
    col1  col2
0    1    3
1    2    4
```

**Constructing DataFrame from numpy ndarray:**

```python
>>> df2 = pd.DataFrame(np.random.randint(low=0, high=10, size=(5, 5)),
                      columns=['a', 'b', 'c', 'd', 'e'])
```

```plaintext
    a  b  c  d  e
0  2  8  8  3  4
1  4  2  9  0  9
2  1  0  7  8  0
3  5  1  7  1  3
4  6  0  2  4  2
```

### Attributes
DataFrame\texttt{T}

Transpose index and columns.

Reflect the DataFrame over its main diagonal by writing rows as columns and vice-versa. The property $T$ is an accessor to the method \texttt{transpose()}

**Parameters**

- **copy**: bool, default False
  
  If True, the underlying data is copied. Otherwise (default), no copy is made if possible.

- **\*args, \*\*kwargs**
  
  Additional keywords have no effect but might be accepted for compatibility with numpy.

**Returns**

DataFrame

The transposed DataFrame.

**See also:**

- \texttt{numpy.transpose} Permute the dimensions of a given array.
Notes

Transposing a DataFrame with mixed dtypes will result in a homogeneous DataFrame with the object dtype. In such a case, a copy of the data is always made.

Examples

Square DataFrame with homogeneous dtype

```python
>>> d1 = {'col1': [1, 2], 'col2': [3, 4]}
>>> df1 = pd.DataFrame(data=d1)
>>> df1
col1  col2
0   1   3
1   2   4
```
```python
>>> df1_transposed = df1.T  # or df1.transpose()
>>> df1_transposed
    col1   col2
0   1   3
1   2   4
```

When the dtype is homogeneous in the original DataFrame, we get a transposed DataFrame with the same dtype:
```python
>>> df1.dtypes
col1  int64
col2  int64
dtype: object
>>> df1_transposed.dtypes
    0 1
col1  int64
col2  int64
dtype: object
```

Non-square DataFrame with mixed dtypes

```python
>>> d2 = {'name': ['Alice', 'Bob'],
...       'score': [9.5, 8],
...       'employed': [False, True],
...       'kids': [0, 0]}
>>> df2 = pd.DataFrame(data=d2)
>>> df2
   name  score  employed  kids
0  Alice   9.5      False   0
1   Bob    8.0      True    0
```
```python
>>> df2_transposed = df2.T  # or df2.transpose()
>>> df2_transposed
    0 1
name Alice Bob
score   9.5  8
employed False True
kids    0   0
```

When the DataFrame has mixed dtypes, we get a transposed DataFrame with the object dtype:
pandas: powerful Python data analysis toolkit, Release 0.23.2

>>> df2.dtypes
name  object
score  float64
employed  bool
kids  int64
dtype: object

>>> df2_transposed.dtypes
0  object
1  object
dtype: object

pandas.DataFrame.at

DataFrame.at
Access a single value for a row/column label pair.
Similar to loc, in that both provide label-based lookups. Use at if you only need to get or set a single value in a DataFrame or Series.

Raises  KeyError
When label does not exist in DataFrame

See also:

DataFrame.iat  Access a single value for a row/column pair by integer position
DataFrame.loc  Access a group of rows and columns by label(s)
Series.at  Access a single value using a label

Examples

>>> df = pd.DataFrame([[0, 2, 3], [0, 4, 1], [10, 20, 30]],
...    index=[4, 5, 6], columns=['A', 'B', 'C'])

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

Get value at specified row/column pair

>>> df.at[4, 'B']
2

Set value at specified row/column pair

>>> df.at[4, 'B'] = 10

Get value within a Series

>>> df.loc[5].at['B']
4
pandas.DataFrame.axes

DataFrame.axes
Return a list representing the axes of the DataFrame.
It has the row axis labels and column axis labels as the only members. They are returned in that order.

Examples

```python
def = pd.DataFrame({'col1': [1, 2], 'col2': [3, 4]})
def.axes
[RangeIndex(start=0, stop=2, step=1), Index(['col1', 'col2'], dtype='object')]
```

pandas.DataFrame.blocks

DataFrame.blocks
Internal property, property synonym for as_blocks()
Deprecated since version 0.21.0.

pandas.DataFrame.columns

DataFrame.columns
The column labels of the DataFrame.

pandas.DataFrame.dtypes

DataFrame.dtypes
Return the dtypes in the DataFrame.
This returns a Series with the data type of each column. The result’s index is the original DataFrame’s columns. Columns with mixed types are stored with the object dtype. See the User Guide for more.

Returns pandas.Series
The data type of each column.

See also:

pandas.DataFrame.ftypes dtype and sparsity information.

Examples

```python
def = pd.DataFrame({'float': [1.0],
... 'int': [1],
... 'datetime': [pd.Timestamp('20180310')],
... 'string': ['foo']})
def.dtypes
float  float64
int    int64
```
### pandas.DataFrame.empty

**DataFrame.empty**

Indicator whether DataFrame is empty.

True if DataFrame is entirely empty (no items), meaning any of the axes are of length 0.

**Returns** bool

If DataFrame is empty, return True, if not return False.

**See also:**

`pandas.Series.dropna`, `pandas.DataFrame.dropna`

**Notes**

If DataFrame contains only NaNs, it is still not considered empty. See the example below.

**Examples**

An example of an actual empty DataFrame. Notice the index is empty:

```python
>>> df_empty = pd.DataFrame({'A' : []})
>>> df_empty
Empty DataFrame
Columns: [A]
Index: []
>>> df_empty.empty
True
```

If we only have NaNs in our DataFrame, it is not considered empty! We will need to drop the NaNs to make the DataFrame empty:

```python
>>> df = pd.DataFrame({'A' : [np.nan]})
>>> df
    A
0  NaN
>>> df.empty
False
>>> df.dropna().empty
True
```

### pandas.DataFrame.ftypes

**DataFrame.ftypes**

Return the ftypes (indication of sparse/dense and dtype) in DataFrame.
This returns a Series with the data type of each column. The result’s index is the original DataFrame’s columns. Columns with mixed types are stored with the object dtype. See the User Guide for more.

**Returns** pandas.Series

The data type and indication of sparse/dense of each column.

See also:

- **pandas.DataFrame.dtypes** Series with just dtype information.
- **pandas.SparseDataFrame** Container for sparse tabular data.

**Notes**

Sparse data should have the same dtypes as its dense representation.

**Examples**

```python
>>> import numpy as np
>>> arr = np.random.RandomState(0).randn(100, 4)
>>> arr[arr < .8] = np.nan
>>> pd.DataFrame(arr).ftypes
0  float64:dense
1  float64:dense
2  float64:dense
3  float64:dense
dtype: object
```

```python
>>> pd.SparseDataFrame(arr).ftypes
0  float64:sparse
1  float64:sparse
2  float64:sparse
3  float64:sparse
dtype: object
```

**pandas.DataFrame.iat**

*DataFrame.iat*

Access a single value for a row/column pair by integer position.

Similar to **iloc**, in that both provide integer-based lookups. Use **iat** if you only need to get or set a single value in a DataFrame or Series.

**Raises** IndexError

When integer position is out of bounds

See also:

- **DataFrame.at** Access a single value for a row/column label pair
- **DataFrame.loc** Access a group of rows and columns by label(s)
- **DataFrame.iloc** Access a group of rows and columns by integer position(s)
Examples

```python
>>> df = pd.DataFrame([[0, 2, 3], [0, 4, 1], [10, 20, 30]],
                    columns=['A', 'B', 'C'])
>>> df
   A  B  C
0  0  2  3
1  0  4  1
2 10 20 30

Get value at specified row/column pair

```python
>>> df.iat[1, 2]
1
```

Set value at specified row/column pair

```python
>>> df.iat[1, 2] = 10
>>> df.iat[1, 2]
10
```

Get value within a series

```python
>>> df.loc[0].iat[1]
2
```

`pandas.DataFrame.iloc`

`DataFrame.iloc`

Purely integer-location based indexing for selection by position.

“.iloc[]” is primarily integer position based (from 0 to `length-1` of the axis), but may also be used with a boolean array.

Allowed inputs are:

- An integer, e.g. 5.
- A list or array of integers, e.g. [4, 3, 0].
- A slice object with ints, e.g. 1:7.
- A boolean array.
- A callable function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above)

.iloc will raise `IndexError` if a requested indexer is out-of-bounds, except `slice` indexers which allow out-of-bounds indexing (this conforms with python/numpy `slice` semantics).

See more at `Selection by Position`

`pandas.DataFrame.index`

`DataFrame.index`

The index (row labels) of the DataFrame.
pandas.DataFrame.ix

DataFrame.ix
A primarily label-location based indexer, with integer position fallback.

Warning: Starting in 0.20.0, the .ix indexer is deprecated, in favor of the more strict .iloc and .loc indexers.

.ix[] supports mixed integer and label based access. It is primarily label based, but will fall back to
integer positional access unless the corresponding axis is of integer type.

.ix is the most general indexer and will support any of the inputs in .loc and .iloc. .ix also
supports floating point label schemes. .ix is exceptionally useful when dealing with mixed positional
and label based hierarchical indexes.

However, when an axis is integer based, ONLY label based access and not positional access is supported.
Thus, in such cases, it’s usually better to be explicit and use .iloc or .loc.

See more at Advanced Indexing.

pandas.DataFrame.loc

DataFrame.loc
Access a group of rows and columns by label(s) or a boolean array.

.loc[] is primarily label based, but may also be used with a boolean array.

Allowed inputs are:

- A single label, e.g. 5 or 'a', (note that 5 is interpreted as a label of the index, and never as an
  integer position along the index).
- A list or array of labels, e.g. ['a', 'b', 'c'].
- A slice object with labels, e.g. 'a':'f'.

Warning: Note that contrary to usual python slices, both the start and the stop are included

- A boolean array of the same length as the axis being sliced, e.g. [True, False, True].
- A callable function with one argument (the calling Series, DataFrame or Panel) and that returns
  valid output for indexing (one of the above)

See more at Selection by Label

Raises KeyError:
when any items are not found

See also:

DataFrame.at Access a single value for a row/column label pair
DataFrame.iloc Access group of rows and columns by integer position(s)
DataFrame.xs Returns a cross-section (row(s) or column(s)) from the Series/DataFrame.
Series.loc Access group of values using labels
**Examples**

**Getting values**

```python
>>> df = pd.DataFrame([[1, 2], [4, 5], [7, 8]],
                   index=['cobra', 'viper', 'sidewinder'],
                   columns=['max_speed', 'shield'])
>>> df
       max_speed  shield
    cobra          1        2
    viper          4        5
    sidewinder     7        8
```

Single label. Note this returns the row as a Series.

```python
>>> df.loc['viper']
max_speed  4
shield    5
Name: viper, dtype: int64
```

List of labels. Note using `[]` returns a DataFrame.

```python
>>> df.loc[['viper', 'sidewinder']]
       max_speed  shield
    viper          4        5
    sidewinder     7        8
```

Single label for row and column

```python
>>> df.loc['cobra', 'shield']
2
```

Slice with labels for row and single label for column. As mentioned above, note that both the start and stop of the slice are included.

```python
>>> df.loc['cobra':'viper', 'max_speed']
    cobra  1
    viper  4
Name: max_speed, dtype: int64
```

Boolean list with the same length as the row axis

```python
>>> df.loc[[False, False, True]]
       max_speed  shield
    sidewinder     7        8
```

Conditional that returns a boolean Series

```python
>>> df.loc[df['shield'] > 6]
       max_speed  shield
    sidewinder     7        8
```

Conditional that returns a boolean Series with column labels specified

```python
>>> df.loc[df['shield'] > 6, ['max_speed']]
       max_speed
    sidewinder     7
```
Callable that returns a boolean Series

```python
>>> df.loc[lambda df: df['shield'] == 8]
max_speed  shield
sidewinder  7  8
```

Setting values

Set value for all items matching the list of labels

```python
>>> df.loc[['viper', 'sidewinder'], ['shield']] = 50
>>> df
max_speed  shield
cobra  1  2
viper  4  50
sidewinder  7  50
```

Set value for an entire row

```python
>>> df.loc['cobra'] = 10
>>> df
max_speed  shield
cobra  10  10
viper  4  50
sidewinder  7  50
```

Set value for an entire column

```python
>>> df.loc[:, 'max_speed'] = 30
>>> df
max_speed  shield
cobra  30  10
viper  30  50
sidewinder  30  50
```

Set value for rows matching callable condition

```python
>>> df.loc[df['shield'] > 35] = 0
>>> df
max_speed  shield
cobra  30  10
viper  0  0
sidewinder  0  0
```

Getting values on a DataFrame with an index that has integer labels

Another example using integers for the index

```python
>>> df = pd.DataFrame([[1, 2], [4, 5], [7, 8]], index=[7, 8, 9], columns=['max_speed', 'shield'])
>>> df
max_speed  shield
7          1  2
8          4  5
9          7  8
```

Slice with integer labels for rows. As mentioned above, note that both the start and stop of the slice are included.
Getting values with a MultiIndex

A number of examples using a DataFrame with a MultiIndex

```python
>>> tuples = [
... ('cobra', 'mark i'), ('cobra', 'mark ii'),
... ('sidewinder', 'mark i'), ('sidewinder', 'mark ii'),
... ('viper', 'mark ii'), ('viper', 'mark iii'),
...]
>>> index = pd.MultiIndex.from_tuples(tuples)
>>> values = [[12, 2], [0, 4], [10, 20],
... [1, 4], [7, 1], [16, 36]]
>>> df = pd.DataFrame(values, columns=['max_speed', 'shield'], index=index)
>>> df
   max_speed  shield
cobra mark i      12     2
    mark ii       0     4
sidewinder mark i  10    20
   mark ii       1     4
    viper mark i  7     1
         mark iii 16    36
```

Single label. Note this returns a DataFrame with a single index.

```python
>>> df.loc['cobra']
   max_speed  shield
mark i      12     2
mark ii       0     4
```

Single index tuple. Note this returns a Series.

```python
>>> df.loc[('cobra', 'mark ii')]
max_speed 0
shield 4
Name: (cobra, mark ii), dtype: int64
```

Single label for row and column. Similar to passing in a tuple, this returns a Series.

```python
>>> df.loc['cobra', 'mark i']
max_speed 12
shield 2
Name: (cobra, mark i), dtype: int64
```

Single tuple. Note using [[]] returns a DataFrame.

```python
>>> df.loc[['cobra', 'mark ii']]  # Note using [[]] returns a DataFrame.
```

Single tuple for the index with a single label for the column
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
>>> df.loc[('cobra', 'mark i'), 'shield']
2
```

Slice from index tuple to single label

```python
>>> df.loc[('cobra', 'mark i'):('viper', 'mark ii')]
max_speed shield
cobra  mark i 12 2
       mark ii 0 4
sidewinder  mark i 10 20
           mark ii 1 4
viper  mark ii 7 1
       mark iii 16 36
```

Slice from index tuple to index tuple

```python
>>> df.loc[('cobra', 'mark i'):('viper', 'mark ii')]
max_speed shield
cobra  mark i 12 2
       mark ii 0 4
sidewinder  mark i 10 20
           mark ii 1 4
viper  mark ii 7 1
```

**pandas.DataFrame.ndim**

DataFrame.ndim

Return an int representing the number of axes / array dimensions.

Return 1 if Series. Otherwise return 2 if DataFrame.

See also:

ndarray.ndim

**Examples**

```python
>>> s = pd.Series({'a': 1, 'b': 2, 'c': 3})
>>> s.ndim
1
```

```python
>>> df = pd.DataFrame({'col1': [1, 2], 'col2': [3, 4]})
>>> df.ndim
2
```

**pandas.DataFrame.shape**

DataFrame.shape

Return a tuple representing the dimensionality of the DataFrame.

See also:

ndarray.shape
Examples

```python
>>> df = pd.DataFrame({'col1': [1, 2], 'col2': [3, 4]})
```

```python
>>> df.shape
(2, 2)
```

```python
>>> df = pd.DataFrame({'col1': [1, 2], 'col2': [3, 4],
                     'col3': [5, 6]})
```

```python
>>> df.shape
(2, 3)
```

**pandas.DataFrame.size**

Dataframe.size

Return an int representing the number of elements in this object.

Return the number of rows if Series. Otherwise return the number of rows times number of columns if DataFrame.

See also:

ndarray.size

Examples

```python
>>> s = pd.Series({'a': 1, 'b': 2, 'c': 3})
```

```python
>>> s.size
3
```

```python
>>> df = pd.DataFrame({'col1': [1, 2], 'col2': [3, 4]})
```

```python
>>> df.size
4
```

**pandas.DataFrame.style**

Dataframe.style

Property returning a Styler object containing methods for building a styled HTML representation fo the DataFrame.

See also:

```
pandas.io.formats.style.Styler
```

**pandas.DataFrame.values**

Dataframe.values

Return a Numpy representation of the DataFrame.

Only the values in the DataFrame will be returned, the axes labels will be removed.

Returns numpy.ndarray

The values of the DataFrame.
See also:

- **pandas.DataFrame.index** Retrieve the index labels
- **pandas.DataFrame.columns** Retrieving the column names

**Notes**

The dtype will be a lower-common-denominator dtype (implicit upcasting); that is to say if the dtypes (even of numeric types) are mixed, the one that accommodates all will be chosen. Use this with care if you are not dealing with the blocks.

e.g. If the dtypes are float16 and float32, dtype will be upcast to float32. If dtypes are int32 and uint8, dtype will be upcast to int32. By `numpy.find_common_type()` convention, mixing int64 and uint64 will result in a float64 dtype.

**Examples**

A DataFrame where all columns are the same type (e.g., int64) results in an array of the same type.

```python
>>> df = pd.DataFrame({'age': [3, 29],
...                     'height': [94, 170],
...                     'weight': [31, 115]})
>>> df
df =

age  height  weight
0    3       94       31  
1    29      170      115
>>> df.dtypes
age  int64
height  int64
weight  int64
dtype: object
>>> df.values
array([[ 3, 94, 31],
       [29, 170, 115]], dtype=int64)
```

A DataFrame with mixed type columns (e.g., str/object, int64, float32) results in an ndarray of the broadest type that accommodates these mixed types (e.g., object).

```python
>>> df2 = pd.DataFrame([('parrot', 24.0, 'second'),
...                      ('lion', 80.5, 1),
...                      ('monkey', np.nan, None)],
...                     columns=('name', 'max_speed', 'rank'))
>>> df2.dtypes
name  object
max_speed  float64
rank  object
dtype: object
>>> df2.values
array([['parrot', 24.0, 'second'],
       ['lion', 80.5, 1],
       ['monkey', nan, None]], dtype=object)
```

```is_copy```
## Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>abs()</code></td>
<td>Return a Series/DataFrame with absolute numeric value of each element.</td>
</tr>
<tr>
<td><code>add(other[, axis, level, fill_value])</code></td>
<td>Addition of dataframe and other, element-wise (binary operator <code>add</code>).</td>
</tr>
<tr>
<td><code>add_prefix(prefix)</code></td>
<td>Prefix labels with string <code>prefix</code>.</td>
</tr>
<tr>
<td><code>add_suffix(suffix)</code></td>
<td>Suffix labels with string <code>suffix</code>.</td>
</tr>
<tr>
<td><code>agg(func[, axis])</code></td>
<td>Aggregate using one or more operations over the specified axis.</td>
</tr>
<tr>
<td><code>aggregate(func[, axis])</code></td>
<td>Aggregate using one or more operations over the specified axis.</td>
</tr>
<tr>
<td><code>align(other[, join, axis, level, copy, . . .])</code></td>
<td>Align two objects on their axes with the specified join method for each axis.</td>
</tr>
<tr>
<td><code>all([axis, bool_only, skipna, level])</code></td>
<td>Return whether all elements are True, potentially over an axis.</td>
</tr>
<tr>
<td><code>any([axis, bool_only, skipna, level])</code></td>
<td>Return whether any element is True over requested axis.</td>
</tr>
<tr>
<td><code>append(other[, ignore_index, . . .])</code></td>
<td>Append rows of <code>other</code> to the end of this frame, returning a new object.</td>
</tr>
<tr>
<td><code>apply(func[, axis, broadcast, raw, reduce, . . .])</code></td>
<td>Apply a function along an axis of the DataFrame.</td>
</tr>
<tr>
<td><code>applymap(func)</code></td>
<td>Apply a function to a Dataframe elementwise.</td>
</tr>
<tr>
<td><code>as_blocks([copy])</code></td>
<td>(DEPRECATED) Convert the frame to a dict of dtype -&gt; Constructor Types that each has a homogeneous dtype.</td>
</tr>
<tr>
<td><code>as_matrix([columns])</code></td>
<td>(DEPRECATED) Convert the frame to its Numpy-array representation.</td>
</tr>
<tr>
<td><code>asof(where[, subset])</code></td>
<td>The last row without any NaN is taken (or the last row without NaN considering only the subset of columns in the case of a DataFrame)</td>
</tr>
<tr>
<td><code>assign(**kwargs)</code></td>
<td>Assign new columns to a DataFrame, returning a new object (a copy) with the new columns added to the original ones.</td>
</tr>
<tr>
<td><code>astype(dtype[, copy, errors])</code></td>
<td>Cast a pandas object to a specified dtype <code>dtype</code>.</td>
</tr>
<tr>
<td><code>at_time(time[, asof])</code></td>
<td>Select values at particular time of day (e.g. 9:00-9:30 AM).</td>
</tr>
<tr>
<td><code>between_time(start_time, end_time[, . . .])</code></td>
<td>Select values between particular times of the day (e.g., 9:00-9:30 AM).</td>
</tr>
<tr>
<td><code>bfill([axis, inplace, limit, downcast])</code></td>
<td>Synonym for <code>DataFrame.fillna(method='bfill')</code>.</td>
</tr>
<tr>
<td><code>bool()</code></td>
<td>Return the bool of a single element PandasObject.</td>
</tr>
<tr>
<td><code>boxplot([column, by, ax, fontsize, rot, . . .])</code></td>
<td>Make a box plot from DataFrame columns.</td>
</tr>
<tr>
<td><code>clip([lower, upper, axis, inplace])</code></td>
<td>Trim values at input threshold(s).</td>
</tr>
<tr>
<td><code>clip_lower(threshold[, axis, inplace])</code></td>
<td>Return copy of the input with values below a threshold truncated.</td>
</tr>
<tr>
<td><code>clip_upper(threshold[, axis, inplace])</code></td>
<td>Return copy of input with values above given value(s) truncated.</td>
</tr>
<tr>
<td><code>combine(other, func[, fill_value, overwrite])</code></td>
<td>Add two DataFrame objects and do not propagate NaN values, so if for a (column, time) one frame is missing a value, it will default to the other frame's value (which might be NaN as well)</td>
</tr>
</tbody>
</table>
Table 61 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>combine_first</code></td>
<td>Combine two DataFrame objects and default to non-null values in frame calling the method.</td>
</tr>
<tr>
<td><code>compound</code></td>
<td>Return the compound percentage of the values for the requested axis</td>
</tr>
<tr>
<td><code>consolidate</code></td>
<td>(DEPRECATED) Compute NDFrame with “consolidated” internals (data of each dtype grouped together in a single ndarray).</td>
</tr>
<tr>
<td><code>convert_objects</code></td>
<td>(DEPRECATED) Attempt to infer better dtype for object columns.</td>
</tr>
<tr>
<td><code>copy</code></td>
<td>Make a copy of this object’s indices and data.</td>
</tr>
<tr>
<td><code>corr</code></td>
<td>Compute pairwise correlation of columns, excluding NA/null values.</td>
</tr>
<tr>
<td><code>corrwith</code></td>
<td>Compute pairwise correlation between rows or columns of two DataFrame objects.</td>
</tr>
<tr>
<td><code>count</code></td>
<td>Count non-NA cells for each column or row.</td>
</tr>
<tr>
<td><code>cov</code></td>
<td>Compute pairwise covariance of columns, excluding NA/null values.</td>
</tr>
<tr>
<td><code>cummax</code></td>
<td>Return cumulative maximum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>cummin</code></td>
<td>Return cumulative minimum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>cumprod</code></td>
<td>Return cumulative product over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>cumsum</code></td>
<td>Return cumulative sum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>describe</code></td>
<td>Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset’s distribution, excluding NaN values.</td>
</tr>
<tr>
<td><code>diff</code></td>
<td>First discrete difference of element.</td>
</tr>
<tr>
<td><code>div</code></td>
<td>Floating division of dataframe and other, element-wise (binary operator truediv).</td>
</tr>
<tr>
<td><code>divide</code></td>
<td>Floating division of dataframe and other, element-wise (binary operator truediv).</td>
</tr>
<tr>
<td><code>dot</code></td>
<td>Matrix multiplication with DataFrame or Series objects.</td>
</tr>
<tr>
<td><code>drop</code></td>
<td>Drop specified labels from rows or columns.</td>
</tr>
<tr>
<td><code>drop_duplicates</code></td>
<td>Return DataFrame with duplicate rows removed, optionally only considering certain columns</td>
</tr>
<tr>
<td><code>dropna</code></td>
<td>Remove missing values.</td>
</tr>
<tr>
<td><code>duplicated</code></td>
<td>Return boolean Series denoting duplicate rows, optionally only considering certain columns</td>
</tr>
<tr>
<td><code>eq</code></td>
<td>Wrapper for flexible comparison methods eq</td>
</tr>
<tr>
<td><code>equals</code></td>
<td>Determines if two NDFrame objects contain the same elements.</td>
</tr>
<tr>
<td><code>eval</code></td>
<td>Evaluate a string describing operations on DataFrame columns.</td>
</tr>
<tr>
<td><code>ewm</code></td>
<td>Provides exponential weighted functions</td>
</tr>
<tr>
<td><code>expanding</code></td>
<td>Provides expanding transformations.</td>
</tr>
<tr>
<td><code>ffill</code></td>
<td>Synonym for DataFrame.fillna(method='ffill')</td>
</tr>
<tr>
<td><code>fillna</code></td>
<td>Fill NA.NaN values using the specified method</td>
</tr>
</tbody>
</table>

Continued on next page
Table 61 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>filter</td>
<td>Subset rows or columns of dataframe according to labels in the specified index.</td>
</tr>
<tr>
<td>first</td>
<td>Convenience method for subsetting initial periods of time series data based on a date offset.</td>
</tr>
<tr>
<td>first_valid_index()</td>
<td>Return index for first non-NA/null value.</td>
</tr>
<tr>
<td>floordiv</td>
<td>Integer division of dataframe and other, element-wise (binary operator floordiv).</td>
</tr>
<tr>
<td>from_csv</td>
<td>(DEPRECATED) Read CSV file.</td>
</tr>
<tr>
<td>from_dict</td>
<td>Construct DataFrame from dict of array-like or dicts.</td>
</tr>
<tr>
<td>from_items</td>
<td>(DEPRECATED) Construct a dataframe from a list of tuples</td>
</tr>
<tr>
<td>from_records</td>
<td>Convert structured or record ndarray to DataFrame</td>
</tr>
<tr>
<td>ge</td>
<td>Wrapper for flexible comparison methods ge</td>
</tr>
<tr>
<td>get</td>
<td>Get item from object for given key (DataFrame column, Panel slice, etc.).</td>
</tr>
<tr>
<td>get_dtypes()</td>
<td>Return counts of unique dtypes in this object.</td>
</tr>
<tr>
<td>get_fnames()</td>
<td>(DEPRECATED) Return counts of unique ftypes in this object.</td>
</tr>
<tr>
<td>get_value</td>
<td>(DEPRECATED) Quickly retrieve single value at passed column and index</td>
</tr>
<tr>
<td>get_values</td>
<td>Return an ndarray after converting sparse values to dense</td>
</tr>
<tr>
<td>groupby</td>
<td>Group series using mapper (dict or key function, apply given function to group, return result as series) or by a series of columns.</td>
</tr>
<tr>
<td>gt</td>
<td>Wrapper for flexible comparison methods gt</td>
</tr>
<tr>
<td>head</td>
<td>Return the first n rows.</td>
</tr>
<tr>
<td>hist</td>
<td>Make a histogram of the DataFrame's.</td>
</tr>
<tr>
<td>idxmax</td>
<td>Return index of first occurrence of maximum over requested axis.</td>
</tr>
<tr>
<td>idxmin</td>
<td>Return index of first occurrence of minimum over requested axis.</td>
</tr>
<tr>
<td>infer_objects()</td>
<td>Attempt to infer better dtypes for object columns.</td>
</tr>
<tr>
<td>info</td>
<td>Print a concise summary of a DataFrame.</td>
</tr>
<tr>
<td>insert</td>
<td>Insert column into DataFrame at specified location.</td>
</tr>
<tr>
<td>interpolate()</td>
<td>Interpolate values according to different methods.</td>
</tr>
<tr>
<td>isin</td>
<td>Return boolean DataFrame showing whether each element in the DataFrame is contained in values.</td>
</tr>
<tr>
<td>isnan</td>
<td>Detect missing values.</td>
</tr>
<tr>
<td>isnull</td>
<td>Detect missing values.</td>
</tr>
<tr>
<td>items()</td>
<td>Iterator over (column name, Series) pairs.</td>
</tr>
<tr>
<td>iteritems</td>
<td>Iterator over (column name, Series) pairs.</td>
</tr>
<tr>
<td>iterrows()</td>
<td>Iterate over DataFrame rows as (index, Series) pairs.</td>
</tr>
<tr>
<td>itertuples()</td>
<td>Iterate over DataFrame rows as namedtuples, with index value as first element of the tuple.</td>
</tr>
<tr>
<td>join</td>
<td>Join columns with other DataFrame either on index or on a key column.</td>
</tr>
<tr>
<td>keys()</td>
<td>Get the ‘info axis’ (see Indexing for more)</td>
</tr>
</tbody>
</table>

Continued on next page
Table 61 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>kurt([axis, skipna, level, numeric_only])</code></td>
<td>Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0).</td>
</tr>
<tr>
<td><code>kurtosis([axis, skipna, level, numeric_only])</code></td>
<td>Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0).</td>
</tr>
<tr>
<td><code>last(offset)</code></td>
<td>Convenience method for subsetting final periods of time series data based on a date offset.</td>
</tr>
<tr>
<td><code>last_valid_index()</code></td>
<td>Return index for last non-NA/null value.</td>
</tr>
<tr>
<td><code>le(other[, axis, level])</code></td>
<td>Wrapper for flexible comparison methods le</td>
</tr>
<tr>
<td><code>lookup(row_labels, col_labels)</code></td>
<td>Label-based “fancy indexing” function for DataFrame.</td>
</tr>
<tr>
<td><code>lt(other[, axis, level])</code></td>
<td>Wrapper for flexible comparison methods lt</td>
</tr>
<tr>
<td><code>mad([axis, skipna, level])</code></td>
<td>Return the mean absolute deviation of the values for the requested axis</td>
</tr>
<tr>
<td><code>mask(cond[, other, inplace, axis, level, ...])</code></td>
<td>Return an object of same shape as self and whose corresponding entries are from self where cond is False and otherwise are from other.</td>
</tr>
<tr>
<td><code>max([axis, skipna, level, numeric_only])</code></td>
<td>This method returns the maximum of the values in the object.</td>
</tr>
<tr>
<td><code>mean([axis, skipna, level, numeric_only])</code></td>
<td>Return the mean of the values for the requested axis</td>
</tr>
<tr>
<td><code>median([axis, skipna, level, numeric_only])</code></td>
<td>Return the median of the values for the requested axis</td>
</tr>
<tr>
<td><code>melt([id_vars, value_vars, var_name, ...])</code></td>
<td>“Unpivots” a DataFrame from wide format to long format, optionally leaving identifier variables set.</td>
</tr>
<tr>
<td><code>memory_usage(index, deep)</code></td>
<td>Return the memory usage of each column in bytes.</td>
</tr>
<tr>
<td><code>merge(right[, how, on, left_on, right_on, ...])</code></td>
<td>Merge DataFrame objects by performing a database-style join operation by columns or indexes.</td>
</tr>
<tr>
<td><code>min([axis, skipna, level, numeric_only])</code></td>
<td>This method returns the minimum of the values in the object.</td>
</tr>
<tr>
<td><code>mod(other[, axis, level, fill_value])</code></td>
<td>Modulo of dataframe and other, element-wise (binary operator mod).</td>
</tr>
<tr>
<td><code>mode([axis, numeric_only])</code></td>
<td>Gets the mode(s) of each element along the axis selected.</td>
</tr>
<tr>
<td><code>mul(other[, axis, level, fill_value])</code></td>
<td>Multiplication of dataframe and other, element-wise (binary operator mul).</td>
</tr>
<tr>
<td><code>multiply(other[, axis, level, fill_value])</code></td>
<td>Multiplication of dataframe and other, element-wise (binary operator mul).</td>
</tr>
<tr>
<td><code>ne(other[, axis, level])</code></td>
<td>Wrapper for flexible comparison methods ne</td>
</tr>
<tr>
<td><code>nlargest(n, columns[, keep])</code></td>
<td>Return the first n rows ordered by columns in descending order.</td>
</tr>
<tr>
<td><code>notna()</code></td>
<td>Detect existing (non-missing) values.</td>
</tr>
<tr>
<td><code>notnull()</code></td>
<td>Detect existing (non-missing) values.</td>
</tr>
<tr>
<td><code>nsmallest(n, columns[, keep])</code></td>
<td>Get the rows of a DataFrame sorted by the n smallest values of columns.</td>
</tr>
<tr>
<td><code>nunique([axis, dropna])</code></td>
<td>Return Series with number of distinct observations over requested axis.</td>
</tr>
<tr>
<td><code>pct_change([periods, fill_method, limit, freq])</code></td>
<td>Percentage change between the current and a prior element.</td>
</tr>
<tr>
<td><code>pipe(func, *args, **kwargs)</code></td>
<td>Apply func(self, *args, **kwargs)</td>
</tr>
</tbody>
</table>

Continued on next page
Table 61 – continued from previous page

<table>
<thead>
<tr>
<th>Function</th>
<th>Documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>pivot</code>([index, columns, values])</td>
<td>Return reshaped DataFrame organized by given index / column values.</td>
</tr>
<tr>
<td><code>pivot_table</code>([values, index, columns, ...])</td>
<td>Create a spreadsheet-style pivot table as a DataFrame.</td>
</tr>
<tr>
<td><code>plot</code></td>
<td>alias of <code>pandas.plotting._core.FramePlotMethods</code>. Return item and drop from frame.</td>
</tr>
<tr>
<td><code>pop</code>(item)</td>
<td>Exponential power of dataframe and other, element-wise (binary operator <code>pow</code>).</td>
</tr>
<tr>
<td><code>prod</code>([axis, skipna, level, numeric_only, ...])</td>
<td>Return the product of the values for the requested axis.</td>
</tr>
<tr>
<td><code>product</code>([axis, skipna, level, numeric_only, ...])</td>
<td>Return the product of the values for the requested axis.</td>
</tr>
<tr>
<td><code>quantile</code>([q, axis, numeric_only, interpolation])</td>
<td>Return values at the given quantile over requested axis, a la numpy.percentile.</td>
</tr>
<tr>
<td><code>query</code>(expr[, inplace])</td>
<td>Query the columns of a frame with a boolean expression.</td>
</tr>
<tr>
<td><code>radd</code>(other[, axis, level, fill_value])</td>
<td>Addition of dataframe and other, element-wise (binary operator <code>radd</code>).</td>
</tr>
<tr>
<td><code>rank</code>([axis, method, numeric_only, ...])</td>
<td>Compute numerical data ranks (1 through n) along axis.</td>
</tr>
<tr>
<td><code>rdiv</code>(other[, axis, level, fill_value])</td>
<td>Floating division of dataframe and other, element-wise (binary operator <code>rtruediv</code>).</td>
</tr>
<tr>
<td><code>reindex</code>([labels, index, columns, axis, ...])</td>
<td>Conform DataFrame to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.</td>
</tr>
<tr>
<td><code>reindex_axis</code>(labels[, axis, method, level, ...])</td>
<td>Conform input object to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.</td>
</tr>
<tr>
<td><code>rename</code>(mapper[, index, columns, axis, copy, ...])</td>
<td>Alter axes labels.</td>
</tr>
<tr>
<td><code>rename_axis</code>(mapper[, axis, copy, inplace])</td>
<td>Alter the name of the index or columns.</td>
</tr>
<tr>
<td><code>reorder_levels</code>(order[, axis])</td>
<td>Rearrange index levels using input order.</td>
</tr>
<tr>
<td><code>replace</code>([to_replace, value, inplace, limit, ...])</td>
<td>Replace values given in <code>to_replace</code> with <code>value</code>.</td>
</tr>
<tr>
<td><code>resample</code>(rule[, how, axis, fill_method, ...])</td>
<td>Convenience method for frequency conversion and resampling of time series.</td>
</tr>
<tr>
<td><code>reset_index</code>([level, drop, inplace, ...])</td>
<td>For DataFrame with multi-level index, return new DataFrame with labeling information in the columns under the index names, defaulting to ‘level_0’, ‘level_1’, etc.</td>
</tr>
<tr>
<td><code>rfloordiv</code>(other[, axis, level, fill_value])</td>
<td>Integer division of dataframe and other, element-wise (binary operator <code>rfloordiv</code>).</td>
</tr>
<tr>
<td><code>rmod</code>(other[, axis, level, fill_value])</td>
<td>Modulo of dataframe and other, element-wise (binary operator <code>rmod</code>).</td>
</tr>
<tr>
<td><code>rmul</code>(other[, axis, level, fill_value])</td>
<td>Multiplication of dataframe and other, element-wise (binary operator <code>rmul</code>).</td>
</tr>
<tr>
<td><code>rolling</code>(window[, min_periods, center, ...])</td>
<td>Provides rolling window calculations.</td>
</tr>
<tr>
<td><code>round</code>([decimals])</td>
<td>Round a DataFrame to a variable number of decimal places.</td>
</tr>
<tr>
<td><code>rpow</code>(other[, axis, level, fill_value])</td>
<td>Exponential power of dataframe and other, element-wise (binary operator <code>rpow</code>).</td>
</tr>
</tbody>
</table>

Continued on next page
Table 61 – continued from previous page

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rsub(other[, axis, level, fill_value])</td>
<td>Subtraction of dataframe and other, element-wise (binary operator rsub).</td>
</tr>
<tr>
<td>rtruediv(other[, axis, level, fill_value])</td>
<td>Floating division of dataframe and other, element-wise (binary operator rtruediv).</td>
</tr>
<tr>
<td>sample([n, frac, replace, weights, ...])</td>
<td>Return a random sample of items from an axis of object.</td>
</tr>
<tr>
<td>select(crit[, axis])</td>
<td>(DEPRECATED) Return data corresponding to axis labels matching criteria.</td>
</tr>
<tr>
<td>select_dtypes([include, exclude])</td>
<td>Return a subset of the DataFrame’s columns based on the column dtypes.</td>
</tr>
<tr>
<td>sem([axis,skipna, level, ddof, numeric_only])</td>
<td>Return unbiased standard error of the mean over requested axis.</td>
</tr>
<tr>
<td>set_axis(labels[, axis, inplace])</td>
<td>Assign desired index to given axis.</td>
</tr>
<tr>
<td>set_index(keys[, drop, append, inplace, ...])</td>
<td>Set the DataFrame index (row labels) using one or more existing columns.</td>
</tr>
<tr>
<td>set_value(index, col, value[, takeable])</td>
<td>(DEPRECATED) Put single value at passed column and index.</td>
</tr>
<tr>
<td>shift([periods, freq, axis])</td>
<td>Shift index by desired number of periods with an optional time freq.</td>
</tr>
<tr>
<td>skew([axis,skipna, level, numeric_only])</td>
<td>Return unbiased skew over requested axis Normalized by N-1.</td>
</tr>
<tr>
<td>slice_shift([periods, axis])</td>
<td>Equivalent to shift without copying data.</td>
</tr>
<tr>
<td>sort_index([axis, level, ascending, ...])</td>
<td>Sort object by labels (along an axis)</td>
</tr>
<tr>
<td>sort_values(by[, axis, ascending, inplace, ...])</td>
<td>Sort by the values along either axis</td>
</tr>
<tr>
<td>sortlevel([level, axis, ascending, inplace, ...])</td>
<td>(DEPRECATED) Sort multilevel index by chosen axis and primary level.</td>
</tr>
<tr>
<td>squeeze([axis])</td>
<td>Squeeze length 1 dimensions.</td>
</tr>
<tr>
<td>stack([level, dropna])</td>
<td>Stack the prescribed level(s) from columns to index.</td>
</tr>
<tr>
<td>std([axis,skipna, level, ddof, numeric_only])</td>
<td>Return sample standard deviation over requested axis.</td>
</tr>
<tr>
<td>sub(other[, axis, level, fill_value])</td>
<td>Subtraction of dataframe and other, element-wise (binary operator sub).</td>
</tr>
<tr>
<td>subtract(other[, axis, level, fill_value])</td>
<td>Subtraction of dataframe and other, element-wise (binary operator sub).</td>
</tr>
<tr>
<td>sum([axis,skipna, level, numeric_only,...])</td>
<td>Return the sum of the values for the requested axis.</td>
</tr>
<tr>
<td>swapaxes(axis1, axis2[, copy])</td>
<td>Interchange axes and swap values axes appropriately.</td>
</tr>
<tr>
<td>swaplevel([i, j, axis])</td>
<td>Swap levels i and j in a MultiIndex on a particular axis.</td>
</tr>
<tr>
<td>tail([n])</td>
<td>Return the last n rows.</td>
</tr>
<tr>
<td>take(indices[, axis, convert, is_copy])</td>
<td>Return the elements in the given positional indices along an axis.</td>
</tr>
<tr>
<td>to_clipboard([excel, sep])</td>
<td>Copy object to the system clipboard.</td>
</tr>
<tr>
<td>to_csv([path_or_buf, sep, na_rep, ...])</td>
<td>Write DataFrame to a comma-separated values (csv) file.</td>
</tr>
<tr>
<td>to_dense()</td>
<td>Return dense representation of NDFrame (as opposed to sparse).</td>
</tr>
<tr>
<td>to_dict([orient, into])</td>
<td>Convert the DataFrame to a dictionary.</td>
</tr>
<tr>
<td>to_excel(excel_writer[, sheet_name, na_rep, ...])</td>
<td>Write DataFrame to an excel sheet</td>
</tr>
<tr>
<td>to_feather(fname)</td>
<td>write out the binary feather-format for DataFrames</td>
</tr>
<tr>
<td>to_gbq(destination_table, project_id[, ...])</td>
<td>Write a DataFrame to a Google BigQuery table.</td>
</tr>
</tbody>
</table>

Continued on next page
Table 61 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>to_hdf(path_or_buf, key, **kwargs)</code></td>
<td>Write the contained data to an HDF5 file using HDFStore.</td>
</tr>
<tr>
<td><code>to_html([buf, columns, col_space, header,...])</code></td>
<td>Render a DataFrame as an HTML table.</td>
</tr>
<tr>
<td><code>to_json([path_or_buf, orient, date_format,...])</code></td>
<td>Convert the object to a JSON string.</td>
</tr>
<tr>
<td><code>to_latex([buf, columns, col_space, header,...])</code></td>
<td>Render an object to a tabular environment table.</td>
</tr>
<tr>
<td><code>to_msgpack([path_or_buf, encoding])</code></td>
<td>msgpack (serialize) object to input file path.</td>
</tr>
<tr>
<td><code>to_panel()</code></td>
<td>(DEPRECATED) Transform long (stacked) format (DataFrame) into wide (3D, Panel) format.</td>
</tr>
<tr>
<td><code>to_parquet(fname[, engine, compression])</code></td>
<td>Write a DataFrame to the binary parquet format.</td>
</tr>
<tr>
<td><code>to_period([freq, axis, copy])</code></td>
<td>Convert DataFrame from DatetimeIndex to PeriodIndex with desired frequency (inferred from index if not passed)</td>
</tr>
<tr>
<td><code>to_pickle([path[, compression, protocol]])</code></td>
<td>Pickle (serialize) object to file.</td>
</tr>
<tr>
<td><code>to_records([index, convert_datetime64])</code></td>
<td>Convert DataFrame to a NumPy record array.</td>
</tr>
<tr>
<td><code>to_sparse([fill_value, kind])</code></td>
<td>Convert to SparseDataFrame</td>
</tr>
<tr>
<td><code>to_sql(name, con[, schema, if_exists,...])</code></td>
<td>Write records stored in a DataFrame to a SQL database.</td>
</tr>
<tr>
<td><code>to_stata(fname[, convert_dates,...])</code></td>
<td>Export Stata binary dta files.</td>
</tr>
<tr>
<td><code>to_string([buf, columns, col_space, header,...])</code></td>
<td>Render a DataFrame to a console-friendly tabular output.</td>
</tr>
<tr>
<td><code>to_timestamp([freq, how, axis, copy])</code></td>
<td>Cast to DatetimeIndex of timestamps, at beginning of period.</td>
</tr>
<tr>
<td><code>to_xarray()</code></td>
<td>Return an xarray object from the pandas object.</td>
</tr>
<tr>
<td><code>transform(func, *args, **kwargs)</code></td>
<td>Call function producing a like-indexed NDFrame and return a NDFrame with the transformed values</td>
</tr>
<tr>
<td><code>transpose(*args, **kwargs)</code></td>
<td>Transpose index and columns.</td>
</tr>
<tr>
<td><code>truediv(other[, axis, level, fill_value])</code></td>
<td>Floating division of dataframe and other, element-wise (binary operator truediv).</td>
</tr>
<tr>
<td><code>truncate([before, after, axis, copy])</code></td>
<td>Truncate a Series or DataFrame before and after some index value.</td>
</tr>
<tr>
<td><code>tshift([periods, freq, axis])</code></td>
<td>Shift the time index, using the index’s frequency if available.</td>
</tr>
<tr>
<td><code>tz_convert(tz[, axis, level, copy])</code></td>
<td>Convert tz-aware axis to target time zone.</td>
</tr>
<tr>
<td><code>tz_localize(tz[, axis, level, copy, ambiguous])</code></td>
<td>Localize tz-naive TimeSeries to target time zone.</td>
</tr>
<tr>
<td><code>unstack([level, fill_value])</code></td>
<td>Pivot a level of the (necessarily hierarchical) index labels, returning a DataFrame having a new level of column labels whose inner-most level consists of the pivoted index labels.</td>
</tr>
<tr>
<td><code>update(other[, join, overwrite,...])</code></td>
<td>Modify in place using non-NA values from another DataFrame.</td>
</tr>
<tr>
<td><code>var([axis, skipna, level, ddof, numeric_only])</code></td>
<td>Return unbiased variance over requested axis.</td>
</tr>
<tr>
<td><code>where(cond[, other, inplace, axis, level,...])</code></td>
<td>Return an object of same shape as self and whose corresponding entries are from self where cond is True and otherwise are from other.</td>
</tr>
<tr>
<td><code>xs(key[, axis, level, drop_level])</code></td>
<td>Returns a cross-section (row(s) or column(s)) from the Series/DataFrame.</td>
</tr>
</tbody>
</table>

**pandas.DataFrame.abs**

DataFrame.abs()

Return a Series/DataFrame with absolute numeric value of each element.
This function only applies to elements that are all numeric.

**Returns abs**

Series/DataFrame containing the absolute value of each element.

**See also:**

`numpy.absolute` calculate the absolute value element-wise.

**Notes**

For complex inputs, `1.2 + 1j`, the absolute value is \( \sqrt{a^2 + b^2} \).

**Examples**

Absolute numeric values in a Series.

```python
>>> s = pd.Series([-1.10, 2, -3.33, 4])
>>> s.abs()
0  1.10
1  2.00
2  3.33
3  4.00
dtype: float64
```

Absolute numeric values in a Series with complex numbers.

```python
>>> s = pd.Series([1.2 + 1j])
>>> s.abs()
0  1.56205
dtype: float64
```

Absolute numeric values in a Series with a Timedelta element.

```python
>>> s = pd.Series([pd.Timedelta('1 days')])
>>> s.abs()
0  1 days
dtype: timedelta64[ns]
```

Select rows with data closest to certain value using argsort (from StackOverflow).

```python
>>> df = pd.DataFrame({
... 'a': [4, 5, 6, 7],
... 'b': [10, 20, 30, 40],
... 'c': [100, 50, -30, -50]
... })
>>> df
    a  b  c
0  4  10  100
1  5  20   50
2  6  30  -30
3  7  40  -50
>>> df.loc[(df.c - 43).abs().argsort()]
    a  b  c
0  1  5  20
pandas.DataFrame.add

DataFrame.add (other, axis=‘columns’, level=None, fill_value=None)
Addition of dataframe and other, element-wise (binary operator add).
Equivalent to dataframe + other, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters

other [Series, DataFrame, or constant]
axis: {0, 1, ‘index’, ‘columns’}
For Series input, axis to match Series index on
level: int or name
Broadcast across a level, matching Index values on the passed MultiIndex level
fill_value: None or float value, default None
Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing

Returns

result [DataFrame]

See also:
DataFrame.radd

Notes
Mismatched indices will be unioned together

Examples

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>30</td>
<td>-30</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>40</td>
<td>-50</td>
</tr>
</tbody>
</table>

>>> a = pd.DataFrame([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'],
columns=['one'])
>>> a
   one
a  1.0
b  1.0
c  1.0
d  NaN
>>> b = pd.DataFrame(dict(one=[1, np.nan, 1, np.nan],
two=[np.nan, 2, np.nan, 2]),
index=['a', 'b', 'd', 'e'])
>>> b
   one   two
a   1.0  NaN
b   NaN   2.0
c   1.0  NaN
d  NaN   2.0
(continues on next page)
pandas.DataFrame.add_prefix

DataFrame.add_prefix (prefix)
Prefix labels with string prefix.

For Series, the row labels are prefixed. For DataFrame, the column labels are prefixed.

Parameters prefix : str
The string to add before each label.

Returns Series or DataFrame
New Series or DataFrame with updated labels.

See also:
Series.add_suffix Suffix row labels with string suffix.
DataFrame.add_suffix Suffix column labels with string suffix.

Examples

>>> s = pd.Series([1, 2, 3, 4])
>>> s
0 1
1 2
2 3
3 4
dtype: int64

>>> s.add_prefix('item_')
item_0 1
item_1 2
item_2 3
item_3 4
dtype: int64

>>> df = pd.DataFrame({'A': [1, 2, 3, 4], 'B': [3, 4, 5, 6]})
>>> df
   A  B
0  1  3
1  2  4
2  3  5
3  4  6
pandas: powerful Python data analysis toolkit, Release 0.23.2

0 1 3
1 2 4
2 3 5
3 4 6

>>> df.add_prefix('col_')
    col_A  col_B
0     1     3
1     2     4
2     3     5
3     4     6

pandas.DataFrame.add_suffix

DataFrame.add_suffix(suffix)

Suffix labels with string suffix.

For Series, the row labels are suffixed. For DataFrame, the column labels are suffixed.

Parameters suffix : str

The string to add after each label.

Returns Series or DataFrame

New Series or DataFrame with updated labels.

See also:

Series.add_prefix Prefix row labels with string prefix.

DataFrame.add_prefix Prefix column labels with string prefix.

Examples

>>> s = pd.Series([1, 2, 3, 4])
>>> s
0    1
1    2
2    3
3    4
.. dtype: int64

>>> s.add_suffix('_item')
   _item
0  1_item
1  2_item
2  3_item
3  4_item
.. dtype: int64

>>> df = pd.DataFrame({'A': [1, 2, 3, 4], 'B': [3, 4, 5, 6]})
>>> df
   A  B
0  1  3
1  2  4
2  3  5
3  4  6

(continues on next page)
1 2 4
2 3 5
3 4 6

```python
>>> df.add_suffix('_col')
   A_col  B_col
0   1   3
1   2   4
2   3   5
3   4   6
```

**pandas.DataFrame.agg**

DataFrame.**agg**(func, axis=0, *args, **kwargs)

Aggregate using one or more operations over the specified axis.

New in version 0.20.0.

**Parameters**

- **func**: function, string, dictionary, or list of string/functions
  - Function to use for aggregating the data. If a function, must either work when passed a DataFrame or when passed to DataFrame.apply. For a DataFrame, can pass a dict, if the keys are DataFrame column names.
  - Accepted combinations are:
    - string function name.
    - function.
    - list of functions.
    - dict of column names -> functions (or list of functions).
- **axis**: {0 or ‘index’, 1 or ‘columns’}, default 0
  - 0 or ‘index’: apply function to each column.
  - 1 or ‘columns’: apply function to each row.
- **args**: Positional arguments to pass to `func`.
- **kwargs**: Keyword arguments to pass to `func`.

**Returns**

- **aggregated**: [DataFrame]

See also:

- **DataFrame.apply** Perform any type of operations.
- **DataFrame.transform** Perform transformation type operations.
- **pandas.core.groupby.GroupBy** Perform operations over groups.
- **pandas.core.resample.Resampler** Perform operations over resampled bins.
- **pandas.core.window.Rolling** Perform operations over rolling window.
**pandas.core.window.Expanding** Perform operations over expanding window.

**pandas.core.window.EWM** Perform operation over exponential weighted window.

**Notes**

*agg* is an alias for *aggregate*. Use the alias.

A passed user-defined-function will be passed a Series for evaluation.

The aggregation operations are always performed over an axis, either the index (default) or the column axis. This behavior is different from *numpy* aggregation functions (*mean*, *median*, *prod*, *sum*, *std*, *var*), where the default is to compute the aggregation of the flattened array, e.g., *numpy.mean(arr_2d)* as opposed to *numpy.mean(arr_2d, axis=0)*.

*agg* is an alias for *aggregate*. Use the alias.

**Examples**

```python
>>> df = pd.DataFrame([[[1, 2, 3],
...                     [4, 5, 6],
...                     [7, 8, 9],
...                     [np.nan, np.nan, np.nan]],
...                    columns=['A', 'B', 'C'])

Aggregate these functions over the rows.

```python
>>> df.agg(['sum', 'min'])

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>12</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Different aggregations per column.

```python
>>> df.agg({'A': ['sum', 'min'], 'B': ['min', 'max']})

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>max</td>
<td>NaN</td>
<td>8.0</td>
</tr>
<tr>
<td>min</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>sum</td>
<td>12.0</td>
<td>NaN</td>
</tr>
</tbody>
</table>
```

Aggregate over the columns.

```python
>>> df.agg("mean", axis="columns")

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>5</td>
<td>8</td>
<td>NaN</td>
</tr>
<tr>
<td>1</td>
<td>NaN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>NaN</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

dtype: float64

**pandas.DataFrame.aggregate**

DataFrame.aggregate (func, axis=0, *args, **kwargs)

Aggregate using one or more operations over the specified axis.

New in version 0.20.0.
**Parameters**  
**func**: function, string, dictionary, or list of string/functions

Function to use for aggregating the data. If a function, must either work when passed a DataFrame or when passed to DataFrame.apply. For a DataFrame, can pass a dict, if the keys are DataFrame column names.

Accepted combinations are:
- string function name.
- function.
- list of functions.
- dict of column names -> functions (or list of functions).

**axis**: {0 or ‘index’, 1 or ‘columns’}, default 0

- 0 or ‘index’: apply function to each column.
- 1 or ‘columns’: apply function to each row.

*args

Positional arguments to pass to **func**.

**kwargs

Keyword arguments to pass to **func**.

**Returns**

aggregated [DataFrame]

**See also:**

*DataFrame.apply* Perform any type of operations.

*DataFrame.transform* Perform transformation type operations.

*pandas.core.groupby.GroupBy* Perform operations over groups.

*pandas.core.resample.Resampler* Perform operations over resampled bins.

*pandas.core.window.Rolling* Perform operations over rolling window.

*pandas.core.window.Expanding* Perform operations over expanding window.

*pandas.core.window.EWM* Perform operation over exponential weighted window.

**Notes**

agg is an alias for aggregate. Use the alias.

A passed user-defined-function will be passed a Series for evaluation.

The aggregation operations are always performed over an axis, either the index (default) or the column axis. This behavior is different from numpy aggregation functions (mean, median, prod, sum, std, var), where the default is to compute the aggregation of the flattened array, e.g., numpy.mean(arr_2d) as opposed to numpy.mean(arr_2d, axis=0).

agg is an alias for aggregate. Use the alias.
Examples

```python
>>> df = pd.DataFrame([[1, 2, 3],
...                     [4, 5, 6],
...                     [7, 8, 9],
...                     [np.nan, np.nan, np.nan]],
...                     columns=['A', 'B', 'C'])
```

Aggregate these functions over the rows.

```python
>>> df.agg(['sum', 'min'])
     A    B    C
sum  12.0 15.0 18.0
min  1.0  2.0  3.0
```

Different aggregations per column.

```python
>>> df.agg({'A' : ['sum', 'min'], 'B' : ['min', 'max']})
     A    B
max  NaN  8.0
min  1.0  2.0
sum 12.0 NaN
```

Aggregate over the columns.

```python
>>> df.agg("mean", axis="columns")
   0   2.0
   1   5.0
   2   8.0
   3  NaN
```

**pandas.DataFrame.align**

DataFrame.align (other, join='outer', axis=None, level=None, copy=True, fill_value=None, method=None, limit=None, fill_axis=0, broadcast_axis=None)

Align two objects on their axes with the specified join method for each axis

**Parameters**

- **other** [DataFrame or Series]
- **join** ['outer', 'inner', 'left', 'right'], default 'outer'
- **axis** : allowed axis of the other object, default None
  - Align on index (0), columns (1), or both (None)
- **level** : int or level name, default None
  - Broadcast across a level, matching Index values on the passed MultiIndex level
- **copy** : boolean, default True
  - Always returns new objects. If copy=False and no reindexing is required then original objects are returned.
- **fill_value** : scalar, default np.NaN
Value to use for missing values. Defaults to NaN, but can be any “compatible” value

**method** [str, default None]

**limit** [int, default None]

**fill_axis** : {0 or ‘index’, 1 or ‘columns’}, default 0
   Filling axis, method and limit

**broadcast_axis** : {0 or ‘index’, 1 or ‘columns’}, default None
   Broadcast values along this axis, if aligning two objects of different dimensions

**Returns** (left, right) : (DataFrame, type of other)
   Aligned objects

---

**pandas.DataFrame.all**

`DataFrame.all(axis=0, bool_only=None, skipna=True, level=None, **kwargs)`

Return whether all elements are True, potentially over an axis.

Returns True if all elements within a series or along a Dataframe axis are non-zero, not-empty or not-False.

**Parameters**

**axis** : {0 or ‘index’, 1 or ‘columns’, None}, default 0
   Indicate which axis or axes should be reduced.
   • 0 / ‘index’ : reduce the index, return a Series whose index is the original column labels.
   • 1 / ‘columns’ : reduce the columns, return a Series whose index is the original index.
   • None : reduce all axes, return a scalar.

**skipna** : boolean, default True
   Exclude NA/null values. If an entire row/column is NA, the result will be NA.

**level** : int or level name, default None
   If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series.

**bool_only** : boolean, default None
   Include only boolean columns. If None, will attempt to use everything, then use only boolean data. Not implemented for Series.

**kwargs** : any, default None
   Additional keywords have no effect but might be accepted for compatibility with NumPy.

**Returns**

**all** [Series or DataFrame (if level specified)]

**See also:**

**pandas.Series.all** Return True if all elements are True
**pandas.DataFrame.any**  Return True if one (or more) elements are True

### Examples

#### Series

```python
>>> pd.Series([True, True]).all()
True
>>> pd.Series([True, False]).all()
False
```

#### DataFrames

Create a dataframe from a dictionary.

```python
>>> df = pd.DataFrame({'col1': [True, True], 'col2': [True, False]})
>>> df
  col1  col2
0  True  True
1  True  False
```

Default behaviour checks if column-wise values all return True.

```python
>>> df.all()
  col1  True
  col2  False
  dtype: bool
```

Specify `axis='columns'` to check if row-wise values all return True.

```python
>>> df.all(axis='columns')
  0  True
  1  False
  dtype: bool
```

Or `axis=None` for whether every value is True.

```python
>>> df.all(axis=None)
False
```

---

**pandas.DataFrame.any**

DataFrame.any (axis=0, bool_only=None, skipna=True, level=None, **kwargs)  
Return whether any element is True over requested axis.

Unlike DataFrame.all(), this performs an or operation. If any of the values along the specified axis is True, this will return True.

**Parameters**

- **axis**: {0 or ‘index’, 1 or ‘columns’, None}, default 0
  
  Indicate which axis or axes should be reduced.
  
  - 0 / ‘index’ : reduce the index, return a Series whose index is the original column labels.
  
  - 1 / ‘columns’ : reduce the columns, return a Series whose index is the original index.
skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA.

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series.

bool_only : boolean, default None

Include only boolean columns. If None, will attempt to use everything, then use only boolean data. Not implemented for Series.

**kwargs : any, default None

Additional keywords have no effect but might be accepted for compatibility with NumPy.

Returns

any [Series or DataFrame (if level specified)]

See also:

pandas.DataFrame.all Return whether all elements are True.

Examples

Series

For Series input, the output is a scalar indicating whether any element is True.

```python
>>> pd.Series([True, False]).any()
True
```

DataFrame

Whether each column contains at least one True element (the default).

```python
>>> df = pd.DataFrame({"A": [1, 2], "B": [0, 2], "C": [0, 0]})
>>> df
   A  B  C
0  1  0  0
1  2  2  0

>>> df.any()
A   True
B   True
C  False
dtype: bool
```

Aggregating over the columns.

```python
>>> df = pd.DataFrame({"A": [True, False], "B": [1, 2]})
>>> df
   A  B
0  True 1
1  False 2
```
```python
>>> df.any(axis='columns')
0   True
1   True
dtype: bool
```

```python
>>> df = pd.DataFrame({"A": [True, False], "B": [1, 0]})
>>> df
   A  B
0  True 1
1  False 0
```

```python
>>> df.any(axis='columns')
0   True
1   False
dtype: bool
```

Aggregating over the entire DataFrame with `axis=None`.

```python
>>> df.any(axis=None)
True
```

`any` for an empty DataFrame is an empty Series.

```python
>>> pd.DataFrame([]).any()
Series([], dtype: bool)
```

**pandas.DataFrame.append**

Dataframe .append *(other, ignore_index=False, verify_integrity=False, sort=None)*

Append rows of `other` to the end of this frame, returning a new object. Columns not in this frame are added as new columns.

**Parameters**

- `other` : DataFrame or Series/dict-like object, or list of these
  - The data to append.
  - `ignore_index` : boolean, default False
    - If True, do not use the index labels.
  - `verify_integrity` : boolean, default False
    - If True, raise ValueError on creating index with duplicates.
  - `sort` : boolean, default None
    - Sort columns if the columns of `self` and `other` are not aligned. The default sorting is deprecated and will change to not-sorting in a future version of pandas. Explicitly pass `sort=True` to silence the warning and sort. Explicitly pass `sort=False` to silence the warning and not sort.

**Returns**

- `appended` [DataFrame]

**See also:**
**pandas.concat**  General function to concatenate DataFrame, Series or Panel objects

**Notes**

If a list of dict/series is passed and the keys are all contained in the DataFrame’s index, the order of the columns in the resulting DataFrame will be unchanged.

Iteratively appending rows to a DataFrame can be more computationally intensive than a single concatenate. A better solution is to append those rows to a list and then concatenate the list with the original DataFrame all at once.

**Examples**

```python
>>> df = pd.DataFrame([[1, 2], [3, 4]], columns=list('AB'))
>>> df
   A  B
0  1  2
1  3  4

>>> df2 = pd.DataFrame([[5, 6], [7, 8]], columns=list('AB'))
>>> df.append(df2)
   A  B
0  1  2
1  3  4
2  5  6
3  7  8

With `ignore_index` set to True:

```python
>>> df.append(df2, ignore_index=True)
   A  B
0  1  2
1  3  4
2  5  6
3  7  8
```

The following, while not recommended methods for generating DataFrames, show two ways to generate a DataFrame from multiple data sources.

**Less efficient:**

```python
>>> df = pd.DataFrame(columns=['A'])
>>> for i in range(5):
...     df = df.append({'A': i}, ignore_index=True)

>>> df
   A
0  0
1  1
2  2
3  3
4  4
```

**More efficient:**

```python
>>> pd.concat([pd.DataFrame([i], columns=['A']) for i in range(5)],
...            ignore_index=True)
```

(continues on next page)
pandas.DataFrame.apply

Dataframe.apply (func, axis=0, broadcast=None, raw=False, reduce=None, result_type=None, args=(), **kwds)

Apply a function along an axis of the DataFrame.

Objects passed to the function are Series objects whose index is either the DataFrame’s index (axis=0) or the DataFrame’s columns (axis=1). By default (result_type=None), the final return type is inferred from the return type of the applied function. Otherwise, it depends on the result_type argument.

Parameters:
- **func**: function
  Function to apply to each column or row.
- **axis**: {0 or ‘index’, 1 or ‘columns’}, default 0
  Axis along which the function is applied:
  - 0 or ‘index’: apply function to each column.
  - 1 or ‘columns’: apply function to each row.
- **broadcast**: bool, optional
  Only relevant for aggregation functions:
  - False or None: returns a Series whose length is the length of the index or the number of columns (based on the axis parameter)
  - True: results will be broadcast to the original shape of the frame, the original index and columns will be retained.

Deprecation warning: This argument will be removed in a future version, replaced by result_type='broadcast'.

- **raw**: bool, default False
  - False: passes each row or column as a Series to the function.
  - True: the passed function will receive ndarray objects instead. If you are just applying a NumPy reduction function this will achieve much better performance.

- **reduce**: bool or None, default None
  Try to apply reduction procedures. If the DataFrame is empty, apply will use reduce to determine whether the result should be a Series or a DataFrame. If reduce=None (the default), apply’s return value will be guessed by calling func on an empty Series (note: while guessing, exceptions raised by func will be ignored). If reduce=True a Series will always be returned, and if reduce=False a DataFrame will always be returned.

Deprecation warning: This argument will be removed in a future version, replaced by result_type='reduce'.

result_type : {'expand', 'reduce', 'broadcast', None}, default None

These only act when axis=1 (columns):

• 'expand': list-like results will be turned into columns.
• 'reduce': returns a Series if possible rather than expanding list-like results. This is the opposite of 'expand'.
• 'broadcast': results will be broadcast to the original shape of the DataFrame, the original index and columns will be retained.

The default behaviour (None) depends on the return value of the applied function: list-like results will be returned as a Series of those. However if the apply function returns a Series these are expanded to columns.

New in version 0.23.0.

args : tuple

Positional arguments to pass to func in addition to the array/series.

**kwds

Additional keyword arguments to pass as keywords arguments to func.

Returns

applied [Series or DataFrame]

See also:

*DataFrame.applymap* For elementwise operations
*DataFrame.aggregate* only perform aggregating type operations
*DataFrame.transform* only perform transforming type operations

Notes

In the current implementation apply calls func twice on the first column/row to decide whether it can take a fast or slow code path. This can lead to unexpected behavior if func has side-effects, as they will take effect twice for the first column/row.

Examples

```python
>>> df = pd.DataFrame([[[4, 9],] * 3, columns=['A', 'B'])
>>> df
A  B
0  4  9
1  4  9
2  4  9

Using a numpy universal function (in this case the same as np.sqrt (df)):

```
Using a reducing function on either axis

```python
>>> df.apply(np.sum, axis=0)
A  12
B  27
dtype: int64
```

```python
>>> df.apply(np.sum, axis=1)
0  13
1  13
2  13
dtype: int64
```

Returning a list-like will result in a Series

```python
>>> df.apply(lambda x: [1, 2], axis=1)
0  [1, 2]
1  [1, 2]
2  [1, 2]
dtype: object
```

Passing result_type='expand' will expand list-like results to columns of a Dataframe

```python
>>> df.apply(lambda x: [1, 2], axis=1, result_type='expand')
   A  B
0  1  2
1  1  2
2  1  2
```

Returning a Series inside the function is similar to passing result_type='expand'. The resulting column names will be the Series index.

```python
>>> df.apply(lambda x: pd.Series([1, 2], index=['foo', 'bar']), axis=1)
   foo  bar
0  1  2
1  1  2
2  1  2
```

Passing result_type='broadcast' will ensure the same shape result, whether list-like or scalar is returned by the function, and broadcast it along the axis. The resulting column names will be the originals.

```python
>>> df.apply(lambda x: [1, 2], axis=1, result_type='broadcast')
  A  B
0  1  2
1  1  2
2  1  2
```

---

**pandas.DataFrame.applymap**

Dataframe.applymap(func)

Apply a function to a Dataframe elementwise.

This method applies a function that accepts and returns a scalar to every element of a DataFrame.

Parameters

- func : callable
  Python function, returns a single value from a single value.
Returns DataFrame

Transformed DataFrame.

See also:

DataFrame.apply Apply a function along input axis of DataFrame

Examples

```python
>>> df = pd.DataFrame([[1, 2.12], [3.356, 4.567]])
>>> df
   0    1
0 1.0000 2.1200
1 3.3560 4.5670

>>> df.applymap(lambda x: len(str(x)))
   0  1
0   3  4
1   5  5
```

Note that a vectorized version of `func` often exists, which will be much faster. You could square each number elementwise.

```python
>>> df.applymap(lambda x: x**2)
   0       1
0 1.00000 4.494400
1 11.26274 20.857489
```

But it’s better to avoid applymap in that case.

```python
>>> df ** 2
   0       1
0 1.00000 4.494400
1 11.26274 20.857489
```

pandas.DataFrame.as_blocks

DataFrame.as_blocks (copy=True)

Convert the frame to a dict of dtype -> Constructor Types that each has a homogeneous dtype.

Deprecated since version 0.21.0.

NOTE: the dtypes of the blocks WILL BE PRESERVED HERE (unlike in as_matrix)

Parameters

- copy [boolean, default True]

Returns

- values [a dict of dtype -> Constructor Types]
pandas.DataFrame.as_matrix

DataFrame.as_matrix(columns=None)
Convert the frame to its Numpy-array representation.

Deprecated since version 0.23.0: Use DataFrame.values() instead.

Parameters columns: list, optional, default:None
If None, return all columns, otherwise, returns specified columns.

Returns values : ndarray
If the caller is heterogeneous and contains booleans or objects, the result will be
doftype=object. See Notes.

See also:
pandas.DataFrame.values

Notes
Return is NOT a Numpy-matrix, rather, a Numpy-array.
The dtype will be a lower-common-denominator dtype (implicit upcasting); that is to say if the dtypes
even of numeric types) are mixed, the one that accommodates all will be chosen. Use this with care if
you are not dealing with the blocks.
e.g. If the dtypes are float16 and float32, dtype will be upcast to float32. If dtypes are int32 and uint8,
dtype will be upcase to int32. By numpy.find_common_type convention, mixing int64 and uint64 will
result in a float64 dtype.

This method is provided for backwards compatibility. Generally, it is recommended to use `.values`.

pandas.DataFrame.asfreq

DataFrame.asfreq(freq=None, method=None, how=None, normalize=False, fill_value=None)
Convert TimeSeries to specified frequency.

Optionally provide filling method to pad/backfill missing values.

Returns the original data conformed to a new index with the specified frequency. resample is more
appropriate if an operation, such as summarization, is necessary to represent the data at the new frequency.

Parameters
 freq [DateOffset object, or string]
 method : {'backfill'/'bfill', 'pad'/'ffill'}, default None
   Method to use for filling holes in reindexed Series (note this does not fill NaNs
   that already were present):
   • 'pad' / 'ffill': propagate last valid observation forward to next valid
   • 'backfill' / 'bfill': use NEXT valid observation to fill
 how : {'start', 'end'}, default end
   For PeriodIndex only, see PeriodIndex.asfreq
 normalize : bool, default False
Whether to reset output index to midnight

**fill_value**: scalar, optional

Value to use for missing values, applied during upsampling (note this does not fill NaNs that already were present).

New in version 0.20.0.

**Returns**

- `converted` [type of caller]

**See also:**

reindex

**Notes**

To learn more about the frequency strings, please see this link.

**Examples**

Start by creating a series with 4 one minute timestamps.

```python
>>> index = pd.date_range('1/1/2000', periods=4, freq='T')
>>> series = pd.Series([0.0, None, 2.0, 3.0], index=index)
>>> df = pd.DataFrame({'s':series})
>>> df
      s
2000-01-01 00:00:00  0.0
2000-01-01 00:01:00  NaN
2000-01-01 00:02:00  2.0
2000-01-01 00:03:00  3.0
```

Upsample the series into 30 second bins.

```python
>>> df.asfreq(freq='30S')
     s
2000-01-01 00:00:00  0.0
2000-01-01 00:00:30  NaN
2000-01-01 00:01:00  NaN
2000-01-01 00:01:30  NaN
2000-01-01 00:02:00  2.0
2000-01-01 00:02:30  NaN
2000-01-01 00:03:00  3.0
```

Upsample again, providing a fill value.

```python
>>> df.asfreq(freq='30S', fill_value=9.0)
     s
2000-01-01 00:00:00  0.0
2000-01-01 00:00:30  9.0
2000-01-01 00:01:00  NaN
2000-01-01 00:01:30  9.0
2000-01-01 00:02:00  2.0
2000-01-01 00:02:30  9.0
2000-01-01 00:03:00  3.0
```
Upsample again, providing a method.

```python
>>> df.asfreq(freq='30S', method='bfill')
   s
2000-01-01 00:00:00   0.0
2000-01-01 00:00:30   NaN
2000-01-01 00:01:00   NaN
2000-01-01 00:01:30   2.0
2000-01-01 00:02:00   2.0
2000-01-01 00:02:30   3.0
2000-01-01 00:03:00   3.0
```

**pandas.DataFrame.asof**

Dataframe.asof(where, subset=None)

The last row without any NaN is taken (or the last row without NaN considering only the subset of columns in the case of a DataFrame)

New in version 0.19.0: For DataFrame

If there is no good value, NaN is returned for a Series a Series of NaN values for a DataFrame

**Parameters**

where [date or array of dates]

subset : string or list of strings, default None

if not None use these columns for NaN propagation

**Returns**

where is scalar

- value or NaN if input is Series
- Series if input is DataFrame

where is Index: same shape object as input

**See also:**

merge_asof

**Notes**

Dates are assumed to be sorted Raises if this is not the case

**pandas.DataFrame.assign**

Dataframe.assign(**kwargs)

Assign new columns to a DataFrame, returning a new object (a copy) with the new columns added to the original ones. Existing columns that are re-assigned will be overwritten.

**Parameters**

kwargs : keyword, value pairs

keywords are the column names. If the values are callable, they are computed on the DataFrame and assigned to the new columns. The callable must not change input DataFrame (though pandas doesn’t check it). If the values are not callable, (e.g. a Series, scalar, or array), they are simply assigned.
Returns `df`: DataFrame

A new DataFrame with the new columns in addition to all the existing columns.

Notes

Assigning multiple columns within the same `assign` is possible. For Python 3.6 and above, later items in `**kwargs` may refer to newly created or modified columns in `df`; items are computed and assigned into `df` in order. For Python 3.5 and below, the order of keyword arguments is not specified, you cannot refer to newly created or modified columns. All items are computed first, and then assigned in alphabetical order.

Changed in version 0.23.0: Keyword argument order is maintained for Python 3.6 and later.

Examples

```python
>>> df = pd.DataFrame({'A': range(1, 11), 'B': np.random.randn(10)})

Where the value is a callable, evaluated on `df`:

```python
>>> df.assign(ln_A = lambda x: np.log(x.A))

```python
A    B         ln_A
0  1 0.426905  0.000000
1  2 -0.780949  0.693147
2  3 -0.418711  1.098612
3  4 -0.269708  1.386294
4  5 -0.274002  1.609438
5  6 -0.500792  1.791759
6  7 1.649697  1.945910
7  8 -1.495604  2.079442
8  9 0.549296  2.197225
9 10 -0.758542  2.302585
```

Where the value already exists and is inserted:

```python
>>> newcol = np.log(df['A'])
>>> df.assign(ln_A=newcol)

```python
A    B         ln_A
0  1 0.426905  0.000000
1  2 -0.780949  0.693147
2  3 -0.418711  1.098612
3  4 -0.269708  1.386294
4  5 -0.274002  1.609438
5  6 -0.500792  1.791759
6  7 1.649697  1.945910
7  8 -1.495604  2.079442
8  9 0.549296  2.197225
9 10 -0.758542  2.302585
```

Where the keyword arguments depend on each other

```python
>>> df = pd.DataFrame({'A': [1, 2, 3]})
```
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
>>> df.assign(B=df.A, C=lambda x: x['A'] + x['B'])
    A  B  C
0  1  1  2
1  2  2  4
2  3  3  6
```

### pandas.DataFrame.astype

`DataFrame.astype(dtype, copy=True, errors='raise', **kwargs)`

Cast a pandas object to a specified dtype `dtype`.

**Parameters**
- `dtype`: data type, or dict of column name -> data type
  - Use a numpy.dtype or Python type to cast entire pandas object to the same type.
  - Alternatively, use `{col: dtype, ...}`, where `col` is a column label and `dtype` is a numpy.dtype or Python type to cast one or more of the DataFrame's columns to column-specific types.
- `copy`: bool, default True.
  - Return a copy when `copy=True` (be very careful setting `copy=False` as changes to values then may propagate to other pandas objects).
- `errors`: {'raise', 'ignore'}, default 'raise'.
  - Control raising of exceptions on invalid data for provided `dtype`.
    - `raise`: allow exceptions to be raised
    - `ignore`: suppress exceptions. On error return original object
  - New in version 0.20.0.
- `raise_on_error`: raise on invalid input
  - Deprecated since version 0.20.0: Use `errors` instead
- `kwargs` [keyword arguments to pass on to the constructor]

**Returns**
- `casted` [type of caller]

**See also:**
- `pandas.to_datetime` Convert argument to datetime.
- `pandas.to_timedelta` Convert argument to timedelta.
- `pandas.to_numeric` Convert argument to a numeric type.
- `numpy.ndarray.astype` Cast a numpy array to a specified type.

**Examples**
Convert to categorical type:

```python
>>> ser.astype('category')
0 1  
1 2  
dtype: category
Categories (2, int64): [1, 2]
```

Convert to ordered categorical type with custom ordering:

```python
>>> ser.astype('category', ordered=True, categories=[2, 1])
0 1  
1 2  
dtype: category
Categories (2, int64): [2 < 1]
```

Note that using `copy=False` and changing data on a new pandas object may propagate changes:

```python
>>> s1 = pd.Series([1, 2])
>>> s2 = s1.astype('int64', copy=False)
>>> s2[0] = 10
>>> s1
# note that s1[0] has changed too
0 10
1 2
```

### pandas.DataFrame.at_time

DataFrame.at_time(time, asof=False)

Select values at particular time of day (e.g. 9:30AM).

**Parameters**

- time [datetime.time or string]

**Returns**

- values_at_time [type of caller]

**Raises**

- TypeError

    If the index is not a DatetimeIndex

**See also:**

- `between_time` Select values between particular times of the day
- `first` Select initial periods of time series based on a date offset
last Select final periods of time series based on a date offset

DatetimeIndex.indexer_at_time Get just the index locations for values at particular time of the day

Examples

```python
>>> i = pd.date_range('2018-04-09', periods=4, freq='12H')
>>> ts = pd.DataFrame({'A': [1,2,3,4]}, index=i)
>>> ts
          A
2018-04-09  00:00:00  1
2018-04-09  12:00:00  2
2018-04-10  00:00:00  3
2018-04-10  12:00:00  4

>>> ts.at_time('12:00')
          A
2018-04-09  12:00:00  2
2018-04-10  12:00:00  4
```

pandas.DataFrame.between_time

DataFrame.between_time(start_time, end_time, include_start=True, include_end=True)  
Select values between particular times of the day (e.g., 9:00-9:30 AM). 
By setting start_time to be later than end_time, you can get the times that are not between the two times.

Parameters

- start_time [datetime.time or string]
- end_time [datetime.time or string]
- include_start [boolean, default True]
- include_end [boolean, default True]

Returns

- values_between_time [type of caller]

Raises TypeError

If the index is not a DatetimeIndex

See also:

- at_time Select values at a particular time of the day
- first Select initial periods of time series based on a date offset
- last Select final periods of time series based on a date offset
- DatetimeIndex.indexer_between_time Get just the index locations for values between particular times of the day
Examples

```
>>> i = pd.date_range('2018-04-09', periods=4, freq='1D20min')
>>> ts = pd.DataFrame({'A': [1,2,3,4]}, index=i)
>>> ts
          A
2018-04-09 00:00:00  1
2018-04-10 00:20:00  2
2018-04-11 00:40:00  3
2018-04-12 01:00:00  4

>>> ts.between_time('0:15', '0:45')
          A
2018-04-10 00:20:00  2
2018-04-11 00:40:00  3
```

You get the times that are not between two times by setting `start_time` later than `end_time`:

```
>>> ts.between_time('0:45', '0:15')
          A
2018-04-09 00:00:00  1
2018-04-12 01:00:00  4
```

**pandas.DataFrame.bfill**

DataFrame . bfill (axis=None, inplace=False, limit=None, downcast=None)

Synonym for `DataFrame.fillna(method='bfill')`

**pandas.DataFrame.bool**

DataFrame . bool ()

Return the bool of a single element PandasObject.

This must be a boolean scalar value, either True or False. Raise a ValueError if the PandasObject does not have exactly 1 element, or that element is not boolean

**pandas.DataFrame.boxplot**

DataFrame . boxplot (column=None, by=None, ax=None, fontsize=None, rot=0, grid=True, figsize=None, layout=None, return_type=None, **kwds)

Make a box plot from DataFrame columns.

Make a box-and-whisker plot from DataFrame columns, optionally grouped by some other columns. A box plot is a method for graphically depicting groups of numerical data through their quartiles. The box extends from the Q1 to Q3 quartile values of the data, with a line at the median (Q2). The whiskers extend from the edges of box to show the range of the data. The position of the whiskers is set by default to 1.5 * IQR (IQR = Q3 - Q1) from the edges of the box. Outlier points are those past the end of the whiskers.

For further details see Wikipedia’s entry for `boxplot`.

**Parameters**

- **column**: str or list of str, optional
  
  Column name or list of names, or vector. Can be any valid input to `pandas.DataFrame.groupby()`.
by : str or array-like, optional
    Column in the DataFrame to pandas.DataFrame.groupby(). One boxplot will be done per value of columns in by.
ax : object of class matplotlib.axes.Axes, optional
    The matplotlib axes to be used by boxplot.
fontsize : float or str
    Tick label font size in points or as a string (e.g., large).
rot : int or float, default 0
    The rotation angle of labels (in degrees) with respect to the screen coordinate system.
grid : boolean, default True
    Setting this to True will show the grid.
figsize : A tuple (width, height) in inches
    The size of the figure to create in matplotlib.
layout : tuple (rows, columns), optional
    For example, (3, 5) will display the subplots using 3 columns and 5 rows, starting from the top-left.
return_type : {'axes', 'dict', 'both'} or None, default 'axes'
    The kind of object to return. The default is axes.
    • 'axes' returns the matplotlib axes the boxplot is drawn on.
    • 'dict' returns a dictionary whose values are the matplotlib Lines of the boxplot.
    • 'both' returns a namedtuple with the axes and dict.
    • when grouping with by, a Series mapping columns to return_type is returned.
    If return_type is None, a NumPy array of axes with the same shape as layout is returned.
**kwds
    All other plotting keyword arguments to be passed to matplotlib.pyplot.boxplot().

Returns result :
    The return type depends on the return_type parameter:
    • 'axes' : object of class matplotlib.axes.Axes
    • 'dict' : dict of matplotlib.lines.Line2D objects
    • 'both' : a namedtuple with strucure (ax, lines)
For data grouped with by:
    • Series
    • array (for return_type = None)

See also:
Series.plot.hist  Make a histogram.

matplotlib.pyplot.boxplot  Matplotlib equivalent plot.

Notes

Use return_type='dict' when you want to tweak the appearance of the lines after plotting. In this case a dict containing the Lines making up the boxes, caps, fliers, medians, and whiskers is returned.

Examples

Boxplots can be created for every column in the dataframe by df.boxplot() or indicating the columns to be used:

```python
>>> np.random.seed(1234)
>>> df = pd.DataFrame(np.random.randn(10,4),
...                   columns=['Col1', 'Col2', 'Col3', 'Col4'])
>>> boxplot = df.boxplot(column=['Col1', 'Col2', 'Col3'])
```

Boxplots of variables distributions grouped by the values of a third variable can be created using the option by. For instance:

```python
>>> df = pd.DataFrame(np.random.randn(10, 2),
...                    columns=['Col1', 'Col2'])
...                      'B', 'B', 'B', 'B', 'B'])
>>> boxplot = df.boxplot(by='X')
```

A list of strings (i.e. ['X', 'Y']) can be passed to boxplot in order to group the data by combination of the variables in the x-axis:

```python
>>> df = pd.DataFrame(np.random.randn(10,3),
...                    columns=['Col1', 'Col2', 'Col3'])
...                      'B', 'B', 'B', 'B', 'B'])
>>> df['Y'] = pd.Series(['A', 'B', 'A', 'B', 'A',
...                      'B', 'A', 'B', 'A', 'B'])
>>> boxplot = df.boxplot(column=['Col1', 'Col2'], by=['X', 'Y'])
```

The layout of boxplot can be adjusted giving a tuple to layout:

```python
>>> boxplot = df.boxplot(column=['Col1', 'Col2'], by='X',
...                       layout=(2, 1))
```

Additional formatting can be done to the boxplot, like suppressing the grid (grid=False), rotating the labels in the x-axis (i.e. rot=45) or changing the fontsize (i.e. fontsize=15):

```python
>>> boxplot = df.boxplot(grid=False, rot=45, fontsize=15)
```

The parameter return_type can be used to select the type of element returned by boxplot. When return_type='axes' is selected, the matplotlib axes on which the boxplot is drawn are returned:

```python
>>> boxplot = df.boxplot(column=['Col1', 'Col2'], return_type='axes')
>>> type(boxplot)
<class 'matplotlib.axes._subplots.AxesSubplot'>
When grouping with `by`, a Series mapping columns to `return_type` is returned:

```python
>>> boxplot = df.boxplot(column=['Col1', 'Col2'], by='X',
...                       return_type='axes')
>>> type(boxplot)
<class 'pandas.core.series.Series'>
```

If `return_type` is `None`, a NumPy array of axes with the same shape as `layout` is returned:

```python
>>> boxplot = df.boxplot(column=['Col1', 'Col2'], by='X',
...                       return_type=None)
>>> type(boxplot)
<class 'numpy.ndarray'>
```

### pandas.DataFrame.clip

`DataFrame.clip(lower=None, upper=None, axis=None, inplace=False, *args, **kwargs)`

Trim values at input threshold(s).

Assigns values outside boundary to boundary values. Thresholds can be singular values or array like, and in the latter case the clipping is performed element-wise in the specified axis.

**Parameters**

- **lower**: float or array_like, default None
  - Minimum threshold value. All values below this threshold will be set to it.

- **upper**: float or array_like, default None
  - Maximum threshold value. All values above this threshold will be set to it.

- **axis**: int or string axis name, optional
  - Align object with lower and upper along the given axis.

- **inplace**: boolean, default False
  - Whether to perform the operation in place on the data.

  New in version 0.21.0.

- ***args**, ****kwargs**
  - Additional keywords have no effect but might be accepted for compatibility with numpy.

**Returns**

- **Series or DataFrame**
  - Same type as calling object with the values outside the clip boundaries replaced

**See also**

- `clip_lower` Clip values below specified threshold(s).
- `clip_upper` Clip values above specified threshold(s).

**Examples**
```python
data = {'col_0': [9, -3, 0, -1, 5], 'col_1': [-2, -7, 6, 8, -5]}
>>> df = pd.DataFrame(data)
>>> df
    col_0 col_1
0      9    -2
1     -3    -7
2      0     6
3     -1     8
4      5    -5

Clips per column using lower and upper thresholds:

```python
>>> df.clip(-4, 6)
    col_0 col_1
0      6    -2
1     -3    -4
2      0     6
3     -1     6
4      5    -4
```
**inplace** : boolean, default False

Whether to perform the operation in place on the data.

New in version 0.21.0.

**Returns**

- **clipped** [same type as input]

**See also:**

- `Series.clip` Return copy of input with values below and above thresholds truncated.
- `Series.clip_upper` Return copy of input with values above threshold truncated.

**Examples**

**Series single threshold clipping:**

```python
>>> s = pd.Series([5, 6, 7, 8, 9])
>>> s.clip_lower(8)
0    8
1    8
2    8
3    8
4    9
dtype: int64
```

**Series clipping element-wise using an array of thresholds.** threshold should be the same length as the Series.

```python
>>> elemwise_thresholds = [4, 8, 7, 2, 5]
>>> s.clip_lower(elemwise_thresholds)
0    5
1    8
2    7
3    8
4    9
dtype: int64
```

**DataFrames can be compared to a scalar.**

```python
>>> df = pd.DataFrame({"A": [1, 3, 5], "B": [2, 4, 6]})
>>> df
 A B
0 1 2
1 3 4
2 5 6
```

```python
>>> df.clip_lower(3)
 A B
0 3 3
1 3 4
2 5 6
```

**Or to an array of values.** By default, threshold should be the same shape as the DataFrame.
>>> df.clip_lower(np.array([[3, 4], [2, 2], [6, 2]]))
A  B
0 3 4
1 3 4
2 6 6

Control how *threshold* is broadcast with *axis*. In this case *threshold* should be the same length as the axis specified by *axis*.

```python
>>> df.clip_lower(np.array([3, 3, 5]), axis='index')
A  B
0 3 3
1 3 4
2 5 6
```

```python
>>> df.clip_lower(np.array([4, 5]), axis='columns')
A  B
0 4 5
1 4 5
2 5 6
```

**pandas.DataFrame.clip_upper**

**DataFrame.clip_upper** *(threshold, axis=None, inplace=False)*

Return copy of input with values above given value(s) truncated.

Parameters

- **threshold** [float or array_like]
- **axis** : int or string axis name, optional
  - Align object with threshold along the given axis.
- **inplace** : boolean, default False
  - Whether to perform the operation in place on the data
  - New in version 0.21.0.

Returns

- **clipped** [same type as input]

See also:

- clip

**pandas.DataFrame.combine**

**DataFrame.combine** *(other, func, fill_value=None, overwrite=True)*

Add two DataFrame objects and do not propagate NaN values, so if for a (column, time) one frame is missing a value, it will default to the other frame’s value (which might be NaN as well)

Parameters

- **other** [DataFrame]
- **func** : function
Function that takes two series as inputs and return a Series or a scalar

**fill_value** [scalar value]

**overwrite** : boolean, default True

If True then overwrite values for common keys in the calling frame

**Returns**

**result** [DataFrame]

See also:

*DataFrame.combine_first* Combine two DataFrame objects and default to non-null values in frame calling the method

**Examples**

```python
>>> df1 = DataFrame({'A': [0, 0], 'B': [4, 4]})
>>> df2 = DataFrame({'A': [1, 1], 'B': [3, 3]})
>>> df1.combine(df2, lambda s1, s2: s1 if s1.sum() < s2.sum() else s2)
   A  B
0  0  3
1  0  3
```

### pandas.DataFrame.combine_first

*DataFrame*. **combine_first**(other)

Combine two DataFrame objects and default to non-null values in frame calling the method. Result index columns will be the union of the respective indexes and columns

**Parameters**

**other** [DataFrame]

**Returns**

**combined** [DataFrame]

See also:

*DataFrame.combine* Perform series-wise operation on two DataFrames using a given function

**Examples**

df1’s values prioritized, use values from df2 to fill holes:

```python
>>> df1 = pd.DataFrame([[1, np.nan]])
>>> df2 = pd.DataFrame([[3, 4]])
>>> df1.combine_first(df2)
   0  1
0  1  4.0
```
pandas.DataFrame.compound

DataFrame.compound (axis=None, skipna=None, level=None)

Return the compound percentage of the values for the requested axis

Parameters

- **axis** [{index (0), columns (1)}]
- **skipna** : boolean, default True
  Exclude NA/null values when computing the result.
- **level** : int or level name, default None
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series
- **numeric_only** : boolean, default None
  Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns

- **compounded** [Series or DataFrame (if level specified)]

pandas.DataFrame.consolidate

DataFrame.consolidate (inplace=False)

Compute NDFrame with “consolidated” internals (data of each dtype grouped together in a single ndarray).

Deprecated since version 0.20.0: Consolidate will be an internal implementation only.

pandas.DataFrame.convert_objects

DataFrame.convert_objects (convert_dates=True, convert_numeric=False, convert_timedeltas=True, copy=True)

Attempt to infer better dtype for object columns.

Deprecated since version 0.21.0.

Parameters

- **convert_dates** : boolean, default True
  If True, convert to date where possible. If ‘coerce’, force conversion, with unconvertible values becoming NaT.
- **convert_numeric** : boolean, default False
  If True, attempt to coerce to numbers (including strings), with unconvertible values becoming NaN.
- **convert_timedeltas** : boolean, default True
  If True, convert to timedelta where possible. If ‘coerce’, force conversion, with unconvertible values becoming NaT.
- **copy** : boolean, default True
  If True, return a copy even if no copy is necessary (e.g. no conversion was done).
  Note: This is meant for internal use, and should not be confused with inplace.
Returns

converted [same as input object]

See also:

pandas.to_datetime Convert argument to datetime.
pandas.to_timedelta Convert argument to timedelta.
pandas.to_numeric Return a fixed frequency timedelta index, with day as the default.

pandas.DataFrame.copy

DataFrame.copy (deep=True)
Make a copy of this object’s indices and data.

When deep=True (default), a new object will be created with a copy of the calling object’s data and indices. Modifications to the data or indices of the copy will not be reflected in the original object (see notes below).

When deep=False, a new object will be created without copying the calling object’s data or index (only references to the data and index are copied). Any changes to the data of the original will be reflected in the shallow copy (and vice versa).

Parameters deep : bool, default True
Make a deep copy, including a copy of the data and the indices. With deep=False neither the indices nor the data are copied.

Returns copy : Series, DataFrame or Panel
Object type matches caller.

Notes

When deep=True, data is copied but actual Python objects will not be copied recursively, only the reference to the object. This is in contrast to copy.deepcopy in the Standard Library, which recursively copies object data (see examples below).

While Index objects are copied when deep=True, the underlying numpy array is not copied for performance reasons. Since Index is immutable, the underlying data can be safely shared and a copy is not needed.

Examples

```python
>>> s = pd.Series([1, 2], index=["a", "b"])
>>> s
a    1
b    2
dtype: int64

>>> s_copy = s.copy()
>>> s_copy
a    1
```
(continues on next page)
Shallow copy versus default (deep) copy:

```python
>>> s = pd.Series([1, 2], index=["a", "b")
>>> deep = s.copy()
>>> shallow = s.copy(deep=False)
```

Shallow copy shares data and index with original.

```python
>>> s is shallow
False
>>> s.values is shallow.values and s.index is shallow.index
```

Deep copy has own copy of data and index.

```python
>>> s is deep
False
>>> s.values is deep.values or s.index is deep.index
False
```

Updates to the data shared by shallow copy and original is reflected in both; deep copy remains unchanged.

```python
>>> s[0] = 3
>>> shallow[1] = 4
>>> s
a 3
b 4
dtype: int64
```

```python
>>> shallow
a 3
b 4
dtype: int64
```

```python
>>> deep
a 1
b 2
dtype: int64
```

Note that when copying an object containing Python objects, a deep copy will copy the data, but will not do so recursively. Updating a nested data object will be reflected in the deep copy.

```python
>>> s = pd.Series([[1, 2], [3, 4]])
>>> deep = s.copy()
>>> s[0][0] = 10
```
pandas.DataFrame.corr

DataFrame.corr(method='pearson', min_periods=1)
Compute pairwise correlation of columns, excluding NA/null values

Parameters
method : {'pearson', 'kendall', 'spearman'}
  • pearson : standard correlation coefficient
  • kendall : Kendall Tau correlation coefficient
  • spearman : Spearman rank correlation
min_periods : int, optional
  Minimum number of observations required per pair of columns to have a valid result. Currently only available for pearson and spearman correlation

Returns
y [DataFrame]

pandas.DataFrame.corrwith

DataFrame.corrwith(other, axis=0, drop=False)
Compute pairwise correlation between rows or columns of two DataFrame objects.

Parameters
other [DataFrame, Series]
axis : {0 or ‘index’, 1 or ‘columns’}, default 0
  0 or ‘index’ to compute column-wise, 1 or ‘columns’ for row-wise
drop : boolean, default False
  Drop missing indices from result, default returns union of all

Returns
correls [Series]

pandas.DataFrame.count

DataFrame.count(axis=0, level=None, numeric_only=False)
Count non-NA cells for each column or row.

The values None, NaN, NaT, and optionally numpy.inf (depending on pandas.options.mode.use_inf_as_na) are considered NA.

Parameters
axis : {0 or ‘index’, 1 or ‘columns’}, default 0
  If 0 or ‘index’ counts are generated for each column. If 1 or ‘columns’ counts are generated for each row.
level : int or str, optional
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame. A str specifies the level name.
numeric_only : boolean, default False
Include only float, int or boolean data.

**Returns** Series or DataFrame

For each column/row the number of non-NA/null entries. If *level* is specified returns a DataFrame.

**See also:**

Series.count number of non-NA elements in a Series

DataFrame.shape number of DataFrame rows and columns (including NA elements)

DataFrame.isna boolean same-sized DataFrame showing places of NA elements

**Examples**

Constructing DataFrame from a dictionary:

```python
>>> df = pd.DataFrame({"Person":
...     ["John", "Myla", None, "John", "Myla"],
...     "Age": [24., np.nan, 21., 33, 26],
...     "Single": [False, True, True, True, False])
```

```plaintext
<table>
<thead>
<tr>
<th>Person</th>
<th>Age</th>
<th>Single</th>
</tr>
</thead>
<tbody>
<tr>
<td>John</td>
<td>24.0</td>
<td>False</td>
</tr>
<tr>
<td>Myla</td>
<td>NaN</td>
<td>True</td>
</tr>
<tr>
<td>None</td>
<td>21.0</td>
<td>True</td>
</tr>
<tr>
<td>John</td>
<td>33.0</td>
<td>True</td>
</tr>
<tr>
<td>Myla</td>
<td>26.0</td>
<td>False</td>
</tr>
</tbody>
</table>
```

Notice the uncounted NA values:

```python
>>> df.count()
Person    4
Age       4
Single    5
dtype: int64
```

Counts for each row:

```python
>>> df.count(axis='columns')
0   3
1   2
2   2
3   3
4   3
dtype: int64
```

Counts for one level of a MultiIndex:

```python
>>> df.set_index(["Person", "Single"]).count(level="Person")
<table>
<thead>
<tr>
<th>Person</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>John</td>
<td>2</td>
</tr>
<tr>
<td>Myla</td>
<td>1</td>
</tr>
</tbody>
</table>
```

1768 Chapter 34. API Reference
DataFrame.cov

Compute pairwise covariance of columns, excluding NA/null values.

Compute the pairwise covariance among the series of a DataFrame. The returned data frame is the covariance matrix of the columns of the DataFrame.

Both NA and null values are automatically excluded from the calculation. (See the note below about bias from missing values.) A threshold can be set for the minimum number of observations for each value created. Comparisons with observations below this threshold will be returned as NaN.

This method is generally used for the analysis of time series data to understand the relationship between different measures across time.

**Parameters**

- **min_periods** : int, optional
  Minimum number of observations required per pair of columns to have a valid result.

**Returns**

DataFrame

The covariance matrix of the series of the DataFrame.

See also:

- pandas.Series.cov compute covariance with another Series
- pandas.core.window.EWM.cov exponential weighted sample covariance
- pandas.core.window.Expanding.cov expanding sample covariance
- pandas.core.window.Rolling.cov rolling sample covariance

**Notes**

Returns the covariance matrix of the DataFrame’s time series. The covariance is normalized by N-1.

For DataFrames that have Series that are missing data (assuming that data is missing at random) the returned covariance matrix will be an unbiased estimate of the variance and covariance between the member Series.

However, for many applications this estimate may not be acceptable because the estimate covariance matrix is not guaranteed to be positive semi-definite. This could lead to estimate correlations having absolute values which are greater than one, and/or a non-invertible covariance matrix. See Estimation of covariance matrices for more details.

**Examples**

```python
df = pd.DataFrame([(1, 2), (0, 3), (2, 0), (1, 1)],
columns=['dogs', 'cats'])
df.cov()
```

<table>
<thead>
<tr>
<th></th>
<th>dogs</th>
<th>cats</th>
</tr>
</thead>
<tbody>
<tr>
<td>dogs</td>
<td>0.66667</td>
<td>-1.00000</td>
</tr>
<tr>
<td>cats</td>
<td>-1.00000</td>
<td>1.66667</td>
</tr>
</tbody>
</table>
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
>>> np.random.seed(42)
>>> df = pd.DataFrame(np.random.randn(1000, 5),
...                   columns=['a', 'b', 'c', 'd', 'e'])
>>> df.cov()

   a        b        c        d        e
a 0.998438 -0.020161  0.059277 -0.008943  0.014144
b -0.020161  1.059352 -0.008543 -0.024738  0.009826
c  0.059277 -0.008543  1.010670 -0.001486 -0.000271
d -0.008943 -0.024738 -0.001486  0.921297 -0.013692
e  0.014144  0.009826 -0.000271 -0.013692  0.977795
```

Minimum number of periods

This method also supports an optional `min_periods` keyword that specifies the required minimum number of non-NA observations for each column pair in order to have a valid result:

```python
>>> np.random.seed(42)
>>> df = pd.DataFrame(np.random.randn(20, 3),
...                   columns=['a', 'b', 'c'])
>>> df.loc[df.index[:5], 'a'] = np.nan
>>> df.loc[df.index[5:10], 'b'] = np.nan
>>> df.cov(min_periods=12)

   a  b   c
a 0.316741 NaN -0.150812
b NaN 1.248003  0.191417
c -0.150812  0.191417  0.895202
```

pandas.DataFrame.cummax

DataFrame.cummax(axis=None, skipna=True, *args, **kwargs)

Return cumulative maximum over a DataFrame or Series axis.

Returns a DataFrame or Series of the same size containing the cumulative maximum.

**Parameters**

- **axis**: {0 or ‘index’, 1 or ‘columns’}, default 0
  
  The index or the name of the axis. 0 is equivalent to None or ‘index’.

- **skipna**: boolean, default True
  
  Exclude NA/null values. If an entire row/column is NA, the result will be NA.

- ***args, **kwargs**:
  
  Additional keywords have no effect but might be accepted for compatibility with NumPy.

**Returns**

- **cummax**: [Series or DataFrame]

**See also:**

- **pandas.core.window.Expanding.max** Similar functionality but ignores NaN values.

- **DataFrame.max** Return the maximum over DataFrame axis.

- **DataFrame.cummax** Return cumulative maximum over DataFrame axis.

- **DataFrame.cummin** Return cumulative minimum over DataFrame axis.
**DataFrame.cumsum**  Return cumulative sum over DataFrame axis.

**DataFrame.cumprod**  Return cumulative product over DataFrame axis.

### Examples

#### Series

```python
>>> s = pd.Series([2, np.nan, 5, -1, 0])
>>> s
0    2.0
1   NaN
2    5.0
3   -1.0
4    0.0
dtype: float64
```

By default, NA values are ignored.

```python
>>> s.cummax()
0    2.0
1   NaN
2    5.0
3    5.0
4    5.0
dtype: float64
```

To include NA values in the operation, use `skipna=False`

```python
>>> s.cummax(skipna=False)
0    2.0
1   NaN
2   NaN
3   NaN
4   NaN
dtype: float64
```

#### DataFrame

```python
>>> df = pd.DataFrame([[2.0, 1.0],
...                     [3.0, np.nan],
...                     [1.0, 0.0]],
...                    columns=list('AB'))
>>> df
   A   B
0  2.0  1.0
1  3.0  NaN
2  1.0  0.0
```

By default, iterates over rows and finds the maximum in each column. This is equivalent to `axis=None` or `axis='index'`.

```python
>>> df.cummax()
   A   B
0  2.0  1.0
1  3.0  NaN
2  3.0  1.0
```
To iterate over columns and find the maximum in each row, use `axis=1`

```python
>>> df.cummax(axis=1)
   A  B
0  2.0  2.0
1  3.0  NaN
2  1.0  1.0
```

**pandas.DataFrame.cummin**

`DataFrame.cummin(axis=None, skipna=True, *args, **kwargs)`

Return cumulative minimum over a DataFrame or Series axis.

Returns a DataFrame or Series of the same size containing the cumulative minimum.

**Parameters**

- `axis`: {0 or ‘index’, 1 or ‘columns’}, default 0
  - The index or the name of the axis. 0 is equivalent to None or ‘index’.
- `skipna`: boolean, default True
  - Exclude NA/null values. If an entire row/column is NA, the result will be NA.
- `*args, **kwargs`
  - Additional keywords have no effect but might be accepted for compatibility with NumPy.

**Returns**

- `cummin` [Series or DataFrame]

**See also:**

- `pandas.core.window.Expanding.min` Similar functionality but ignores NaN values.
- `DataFrame.min` Return the minimum over DataFrame axis.
- `DataFrame.cummax` Return cumulative maximum over DataFrame axis.
- `DataFrame.cummin` Return cumulative minimum over DataFrame axis.
- `DataFrame.cumsum` Return cumulative sum over DataFrame axis.
- `DataFrame.cumprod` Return cumulative product over DataFrame axis.

**Examples**

**Series**

```python
>>> s = pd.Series([2, np.nan, 5, -1, 0])
>>> s
0   2.0
1   NaN
2   5.0
3  -1.0
4   0.0
dtype: float64
```

By default, NA values are ignored.
To include NA values in the operation, use `skipna=False`

```python
>>> s.cummin(skipna=False)
0   2.0
1   NaN
2   NaN
3   NaN
4   NaN
dtype: float64
```

**DataFrame**

```python
>>> df = pd.DataFrame([[2.0, 1.0],
...                     [3.0, np.nan],
...                     [1.0, 0.0]],
...                    columns=list('AB'))
```

By default, iterates over rows and finds the minimum in each column. This is equivalent to `axis=None` or `axis='index'`.

```python
>>> df.cummin()
   A  B
0  2.0 1.0
1  2.0 NaN
2  1.0 0.0
```

To iterate over columns and find the minimum in each row, use `axis=1`

```python
>>> df.cummin(axis=1)
   A  B
0  2.0 1.0
1  3.0 NaN
2  1.0 0.0
```

**pandas.DataFrame.cumprod**

`DataFrame.cumprod(axis=None, skipna=True, *args, **kwargs)`

Return cumulative product over a DataFrame or Series axis.

Returns a DataFrame or Series of the same size containing the cumulative product.

**Parameters**

- `axis`: {0 or ‘index’, 1 or ‘columns’}, default 0
  - The index or the name of the axis. 0 is equivalent to None or ‘index’.
skipna : boolean, default True
    Exclude NA/null values. If an entire row/column is NA, the result will be NA.

*args, **kwargs :
    Additional keywords have no effect but might be accepted for compatibility with NumPy.

Returns

cumprod  [Series or DataFrame]

See also:

pandas.core.window.Expanding.prod  Similar functionality but ignores NaN values.

DataFrame.prod  Return the product over DataFrame axis.

DataFrame.cummax  Return cumulative maximum over DataFrame axis.

DataFrame.cummin  Return cumulative minimum over DataFrame axis.

DataFrame.cumsum  Return cumulative sum over DataFrame axis.

DataFrame.cumprod  Return cumulative product over DataFrame axis.

Examples

Series

>>> s = pd.Series([2, np.nan, 5, -1, 0])

By default, NA values are ignored.

>>> s.cumprod()

To include NA values in the operation, use skipna=False

>>> s.cumprod(skipna=False)

Dataframe
>>> df = pd.DataFrame([[2.0, 1.0],
...                    [3.0, np.nan],
...                    [1.0, 0.0]],
...                    columns=list('AB'))
>>> df
   A  B
0  2.0  1.0
1  3.0   NaN
2  1.0  0.0

By default, iterates over rows and finds the product in each column. This is equivalent to axis=None or axis='index'.

>>> df.cumprod()
   A   B
0  2.0  1.0
1  6.0   NaN
2  6.0  0.0

To iterate over columns and find the product in each row, use axis=1

>>> df.cumprod(axis=1)
   A   B
0  2.0  2.0
1  3.0   NaN
2  1.0  0.0

pandas.DataFrame.cumsum

DataFrame.cumsum(axis=None, skipna=True, *args, **kwargs)
Return cumulative sum over a DataFrame or Series axis.

Returns a DataFrame or Series of the same size containing the cumulative sum.

Parameters
axis : {0 or ‘index’, 1 or ‘columns’}, default 0
The index or the name of the axis. 0 is equivalent to None or ‘index’.

skipna : boolean, default True
Exclude NA/null values. If an entire row/column is NA, the result will be NA.

*args, **kwargs :
Additional keywords have no effect but might be accepted for compatibility with NumPy.

Returns
cumsum [Series or DataFrame]

See also:

pandas.core.window.Expanding.sum Similar functionality but ignores NaN values.
DataFrame.sum Return the sum over DataFrame axis.
DataFrame.cummax Return cumulative maximum over DataFrame axis.
DataFrame.cummin Return cumulative minimum over DataFrame axis.
**DataFrame.cumsum**  Return cumulative sum over DataFrame axis.

**DataFrame.cumprod**  Return cumulative product over DataFrame axis.

### Examples

#### Series

```python
>>> s = pd.Series([2, np.nan, 5, -1, 0])
>>> s
0    2.0
1     NaN
2    5.0
3    -1.0
4     0.0
dtype: float64
```

By default, NA values are ignored.

```python
>>> s.cumsum()
0    2.0
1    NaN
2    7.0
3    6.0
4    6.0
dtype: float64
```

To include NA values in the operation, use `skipna=False`

```python
>>> s.cumsum(skipna=False)
0    2.0
1    NaN
2    NaN
3    NaN
4    NaN
dtype: float64
```

#### DataFrame

```python
>>> df = pd.DataFrame(
...     [[2.0, 1.0],
...      [3.0, np.nan],
...      [1.0, 0.0]],
...     columns=list('AB'))
>>> df
   A   B
0  2.0  1.0
1  3.0  NaN
2  1.0  0.0
```

By default, iterates over rows and finds the sum in each column. This is equivalent to `axis=None` or `axis='index'`.

```python
>>> df.cumsum()
   A   B
0  2.0  1.0
1  5.0  NaN
2  6.0  1.0
```
To iterate over columns and find the sum in each row, use `axis=1`:

```python
>>> df.cumsum(axis=1)
   A   B
0  2.0  3.0
1  3.0   NaN
2  1.0  1.0
```

### pandas.DataFrame.describe

DataFrame.describe(percentiles=None, include=None, exclude=None)

Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset’s distribution, excluding NaN values.

Analyzes both numeric and object series, as well as DataFrame column sets of mixed data types. The output will vary depending on what is provided. Refer to the notes below for more detail.

**Parameters**

- **percentiles** : list-like of numbers, optional
  The percentiles to include in the output. All should fall between 0 and 1. The default is [.25, .5, .75], which returns the 25th, 50th, and 75th percentiles.

- **include** : ‘all’, list-like of dtypes or None (default), optional
  A white list of data types to include in the result. Ignored for Series. Here are the options:
  - ‘all’ : All columns of the input will be included in the output.
  - A list-like of dtypes : Limits the results to the provided data types. To limit the result to numeric types submit numpy.number. To limit it instead to object columns submit the numpy.object data type. Strings can also be used in the style of select_dtypes (e.g. df.describe(include=[‘O’])). To select pandas categorical columns, use ‘category’
  - None (default) : The result will include all numeric columns.

- **exclude** : list-like of dtypes or None (default), optional,
  A black list of data types to omit from the result. Ignored for Series. Here are the options:
  - A list-like of dtypes : Excludes the provided data types from the result. To exclude numeric types submit numpy.number. To exclude object columns submit the data type numpy.object. Strings can also be used in the style of select_dtypes (e.g. df.describe(include=[‘O’])). To exclude pandas categorical columns, use ‘category’
  - None (default) : The result will exclude nothing.

**Returns**

- summary: Series/DataFrame of summary statistics

See also:

Dataframe.count, Dataframe.max, Dataframe.min, Dataframe.mean, Dataframe.std, Dataframe.select_dtypes
Notes

For numeric data, the result’s index will include count, mean, std, min, max as well as lower, 50 and upper percentiles. By default the lower percentile is 25 and the upper percentile is 75. The 50 percentile is the same as the median.

For object data (e.g. strings or timestamps), the result’s index will include count, unique, top, and freq. The top is the most common value. The freq is the most common value’s frequency. Timestamps also include the first and last items.

If multiple object values have the highest count, then the count and top results will be arbitrarily chosen from among those with the highest count.

For mixed data types provided via a DataFrame, the default is to return only an analysis of numeric columns. If the dataframe consists only of object and categorical data without any numeric columns, the default is to return an analysis of both the object and categorical columns. If include='all' is provided as an option, the result will include a union of attributes of each type.

The include and exclude parameters can be used to limit which columns in a DataFrame are analyzed for the output. The parameters are ignored when analyzing a Series.

Examples

Describing a numeric Series.

```python
>>> s = pd.Series([1, 2, 3])
>>> s.describe()
   count 3.0
   mean 2.0
   std  1.0
   min  1.0
  25%  1.5
  50%  2.0
  75%  2.5
   max  3.0
```

Describing a categorical Series.

```python
>>> s = pd.Series(['a', 'a', 'b', 'c'])
>>> s.describe()
   count 4
   unique 3
   top a
   freq  2
dtype: object
```

Describing a timestamp Series.

```python
>>> s = pd.Series([
...     np.datetime64("2000-01-01"),
...     np.datetime64("2010-01-01"),
...     np.datetime64("2010-01-01")
... ])
>>> s.describe()
   count 3
   unique 2
   top    2010-01-01 00:00:00
```

(continues on next page)
Describing a DataFrame. By default only numeric fields are returned.

```python
>>> df = pd.DataFrame({
    'object': ['a', 'b', 'c'],
    'numeric': [1, 2, 3],
    'categorical': pd.Categorical(['d', 'e', 'f'])
})
>>> df.describe()

<table>
<thead>
<tr>
<th></th>
<th>count</th>
<th>mean</th>
<th>std</th>
</tr>
</thead>
<tbody>
<tr>
<td>numeric</td>
<td>3.0</td>
<td>2.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>min</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25%</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>75%</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>max</td>
<td>3.0</td>
<td></td>
</tr>
</tbody>
</table>
```

Describing all columns of a DataFrame regardless of data type.

```python
>>> df.describe(include='all')

<table>
<thead>
<tr>
<th></th>
<th>count</th>
<th>unique</th>
<th>top</th>
<th>freq</th>
<th>mean</th>
<th>std</th>
<th>min</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>categoric</td>
<td>3</td>
<td>3</td>
<td>c</td>
<td>1</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>numeric</td>
<td>3.0</td>
<td>NaN</td>
<td>NaN</td>
<td>NaN</td>
<td>2.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
<td>2.5</td>
<td>3.0</td>
</tr>
</tbody>
</table>
```

Describing a column from a DataFrame by accessing it as an attribute.

```python
>>> df.numeric.describe()

<table>
<thead>
<tr>
<th></th>
<th>count</th>
<th>mean</th>
<th>std</th>
</tr>
</thead>
<tbody>
<tr>
<td>numeric</td>
<td>3.0</td>
<td>2.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>min</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25%</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>75%</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>max</td>
<td>3.0</td>
<td></td>
</tr>
</tbody>
</table>
```

Including only numeric columns in a DataFrame description.

```python
>>> df.describe(include=[np.number])

<table>
<thead>
<tr>
<th>numeric</th>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>numeric</td>
<td>3.0</td>
</tr>
</tbody>
</table>
```

(continues on next page)
Including only string columns in a DataFrame description.

```python
>>> df.describe(include=[np.object])

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>object</td>
<td></td>
<td></td>
</tr>
<tr>
<td>count</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>unique</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>top</td>
<td>c</td>
<td></td>
</tr>
<tr>
<td>freq</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
```

Including only categorical columns from a DataFrame description.

```python
>>> df.describe(include=['category'])

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>categorical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>count</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>unique</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>top</td>
<td>f</td>
<td>c</td>
</tr>
<tr>
<td>freq</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
```

Excluding numeric columns from a DataFrame description.

```python
>>> df.describe(exclude=[np.number])

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>categorical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>count</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>unique</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>top</td>
<td>f</td>
<td>c</td>
<td></td>
<td></td>
</tr>
<tr>
<td>freq</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

Excluding object columns from a DataFrame description.

```python
>>> df.describe(exclude=[np.object])

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>categorical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>numeric</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>count</td>
<td>3</td>
<td>3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>unique</td>
<td>3</td>
<td>NaN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>top</td>
<td>f</td>
<td>NaN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>freq</td>
<td>1</td>
<td>NaN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>NaN</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>std</td>
<td>NaN</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>min</td>
<td>NaN</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25%</td>
<td>NaN</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td>NaN</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75%</td>
<td>NaN</td>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>max</td>
<td>NaN</td>
<td>3.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

**pandas.DataFrame.diff**

DataFrame.diff(periods=1, axis=0)

First discrete difference of element.
Calculates the difference of a DataFrame element compared with another element in the DataFrame (default is the element in the same column of the previous row).

**Parameters**

- **periods**: int, default 1
  
  Periods to shift for calculating difference, accepts negative values.

- **axis**: {0 or 'index', 1 or 'columns'}, default 0
  
  Take difference over rows (0) or columns (1).

**Returns**

- **diffed** [DataFrame]

**See also:**

- **Series.diff** First discrete difference for a Series.
- **DataFrame.pct_change** Percent change over given number of periods.
- **DataFrame.shift** Shift index by desired number of periods with an optional time freq.

**Examples**

Difference with previous row

```python
>>> df = pd.DataFrame({'a': [1, 2, 3, 4, 5, 6],
                     'b': [1, 1, 2, 3, 5, 8],
                     'c': [1, 4, 9, 16, 25, 36]})
>>> df
   a  b  c
0  1  1  1
1  2  1  4
2  3  2  9
3  4  3 16
4  5  5 25
5  6  8 36

>>> df.diff()
   a  b  c
0  NaN NaN NaN
1  1.0 0.0 3.0
2  1.0 1.0 5.0
3  1.0 1.0 7.0
4  1.0 2.0 9.0
5  1.0 3.0 11.0
```

Difference with previous column

```python
>>> df.diff(axis=1)
   a  b  c
0  NaN NaN NaN
1  1.0 0.0 3.0
2  1.0 1.0 5.0
3  1.0 1.0 7.0
4  1.0 2.0 9.0
5  1.0 3.0 11.0
```
Difference with 3rd previous row

```python
>>> df.diff(periods=3)
   a  b  c
0  NaN NaN NaN
1  NaN NaN NaN
2  NaN NaN NaN
3  3.0 2.0 15.0
4  3.0 4.0 21.0
5  3.0 6.0 27.0
```

Difference with following row

```python
>>> df.diff(periods=-1)
   a  b  c
0  -1.0 0.0 -3.0
1  -1.0 -1.0 -5.0
2  -1.0 -1.0 -7.0
3  -1.0 -2.0 -9.0
4  -1.0 -3.0 -11.0
5  NaN NaN NaN
```

**pandas.DataFrame.div**

Dataframe.div(other, axis='columns', level=None, fill_value=None)

Floating division of dataframe and other, element-wise (binary operator truediv).

Equivalent to dataframe / other, but with support to substitute a fill_value for missing data in one of the inputs.

**Parameters**

- **other** [Series, DataFrame, or constant]
- **axis** : {0, 1, ‘index’, ‘columns’}
  - For Series input, axis to match Series index on
- **level** : int or name
  - Broadcast across a level, matching Index values on the passed MultiIndex level
- **fill_value** : None or float value, default None
  - Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing

**Returns**

- **result** [DataFrame]

See also:

- `DataFrame.rtruediv`

**Notes**

Mismatched indices will be unioned together
**Examples**

None

**pandas.DataFrame.divide**

`DataFrame.divide(other, axis='columns', level=None, fill_value=None)`

Floating division of dataframe and other, element-wise (binary operator `truediv`). Equivalent to `dataframe / other`, but with support to substitute a `fill_value` for missing data in one of the inputs.

**Parameters**

- `other` [Series, DataFrame, or constant]
- `axis` : {0, 1, ‘index’, ‘columns’}
  - For Series input, axis to match Series index on
- `level` : int or name
  - Broadcast across a level, matching Index values on the passed MultiIndex level
- `fill_value` : None or float value, default None
  - Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing

**Returns**

- `result` [DataFrame]

**See also:**

`DataFrame.rtruediv`

**Notes**

Mismatched indices will be unioned together

**Examples**

None

**pandas.DataFrame.dot**

`DataFrame.dot(other)`

Matrix multiplication with DataFrame or Series objects. Can also be called using `self @ other` in Python >= 3.5.

**Parameters**

- `other` [DataFrame or Series]

**Returns**
dot_product  [DataFrame or Series]

pandas.DataFrame.drop

DataFrame.drop(labels=None, axis=0, index=None, columns=None, level=None, inplace=False, errors='raise')
Drop specified labels from rows or columns.
Remove rows or columns by specifying label names and corresponding axis, or by specifying directly index or column names. When using a multi-index, labels on different levels can be removed by specifying the level.

Parameters labels : single label or list-like
   Index or column labels to drop.
axis : {0 or ‘index’, 1 or ‘columns’}, default 0
   Whether to drop labels from the index (0 or ‘index’) or columns (1 or ‘columns’).
index, columns : single label or list-like
   Alternative to specifying axis (labels, axis=1 is equivalent to columns=labels).
   New in version 0.21.0.
level : int or level name, optional
   For MultiIndex, level from which the labels will be removed.
inplace : bool, default False
   If True, do operation inplace and return None.
errors : {'ignore', 'raise'}, default 'raise'
   If ‘ignore’, suppress error and only existing labels are dropped.

Returns

dropped  [pandas.DataFrame]

Raises KeyError
   If none of the labels are found in the selected axis

See also:

DataFrame.loc  Label-location based indexer for selection by label.
DataFrame.dropna  Return DataFrame with labels on given axis omitted where (all or any) data are missing
DataFrame.drop_duplicates  Return DataFrame with duplicate rows removed, optionally only considering certain columns
Series.drop  Return Series with specified index labels removed.

Examples
>>> df = pd.DataFrame(np.arange(12).reshape(3,4),
...                   columns=['A', 'B', 'C', 'D'])
>>> df
   A  B  C  D
0  0  1  2  3
1  4  5  6  7
2  8  9 10 11

Drop columns

>>> df.drop(['B', 'C'], axis=1)
   A  D
0  0  3
1  4  7
2  8 11

>>> df.drop(columns=['B', 'C'])
   A  D
0  0  3
1  4  7
2  8 11

Drop a row by index

>>> df.drop([0, 1])
   A  B  C  D
2  8  9 10 11

Drop columns and/or rows of MultiIndex DataFrame

>>> midx = pd.MultiIndex(levels=[['lama', 'cow', 'falcon'],
...                            ['speed', 'weight', 'length']],
...                       labels=[[0, 0, 0, 1, 1, 1, 2, 2, 2],
...                                [0, 1, 2, 0, 1, 2, 0, 1, 2]])
>>> df = pd.DataFrame(index=midx, columns=['big', 'small'],
...                    data=[[45, 30], [200, 100], [1.5, 1], [30, 20],
...                         [250, 150], [1.5, 0.8], [320, 250],
...                         [1, 0.8], [0.3,0.2]])
>>> df
    big   small
lama   speed   45.0   30.0
        weight  200.0  100.0
        length  1.5   1.0
cow    speed   30.0   20.0
        weight  250.0  150.0
        length  1.5   0.8
falcon  speed  320.0  250.0
        weight  1.0   0.8
        length  0.3   0.2

>>> df.drop(index='cow', columns='small')
    big
lama   speed   45.0
        weight  200.0
        length  1.5
falcon  speed  320.0
(continues on next page)
weight 1.0
length 0.3

```python
>>> df.drop(index='length', level=1)
big   small
lama  speed  45.0  30.0
      weight 200.0 100.0
cow   speed  30.0  20.0
      weight 250.0 150.0
falcon speed 320.0 250.0
      weight 1.0 0.8
```

**pandas.DataFrame.drop_duplicates**

DataFrame.drop_duplicates(subset=None, keep='first', inplace=False)
Return DataFrame with duplicate rows removed, optionally only considering certain columns

**Parameters**

- **subset** : column label or sequence of labels, optional
  
  Only consider certain columns for identifying duplicates, by default use all of the columns

- **keep** : {'first', 'last', False}, default ‘first’
  
  - first : Drop duplicates except for the first occurrence.
  - last : Drop duplicates except for the last occurrence.
  - False : Drop all duplicates.

- **inplace** : boolean, default False
  
  Whether to drop duplicates in place or to return a copy

**Returns**

deduplicated [DataFrame]

**pandas.DataFrame.dropna**

DataFrame.dropna(axis=0, how='any', thresh=None, subset=None, inplace=False)
Remove missing values.

See the User Guide for more on which values are considered missing, and how to work with missing data.

**Parameters**

- **axis** : {0 or ‘index’, 1 or ‘columns’}, default 0
  
  Determine if rows or columns which contain missing values are removed.
  
  - 0, or ‘index’ : Drop rows which contain missing values.
  - 1, or ‘columns’ : Drop columns which contain missing value.

  Deprecated since version 0.23.0:: Pass tuple or list to drop on multiple axes.

- **how** : {'any', 'all'}, default ‘any’
Determine if row or column is removed from DataFrame, when we have at least one NA or all NA.

- ‘any’: If any NA values are present, drop that row or column.
- ‘all’: If all values are NA, drop that row or column.

`thresh` : int, optional

Require that many non-NA values.

`subset` : array-like, optional

Labels along other axis to consider, e.g. if you are dropping rows these would be a list of columns to include.

`inplace` : bool, default False

If True, do operation inplace and return None.

**Returns** DataFrame

DataFrame with NA entries dropped from it.

See also:

*DataFrame.isna*  Indicate missing values.

*DataFrame.notna*  Indicate existing (non-missing) values.

*DataFrame.fillna*  Replace missing values.

*Series.dropna*  Drop missing values.

*Index.dropna*  Drop missing indices.

**Examples**

```python
>>> df = pd.DataFrame({'name': ['Alfred', 'Batman', 'Catwoman'],
...                     'toy': [np.nan, 'Batmobile', 'Bullwhip'],
...                     'born': [pd.NaT, pd.Timestamp('1940-04-25'),
...                              pd.NaT]})
>>> df
        name      toy     born
0   Alfred     NaN      NaT
1  Batman  Batmobile 1940-04-25
2 Catwoman    Bullwhip      NaT

Drop the rows where at least one element is missing.

```python
>>> df.dropna()
     name      toy     born
  0   Alfred     NaN      NaT
  1  Batman  Batmobile 1940-04-25

Drop the columns where at least one element is missing.

```python
>>> df.dropna(axis='columns')
     name
  0   Alfred
  1  Batman
  2 Catwoman
```
Drop the rows where all elements are missing.

```python
>>> df.dropna(how='all')
   name  toy  born
0  Alfred  NaN  NaT
1    Batman  Batmobile  1940-04-25
2  Catwoman  Bullwhip  NaT
```

Keep only the rows with at least 2 non-NA values.

```python
>>> df.dropna(thresh=2)
   name  toy  born
1    Batman  Batmobile  1940-04-25
2  Catwoman  Bullwhip  NaT
```

Define in which columns to look for missing values.

```python
>>> df.dropna(subset=['name', 'born'])
   name  toy  born
1    Batman  Batmobile  1940-04-25
```

Keep the DataFrame with valid entries in the same variable.

```python
>>> df.dropna(inplace=True)
>>> df
   name  toy  born
1    Batman  Batmobile  1940-04-25
```

**pandas.DataFrame.duplicated**

DataFrame.duplicated(subset=None, keep='first')

Return boolean Series denoting duplicate rows, optionally only considering certain columns

**Parameters**

- **subset** : column label or sequence of labels, optional
  Only consider certain columns for identifying duplicates, by default use all of the columns
- **keep** : {'first', 'last', False}, default ‘first’
  - **first** : Mark duplicates as True except for the first occurrence.
  - **last** : Mark duplicates as True except for the last occurrence.
  - **False** : Mark all duplicates as True.

**Returns**

duplicated [Series]

**pandas.DataFrame.eq**

DataFrame.eq(other, axis='columns', level=None)

Wrapper for flexible comparison methods eq
pandas.DataFrame.equals

DataFrame.equals(other)
Determines if two NDFrame objects contain the same elements. NaNs in the same location are considered equal.

pandas.DataFrame.eval

DataFrame.eval(expr, inplace=False, **kwargs)
Evaluate a string describing operations on DataFrame columns.
Operates on columns only, not specific rows or elements. This allows eval to run arbitrary code, which can make you vulnerable to code injection if you pass user input to this function.

Parameters

expr : str
The expression string to evaluate.
inplace : bool, default False
If the expression contains an assignment, whether to perform the operation in-place and mutate the existing DataFrame. Otherwise, a new DataFrame is returned.

New in version 0.18.0.

kwargs : dict
See the documentation for eval() for complete details on the keyword arguments accepted by query().

Returns ndarray, scalar, or pandas object
The result of the evaluation.

See also:

DataFrame.query Evaluates a boolean expression to query the columns of a frame.
DataFrame.assign Can evaluate an expression or function to create new values for a column.
pandas.eval Evaluate a Python expression as a string using various backends.

Notes

For more details see the API documentation for eval(). For detailed examples see enhancing performance with eval.

Examples

```python
>>> df = pd.DataFrame({'A': range(1, 6), 'B': range(10, 0, -2)})
>>> df
   A  B
0  1  10
1  2   8
2  3   6
3  4   4
```
(continues on next page)
Assignment is allowed though by default the original DataFrame is not modified.

```python
>>> df.eval('C = A + B')
     A  B  C
0   1  10 11
1   2   8 10
2   3   6  9
3   4   4  8
4   5   2  7
```

Use `inplace=True` to modify the original DataFrame.

```python
>>> df.eval('C = A + B', inplace=True)
>>> df
     A  B  C
0   1  10 11
1   2   8 10
2   3   6  9
3   4   4  8
4   5   2  7
```

**pandas.DataFrame.ewm**

`DataFrame.ewm` has the following parameters:

- **com**: float, optional
  Specify decay in terms of center of mass, $\alpha = 1/(1 + \text{com})$, for $\text{com} \geq 0$

- **span**: float, optional
  Specify decay in terms of span, $\alpha = 2/(\text{span} + 1)$, for $\text{span} \geq 1$

- **halflife**: float, optional
  Specify decay in terms of half-life, $\alpha = 1 - \exp(\log(0.5)/\text{halflife})$, for $\text{halflife} > 0$
alpha : float, optional
    Specify smoothing factor \( \alpha \) directly, \( 0 < \alpha \leq 1 \)
    New in version 0.18.0.

min_periods : int, default 0
    Minimum number of observations in window required to have a value (otherwise result is NA).

adjust : boolean, default True
    Divide by decaying adjustment factor in beginning periods to account for imbalance in relative weightings (viewing EWMA as a moving average)

ignore_na : boolean, default False
    Ignore missing values when calculating weights; specify True to reproduce pre-0.15.0 behavior

Returns
    a Window sub-classed for the particular operation

See also:
    rolling Provides rolling window calculations
    expanding Provides expanding transformations.

Notes

Exactly one of center of mass, span, half-life, and alpha must be provided. Allowed values and relationship between the parameters are specified in the parameter descriptions above; see the link at the end of this section for a detailed explanation.

When adjust is True (default), weighted averages are calculated using weights \((1-\alpha)^{(n-1)}, (1-\alpha)^{(n-2)}, \ldots, 1-\alpha, 1\).

When adjust is False, weighted averages are calculated recursively as:

\[
\text{weighted_average}[0] = \text{arg}[0]; \quad \text{weighted_average}[i] = (1-\alpha) \times \text{weighted_average}[i-1] + \alpha \times \text{arg}[i].
\]

When ignore_na is False (default), weights are based on absolute positions. For example, the weights of \(x\) and \(y\) used in calculating the final weighted average of \([x, \text{None}, y]\) are \((1-\alpha)^2\) and \(1\) (if adjust is True), and \((1-\alpha)^2\) and \(\alpha\) (if adjust is False).

When ignore_na is True (reproducing pre-0.15.0 behavior), weights are based on relative positions. For example, the weights of \(x\) and \(y\) used in calculating the final weighted average of \([x, \text{None}, y]\) are \(1-\alpha\) and \(1\) (if adjust is True), and \(1-\alpha\) and \(\alpha\) (if adjust is False).

More details can be found at http://pandas.pydata.org/pandas-docs/stable/computation.html#exponentially-weighted-windows

Examples

```python
>>> df = DataFrame({'B': [0, 1, 2, np.nan, 4]})
   B
0  0.0
1  1.0
(continues on next page)
```
pandas: powerful Python data analysis toolkit, Release 0.23.2

(continued from previous page)

```python
>>> df.ewm(com=0.5).mean()
    B
0  0.000000
1  0.750000
2  1.615385
3  1.615385
4  3.670213
```

**pandas.DataFrame.expanding**

Dataframe `expanding` *(min_periods=1, center=False, axis=0)*

Provides expanding transformations.

New in version 0.18.0.

**Parameters**

- `min_periods`: int, default 1
  Minimum number of observations in window required to have a value (otherwise result is NA).
- `center`: boolean, default False
  Set the labels at the center of the window.
- `axis` [int or string, default 0]

**Returns**

a Window sub-classed for the particular operation

**See also:**

- `rolling` Provides rolling window calculations
- `ewm` Provides exponential weighted functions

**Notes**

By default, the result is set to the right edge of the window. This can be changed to the center of the window by setting `center=True`.

**Examples**

```python
>>> df = DataFrame({'B': [0, 1, 2, np.nan, 4]})
   B
0  0
1  1
2  2
3  NaN
4  4
```
```python
>>> df.expanding(2).sum()
   B
0  NaN
1  1.0
2  3.0
3  3.0
4  7.0
```

**pandas.DataFrame.ffill**

`DataFrame.ffill` *(axis=None, inplace=False, limit=None, downcast=None)*

Synonym for `DataFrame.fillna(method='ffill')`

**pandas.DataFrame.fillna**

`DataFrame.fillna` *(value=None, method=None, axis=None, inplace=False, limit=None, downcast=None, **kwargs)*

Fill NA/NaN values using the specified method

**Parameters**

- **value**: scalar, dict, Series, or DataFrame
  
  Value to use to fill holes (e.g. 0), alternately a dict/Series/DataFrame of values specifying which value to use for each index (for a Series) or column (for a DataFrame). (values not in the dict/Series/DataFrame will not be filled). This value cannot be a list.

- **method**: {'backfill', 'bfill', 'pad', 'ffill', None}, default None
  
  Method to use for filling holes in reindexed Series pad / ffill: propagate last valid observation forward to next valid backfill / bfill: use NEXT valid observation to fill gap

- **axis** [{0 or ‘index’, 1 or ‘columns’}]

- **inplace**: boolean, default False
  
  If True, fill in place. Note: this will modify any other views on this object, (e.g. a no-copy slice for a column in a DataFrame).

- **limit**: int, default None

  If method is specified, this is the maximum number of consecutive NaN values to forward/backward fill. In other words, if there is a gap with more than this number of consecutive NaNs, it will only be partially filled. If method is not specified, this is the maximum number of entries along the entire axis where NaNs will be filled. Must be greater than 0 if not None.

- **downcast**: dict, default is None

  a dict of item->dtype of what to downcast if possible, or the string ‘infer’ which will try to downcast to an appropriate equal type (e.g. float64 to int64 if possible)

**Returns**

- **filled** [DataFrame]

**See also:**

34.4. DataFrame
**interpolate** Fill NaN values using interpolation.

**reindex**, **asfreq**

**Examples**

```python
>>> df = pd.DataFrame([[np.nan, 2, np.nan, 0],
...                     [3, 4, np.nan, 1],
...                     [np.nan, np.nan, np.nan, 5],
...                     [np.nan, 3, np.nan, 4]],
...                     columns=list('ABCD'))
>>> df
   A     B     C     D
0 NaN   2.0   NaN   0.0
1  3.0  4.0   NaN   1.0
2  NaN  NaN  NaN   5.0
3  NaN  3.0   NaN   4.0

Replace all NaN elements with 0s.

```python
>>> df.fillna(0)
   A    B     C    D
0  0.0  2.0   0.0  0.0
1  3.0  4.0   0.0  1.0
2  0.0  0.0   0.0  5.0
3  0.0  3.0   0.0  4.0
```

We can also propagate non-null values forward or backward.

```python
>>> df.fillna(method='ffill')
   A    B     C    D
0 NaN  2.0   NaN  0.0
1  3.0  4.0   NaN  1.0
2  3.0  4.0   NaN  5.0
3  3.0  3.0   NaN  4.0
```

Replace all NaN elements in column ‘A’, ‘B’, ‘C’, and ‘D’, with 0, 1, 2, and 3 respectively.

```python
>>> values = {'A': 0, 'B': 1, 'C': 2, 'D': 3}
>>> df.fillna(value=values)
   A    B    C    D
0  0.0  2.0  2.0  0.0
1  3.0  4.0  1.0  1.0
2  0.0  1.0  2.0  5.0
3  0.0  3.0  2.0  4.0
```

Only replace the first NaN element.

```python
>>> df.fillna(value=values, limit=1)
   A    B    C    D
0  0.0  2.0  2.0  0.0
1  3.0  4.0  NaN  1.0
2  NaN  1.0  NaN  5.0
3  NaN  3.0  NaN  4.0
```
**DataFrame.filter**

```python
DataFrame.filter(items=None, like=None, regex=None, axis=None)
```

Subset rows or columns of dataframe according to labels in the specified index.

Note that this routine does not filter a dataframe on its contents. The filter is applied to the labels of the index.

**Parameters**

- **items**: list-like
  
  List of info axis to restrict to (must not all be present)
  
  - **like**: string
    
    Keep info axis where “arg in col == True”
  
  - **regex**: string (regular expression)
    
    Keep info axis with re.search(regex, col) == True
  
  - **axis**: int or string axis name
    
    The axis to filter on. By default this is the info axis, ‘index’ for Series, ‘columns’ for DataFrame

**Returns**

same type as input object

**See also:**

`pandas.DataFrame.loc`

**Notes**

The **items**, **like**, and **regex** parameters are enforced to be mutually exclusive.

**Examples**

```python
>>> df
one  two  three
mouse 1  2  3
rabbit 4  5  6

>>> # select columns by name
>>> df.filter(items=['one', 'three'])
one  three
mouse 1  3
rabbit 4  6

>>> # select columns by regular expression
>>> df.filter(regex='e$', axis=1)
one  three
mouse 1  3
rabbit 4  6
```
```python
>>> # select rows containing 'bbi'
>>> df.filter(like='bbi', axis=0)
one two three
rabbit 4 5 6
```

### pandas.DataFrame.first

`DataFrame.first(offset)`

Convenience method for subsetting initial periods of time series data based on a date offset.

**Parameters**

- `offset` [string, DateOffset, dateutil.relativedelta]

**Returns**

- `subset` [type of caller]

**Raises** `TypeError`

If the index is not a `DatetimeIndex`

**See also:**

- `last` Select final periods of time series based on a date offset
- `at_time` Select values at a particular time of the day
- `between_time` Select values between particular times of the day

**Examples**

```python
>>> i = pd.date_range('2018-04-09', periods=4, freq='2D')
>>> ts = pd.DataFrame({'A': [1,2,3,4]}, index=i)
>>> ts
   A
2018-04-09 1
2018-04-11 2
2018-04-13 3
2018-04-15 4
```

Get the rows for the first 3 days:

```python
>>> ts.first('3D')
   A
2018-04-09 1
2018-04-11 2
```

Notice the data for 3 first calender days were returned, not the first 3 days observed in the dataset, and therefore data for 2018-04-13 was not returned.

### pandas.DataFrame.first_valid_index

`DataFrame.first_valid_index()`

Return index for first non-NA/null value.
Returns

*scalar* [type of index]

Notes

If all elements are non-NA/null, returns None. Also returns None for empty NDFrame.

**pandas.DataFrame.floordiv**

*DataFrame.floordiv*(*other*, *axis='columns*', *level=None*, *fill_value=None*)

Integer division of dataframe and other, element-wise (binary operator *floordiv*).

Equivalent to *dataframe // other*, but with support to substitute a *fill_value* for missing data in one of the inputs.

**Parameters**

*other* [Series, DataFrame, or constant]

*axis* : {0, 1, ‘index’, ‘columns’}

For Series input, axis to match Series index on

*level* : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

*fill_value* : None or float value, default None

Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing

**Returns**

*result* [DataFrame]

See also:

*DataFrame.rfloordiv*

Notes

Mismatched indices will be unioned together

Examples

None

**pandas.DataFrame.from_csv**

*classmethod* *DataFrame.from_csv*(*path*, *header=0*, *sep=',', *index_col=0*, *parse_dates=True*, *encoding=None*, *tupleize_cols=None*, *infer_datetime_format=False*)

Read CSV file.
Deprecation since version 0.21.0: Use `pandas.read_csv()` instead.

It is preferable to use the more powerful `pandas.read_csv()` for most general purposes, but `from_csv` makes for an easy roundtrip to and from a file (the exact counterpart of `to_csv`), especially with a DataFrame of time series data.

This method only differs from the preferred `pandas.read_csv()` in some defaults:

- `index_col` is 0 instead of None (take first column as index by default)
- `parse_dates` is True instead of False (try parsing the index as datetime by default)

So a `pd.DataFrame.from_csv(path)` can be replaced by `pd.read_csv(path, index_col=0, parse_dates=True)`.

**Parameters**

- `path` [string file path or file handle / StringIO]
- `header` : int, default 0
  Row to use as header (skip prior rows)
- `sep` : string, default ‘,’
  Field delimiter
- `index_col` : int or sequence, default 0
  Column to use for index. If a sequence is given, a MultiIndex is used. Different default from `read_table`
- `parse_dates` : boolean, default True
  Parse dates. Different default from `read_table`
- `tupleize_cols` : boolean, default False
  Write multi_index columns as a list of tuples (if True) or new (expanded format) if False
- `infer_datetime_format` : boolean, default False
  If True and `parse_dates` is True for a column, try to infer the datetime format based on the first datetime string. If the format can be inferred, there often will be a large parsing speed-up.

**Returns**

- `y` [DataFrame]

**See also:**

- `pandas.read_csv`

### pandas.DataFrame.from_dict

**classmethod** `DataFrame.from_dict`(*data, orient='columns', dtype=None, columns=None*)

Construct DataFrame from dict of array-like or dicts.

Creates DataFrame object from dictionary by columns or by index allowing dtype specification.

**Parameters**

- `data` : dict
  Of the form `{field : array-like}` or `{field : dict}`.
orient : {'columns', 'index'}, default 'columns'

The “orientation” of the data. If the keys of the passed dict should be the columns of the resulting DataFrame, pass ‘columns’ (default). Otherwise if the keys should be rows, pass ‘index’.

dtype : dtype, default None

Data type to force, otherwise infer.

columns : list, default None

Column labels to use when orient='index'. Raises a ValueError if used with orient='columns'.

New in version 0.23.0.

Returns

pandas.DataFrame

See also:

DataFrame.from_records DataFrame from ndarray (structured dtype), list of tuples, dict, or DataFrame

DataFrame DataFrame object creation using constructor

Examples

By default the keys of the dict become the DataFrame columns:

```python
>>> data = {'col_1': [3, 2, 1, 0], 'col_2': ['a', 'b', 'c', 'd']}
>>> pd.DataFrame.from_dict(data)
   col_1 col_2
0      3    a
1      2    b
2      1    c
3      0    d
```

Specify orient='index' to create the DataFrame using dictionary keys as rows:

```python
>>> data = {'row_1': [3, 2, 1, 0], 'row_2': ['a', 'b', 'c', 'd']}
>>> pd.DataFrame.from_dict(data, orient='index')
     0  1  2  3
row_1  3  2  1  0
row_2   a  b  c  d
```

When using the ‘index’ orientation, the column names can be specified manually:

```python
>>> pd.DataFrame.from_dict(data, orient='index',
                          columns=['A', 'B', 'C', 'D'])
     A  B  C  D
row_1  3  2  1  0
row_2   a  b  c  d
```
**pandas.DataFrame.from_items**

**class method DataFrame.from_items(items, columns=None, orient='columns')**

Construct a dataframe from a list of tuples

Deprecated since version 0.23.0: from_items is deprecated and will be removed in a future version. Use DataFrame.from_dict(dict(items)) instead. DataFrame.from_dict(OrderedDict(items)) may be used to preserve the key order.

Convert (key, value) pairs to DataFrame. The keys will be the axis index (usually the columns, but depends on the specified orientation). The values should be arrays or Series.

**Parameters**
- **items**: sequence of (key, value) pairs
  - Values should be arrays or Series.
- **columns**: sequence of column labels, optional
  - Must be passed if orient='index'.
- **orient**: {'columns', 'index'}, default 'columns'
  - The “orientation” of the data. If the keys of the input correspond to column labels, pass ‘columns’ (default). Otherwise if the keys correspond to the index, pass ‘index’.

**Returns**
- **frame**: [Dataframe]

**pandas.DataFrame.from_records**

**class method DataFrame.from_records(data, index=None, exclude=None, columns=None, coerce_float=False, nrows=None)**

Convert structured or record ndarray to DataFrame

**Parameters**
- **data**: [ndarray (structured dtype), list of tuples, dict, or DataFrame]
- **index**: string, list of fields, array-like
  - Field of array to use as the index, alternately a specific set of input labels to use
- **exclude**: sequence, default None
  - Columns or fields to exclude
- **columns**: sequence, default None
  - Column names to use. If the passed data do not have names associated with them, this argument provides names for the columns. Otherwise this argument indicates the order of the columns in the result (any names not found in the data will become all-NA columns)
- **coerce_float**: boolean, default False
  - Attempt to convert values of non-string, non-numeric objects (like decimal.Decimal) to floating point, useful for SQL result sets

**Returns**
- **df**: [Dataframe]
pandas.DataFrame.ge

DataFrame.ge(other, axis='columns', level=None)
Wrapper for flexible comparison methods ge

pandas.DataFrame.get

DataFrame.get(key, default=None)
Get item from object for given key (DataFrame column, Panel slice, etc.). Returns default value if not found.

Parameters
key [object]

Returns
value [type of items contained in object]

pandas.DataFrame.get_dtype_counts

DataFrame.get_dtype_counts()
Return counts of unique dtypes in this object.

Returns dtype: Series
Series with the count of columns with each dtype.

See also:
dtypes Return the dtypes in this object.

Examples

```python
>>> a = [['a', 1, 1.0], ['b', 2, 2.0], ['c', 3, 3.0]]
>>> df = pd.DataFrame(a, columns=['str', 'int', 'float'])
>>> df
   str  int  float
0   a    1   1.0
1   b    2   2.0
2   c    3   3.0

>>> df.get_dtype_counts()
float64    1
int64      1
object     1
dtype: int64
```

pandas.DataFrame.get_ftype_counts

DataFrame.get_ftype_counts()
Return counts of unique ftypes in this object.
Deprecated since version 0.23.0.
This is useful for SparseDataFrame or for DataFrames containing sparse arrays.

**Returns**

`dtype` : Series

Series with the count of columns with each type and sparsity (dense/sparse)

**See also:**

`ftypes` Return ftypes (indication of sparse/dense and dtype) in this object.

**Examples**

```python
>>> a = [['a', 1, 1.0], ['b', 2, 2.0], ['c', 3, 3.0]]
>>> df = pd.DataFrame(a, columns=['str', 'int', 'float'])
>>> df
   str int   float
  0   a   1   1.0
  1   b   2   2.0
  2   c   3   3.0

>>> df.get_ftype_counts()
float64:dense 1
int64:dense   1
object:dense  1
dtype: int64
```

**pandas.DataFrame.get_value**

DataFrame.get_value(index, col, takeable=False)

Quickly retrieve single value at passed column and index

Deprecated since version 0.21.0: Use .at[] or .iat[] accessors instead.

**Parameters**

- `index` [row label]
- `col` [column label]
- `takeable` [interpret the index/col as indexers, default False]

**Returns**

- `value` [scalar value]

**pandas.DataFrame.get_values**

DataFrame.get_values()

Return an ndarray after converting sparse values to dense.

This is the same as .values for non-sparse data. For sparse data contained in a pandas.SparseArray, the data are first converted to a dense representation.

**Returns**

- `ndarray` Numpy representation of DataFrame

**See also:**
values  Numpy representation of DataFrame.

pandas.SparseArray  Container for sparse data.

Examples

```python
>>> df = pd.DataFrame({'a': [1, 2], 'b': [True, False], 'c': [1.0, 2.0]})
>>> df
   a   b   c
0  1  True  1.0
1  2  False  2.0

>>> df.get_values()
array([[1, True, 1.0], [2, False, 2.0]], dtype=object)

>>> df = pd.DataFrame({"a": pd.SparseArray([1, None, None]), ... "c": [1.0, 2.0, 3.0]})
>>> df
   a   c
0  1.0  1.0
1  NaN  2.0
2  NaN  3.0

>>> df.get_values()
array([[ 1., 1.], [nan, 2.], [nan, 3.]])
```

pandas.DataFrame.groupby

DataFrame.groupby(by=None, axis=0, level=None, as_index=True, sort=True, group_keys=True, squeeze=False, **kwargs)

Group series using mapper (dict or key function, apply given function to group, return result as series) or by a series of columns.

Parameters

- **by**: mapping, function, label, or list of labels
  
  Used to determine the groups for the groupby. If `by` is a function, it’s called on each value of the object’s index. If a dict or Series is passed, the Series or dict VALUES will be used to determine the groups (the Series’ values are first aligned; see `.align()` method). If an ndarray is passed, the values are used as-is determine the groups. A label or list of labels may be passed to group by the columns in `self`. Notice that a tuple is interpreted a (single) key.

- **axis**: int, default 0

- **level**: int, level name, or sequence of such, default None

  If the axis is a MultiIndex (hierarchical), group by a particular level or levels

- **as_index**: boolean, default True

  For aggregated output, return object with group labels as the index. Only relevant for DataFrame input. as_index=False is effectively “SQL-style” grouped output
sort : boolean, default True

Sort group keys. Get better performance by turning this off. Note this does not influence the order of observations within each group. groupby preserves the order of rows within each group.

group_keys : boolean, default True

When calling apply, add group keys to index to identify pieces

squeeze : boolean, default False

reduce the dimensionality of the return type if possible, otherwise return a consistent type

observed : boolean, default False

This only applies if any of the groupers are Categoricals If True: only show observed values for categorical groupers. If False: show all values for categorical groupers.

New in version 0.23.0.

Returns

GroupBy object

See also:

resample Convenience method for frequency conversion and resampling of time series.

Notes

See the user guide for more.

Examples

DataFrame results

```python
>>> data.groupby(func, axis=0).mean()
>>> data.groupby(['col1', 'col2'])['col3'].mean()
```

DataFrame with hierarchical index

```python
>>> data.groupby(['col1', 'col2']).mean()
```

pandas.DataFrame.gt

DataFrame.gt (other, axis='columns', level=None)

Wrapper for flexible comparison methods gt

pandas.DataFrame.head

DataFrame.head (n=5)

Return the first n rows.
This function returns the first $n$ rows for the object based on position. It is useful for quickly testing if your object has the right type of data in it.

**Parameters**

- **n**: int, default 5
  - Number of rows to select.

**Returns**

- **obj_head**: type of caller
  - The first $n$ rows of the caller object.

**See also:**

- `pandas.DataFrame.tail` Returns the last $n$ rows.

**Examples**

```python
>>> df = pd.DataFrame({'animal': ['alligator', 'bee', 'falcon', 'lion', ...
       'monkey', 'parrot', 'shark', 'whale', 'zebra']})

>>> df
animal
0  alligator
1    bee
2  falcon
3   lion
4  monkey
5  parrot
6    shark
7  whale
8   zebra

Viewing the first 5 lines

```python
>>> df.head()
animal
0  alligator
1    bee
2  falcon
3   lion
4  monkey
```

Viewing the first $n$ lines (three in this case)

```python
>>> df.head(3)
animal
0  alligator
1    bee
2  falcon
```

**pandas.DataFrame.hist**

Dataframe.hist(column=None, by=None, grid=True, xlabels=None, xrot=None, ylabelsize=None, yrot=None, ax=None, sharex=False, sharey=False, figsize=None, layout=None, bins=10, **kwds)

Make a histogram of the DataFrame’s.
A histogram is a representation of the distribution of data. This function calls `matplotlib.pyplot.hist()`, on each series in the DataFrame, resulting in one histogram per column.

**Parameters**

- **data** : DataFrame
  - The pandas object holding the data.

- **column** : string or sequence
  - If passed, will be used to limit data to a subset of columns.

- **by** : object, optional
  - If passed, then used to form histograms for separate groups.

- **grid** : boolean, default True
  - Whether to show axis grid lines.

- **xlabelsize** : int, default None
  - If specified changes the x-axis label size.

- **xrot** : float, default None
  - Rotation of x axis labels. For example, a value of 90 displays the x labels rotated 90 degrees clockwise.

- **ylabelsize** : int, default None
  - If specified changes the y-axis label size.

- **yrot** : float, default None
  - Rotation of y axis labels. For example, a value of 90 displays the y labels rotated 90 degrees clockwise.

- **ax** : Matplotlib axes object, default None
  - The axes to plot the histogram on.

- **sharex** : boolean, default True if ax is None else False
  - In case subplots=True, share x axis and set some x axis labels to invisible; defaults to True if ax is None otherwise False if an ax is passed in. Note that passing in both an ax and sharex=True will alter all x axis labels for all subplots in a figure.

- **sharey** : boolean, default False
  - In case subplots=True, share y axis and set some y axis labels to invisible.

- **figsize** : tuple
  - The size in inches of the figure to create. Uses the value in `matplotlib.rcParams` by default.

- **layout** : tuple, optional
  - Tuple of (rows, columns) for the layout of the histograms.

- **bins** : integer or sequence, default 10
  - Number of histogram bins to be used. If an integer is given, bins + 1 bin edges are calculated and returned. If bins is a sequence, gives bin edges, including left edge of first bin and right edge of last bin. In this case, bins is returned unmodified.

**kwds**
All other plotting keyword arguments to be passed to `matplotlib.pyplot.hist()`.

Returns

```
axes [matplotlib.AxesSubplot or numpy.ndarray of them]
```

See also:

```
matplotlib.pyplot.hist   Plot a histogram using matplotlib.
```

Examples

This example draws a histogram based on the length and width of some animals, displayed in three bins

```
>>> df = pd.DataFrame({
...     'length': [1.5, 0.5, 1.2, 0.9, 3],
...     'width': [0.7, 0.2, 0.15, 0.2, 1.1]
... }, index=['pig', 'rabbit', 'duck', 'chicken', 'horse'])
>>> hist = df.hist(bins=3)
```

`pandas.DataFrame.idxmax`

DataFrame. **idxmax**(axis=0, skipna=True)

Return index of first occurrence of maximum over requested axis. NA/null values are excluded.

Parameters

```
axis : {0 or ‘index’, 1 or ‘columns’}, default 0
```

0 or ‘index’ for row-wise, 1 or ‘columns’ for column-wise

```
skipna : boolean, default True
```

Exclude NA/null values. If an entire row/column is NA, the result will be NA.

Returns

```
idxmax [Series]
```

Raises

```
ValueError
```

• If the row/column is empty

See also:

```
Series.idxmax
```

Notes

This method is the DataFrame version of `ndarray.argmax`.

`pandas.DataFrame.idxmin`

DataFrame. **idxmin**(axis=0, skipna=True)

Return index of first occurrence of minimum over requested axis. NA/null values are excluded.

Parameters

```
axis : {0 or ‘index’, 1 or ‘columns’}, default 0
```

0 or ‘index’ for row-wise, 1 or ‘columns’ for column-wise
**skipna** : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA.

**Returns**

**idxmin** [Series]

**Raises** ValueError

- If the row/column is empty

**See also:**

*Series.idxmin*

**Notes**

This method is the DataFrame version of *ndarray.argmin*.

**pandas.DataFrame.infer_objects**

Dataframe.infer_objects()

Attempt to infer better dtypes for object columns.

Attempts soft conversion of object-dtyped columns, leaving non-object and unconvertible columns unchanged. The inference rules are the same as during normal Series/DataFrame construction.

New in version 0.21.0.

**Returns**

**converted** [same type as input object]

**See also:**

* pandas.to_datetime Convert argument to datetime.
  * pandas.to_timedelta Convert argument to timedelta.
  * pandas.to_numeric Convert argument to numeric type

**Examples**

```python
>>> df = pd.DataFrame({'A': ['a', 1, 2, 3]})
>>> df = df.iloc[1:]
>>> df
   A
1  1
2  2
3  3

>>> df.dtypes
A    object
dtype: object
```
```python
>>> df.infer_objects().dtypes
A    int64
dtype: object
```

### pandas.DataFrame.info

`DataFrame.info(verbose=None, buf=None, max_cols=None, memory_usage=None, null_counts=None)`

Print a concise summary of a DataFrame.

This method prints information about a DataFrame including the index dtype and column dtypes, non-null values and memory usage.

**Parameters**

- `verbose` : bool, optional
  Whether to print the full summary. By default, the setting in `pandas.options.display.max_info_columns` is followed.

- `buf` : writable buffer, defaults to `sys.stdout`
  Where to send the output. By default, the output is printed to `sys.stdout`. Pass a writable buffer if you need to further process the output.

- `max_cols` : int, optional
  When to switch from the verbose to the truncated output. If the DataFrame has more than `max_cols` columns, the truncated output is used. By default, the setting in `pandas.options.display.max_info_columns` is used.

- `memory_usage` : bool, str, optional
  Specifies whether total memory usage of the DataFrame elements (including the index) should be displayed. By default, this follows the `pandas.options.display.memory_usage` setting.

  - True always show memory usage. False never shows memory usage. A value of ‘deep’ is equivalent to “True with deep introspection”. Memory usage is shown in human-readable units (base-2 representation). Without deep introspection a memory estimation is made based in column dtype and number of rows assuming values consume the same memory amount for corresponding dtypes. With deep memory introspection, a real memory usage calculation is performed at the cost of computational resources.

- `null_counts` : bool, optional
  Whether to show the non-null counts. By default, this is shown only if the frame is smaller than `pandas.options.display.max_info_rows` and `pandas.options.display.max_info_columns`. A value of True always shows the counts, and False never shows the counts.

**Returns**

None

**See also:**

- `DataFrame.describe` Generate descriptive statistics of DataFrame columns.
- `DataFrame.memory_usage` Memory usage of DataFrame columns.
Examples

```python
>>> int_values = [1, 2, 3, 4, 5]
>>> text_values = ['alpha', 'beta', 'gamma', 'delta', 'epsilon']
>>> float_values = [0.0, 0.25, 0.5, 0.75, 1.0]
>>> df = pd.DataFrame({'int_col': int_values, 'text_col': text_values, ...
... 'float_col': float_values})
>>> df
          int_col text_col   float_col
0          1     alpha  0.000000
1          2      beta  0.250000
2          3     gamma  0.500000
3          4     delta  0.750000
4          5    epsilon  1.000000
```

Prints information of all columns:

```python
>>> df.info(verbose=True)
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5 entries, 0 to 4
Data columns (total 3 columns):
int_col 5 non-null int64
text_col 5 non-null object
float_col 5 non-null float64
dtypes: float64(1), int64(1), object(1)
memory usage: 200.0+ bytes
```

Prints a summary of columns count and its dtypes but not per column information:

```python
>>> df.info(verbose=False)
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5 entries, 0 to 4
Columns: 3 entries, int_col to float_col
dtypes: float64(1), int64(1), object(1)
memory usage: 200.0+ bytes
```

Pipe output of DataFrame.info to buffer instead of sys.stdout, get buffer content and writes to a text file:

```python
>>> import io
>>> buffer = io.StringIO()
>>> df.info(buf=buffer)
>>> s = buffer.getvalue()
>>> with open("df_info.txt", "w", encoding="utf-8") as f:
...     f.write(s)
... 260
```

The `memory_usage` parameter allows deep introspection mode, specially useful for big DataFrames and fine-tune memory optimization:

```python
>>> random_strings_array = np.random.choice(['a', 'b', 'c'], 10 ** 6)
>>> df = pd.DataFrame({'column_1': np.random.choice(['a', 'b', 'c'], 10 ** 6), ...
... 'column_2': np.random.choice(['a', 'b', 'c'], 10 ** 6), ...
... 'column_3': np.random.choice(['a', 'b', 'c'], 10 ** 6) ...
... })
>>> df.info()
<class 'pandas.core.frame.DataFrame'>
```

(continues on next page)
pandas.DataFrame.insert

DataFrame.insert(loc, column, value, allow_duplicates=False)

Insert column into DataFrame at specified location.

Raises a ValueError if column is already contained in the DataFrame, unless allow_duplicates is set to True.

Parameters

loc : int
    Insertion index. Must verify 0 <= loc <= len(columns)

column : string, number, or hashable object
    label of the inserted column

value [int, Series, or array-like]

allow_duplicates [bool, optional]

pandas.DataFrame.interpolate

DataFrame.interpolate(method='linear', axis=0, limit=None, inplace=False, limit_direction='forward', limit_area=None, downcast=None, **kwargs)

Interpolate values according to different methods.

Please note that only method='linear' is supported for DataFrames/Series with a MultiIndex.

Parameters

method : {'linear', 'time', 'index', 'values', 'nearest', 'zero', 'slinear', 'quadratic', 'cubic', 'barycentric', 'krogh', 'polynomial', 'spline', 'piecewise_polynomial', 'from_derivatives', 'pchip', 'akima'}
    • 'linear': ignore the index and treat the values as equally spaced. This is the only method supported on MultiIndexes. default
• ‘time’: interpolation works on daily and higher resolution data to interpolate given length of interval
• ‘index’, ‘values’: use the actual numerical values of the index
• ‘nearest’, ‘zero’, ‘slinear’, ‘quadratic’, ‘cubic’, ‘barycentric’, ‘polynomial’ is passed to scipy.interpolate.interp1d. Both ‘polynomial’ and ‘spline’ require that you also specify an order (int), e.g. df.interpolate(method='polynomial', order=4). These use the actual numerical values of the index.
• ‘krogh’, ‘piecewise_polynomial’, ‘spline’, ‘pchip’ and ‘akima’ are all wrappers around the scipy interpolation methods of similar names. These use the actual numerical values of the index. For more information on their behavior, see the scipy documentation and tutorial documentation
• ‘from_derivatives’ refers to BPoly.from_derivatives which replaces ‘piecewise_polynomial’ interpolation method in scipy 0.18

New in version 0.18.1: Added support for the ‘akima’ method Added interpolate method ‘from_derivatives’ which replaces ‘piecewise_polynomial’ in scipy 0.18; backwards-compatible with scipy < 0.18

axis : {0, 1}, default 0
• 0: fill column-by-column
• 1: fill row-by-row
limit : int, default None.
    Maximum number of consecutive NaNs to fill. Must be greater than 0.
limit_direction : [‘forward’, ‘backward’, ‘both’], default ‘forward’]
limit_area : [‘inside’, ‘outside’], default None

• None: (default) no fill restriction
• ‘inside’ Only fill NaNs surrounded by valid values (interpolate).
• ‘outside’ Only fill NaNs outside valid values (extrapolate).
If limit is specified, consecutive NaNs will be filled in this direction.
New in version 0.21.0.
inplace : bool, default False
    Update the NDFrame in place if possible.
downcast : optional, ‘infer’ or None, defaults to None
    Downcast dtypes if possible.

ekwarg s [keyword arguments to pass on to the interpolating function.]

Returns

Series or DataFrame of same shape interpolated at the NaNs

See also:

treindex, replace, fillna
Examples

Filling in NaNs

```python
>>> s = pd.Series([0, 1, np.nan, 3])
>>> s.interpolate()
0    0
1    1
2    2
3    3
dtype: float64
```

pandas.DataFrame.isin

DataFrame.isin(values)

Return boolean DataFrame showing whether each element in the DataFrame is contained in values.

Parameters values : iterable, Series, DataFrame or dictionary

The result will only be true at a location if all the labels match. If values is a Series, that’s the index. If values is a dictionary, the keys must be the column names, which must match. If values is a DataFrame, then both the index and column labels must match.

Returns

DataFrame of booleans

Examples

When values is a list:

```python
>>> df = pd.DataFrame({'A': [1, 2, 3], 'B': ['a', 'b', 'f']})
>>> df.isin([1, 3, 12, 'a'])
   A  B
0  True  True
1  False False
2  True  False
```

When values is a dict:

```python
>>> df = pd.DataFrame({'A': [1, 2, 3], 'B': [1, 4, 7]})
>>> df.isin({'A': [1, 3], 'B': [4, 7, 12]})
   A  B
0  True  True # Note that B didn't match the 1 here.
1  False  True
2  True  True
```

When values is a Series or DataFrame:

```python
>>> df = pd.DataFrame({'A': [1, 2, 3], 'B': ['a', 'b', 'f']})
>>> other = DataFrame({'A': [1, 3, 2], 'B': ['e', 'f', 'g']})
>>> df.isin(other)
   A  B
0  True  False
```

(continues on next page)
pandas.DataFrame.isna

DataFrame.isna()

Detect missing values.

Return a boolean same-sized object indicating if the values are NA. NA values, such as None or numpy.NaN, gets mapped to True values. Everything else gets mapped to False values. Characters such as empty strings '' or numpy.inf are not considered NA values (unless you set pandas.options.mode.use_inf_as_na = True).

Returns DataFrame

Mask of bool values for each element in DataFrame that indicates whether an element is not an NA value.

See also:

DataFrame.isnull alias of isna

DataFrame.notna boolean inverse of isna

DataFrame.dropna omit axes labels with missing values

isna top-level isna

Examples

Show which entries in a DataFrame are NA.

```python
>>> df = pd.DataFrame({'age': [5, 6, np.NaN],
...                     'born': [pd.NaT, pd.Timestamp('1939-05-27'),
...                               pd.Timestamp('1940-04-25')],
...                     'name': ['Alfred', 'Batman', ''],
...                     'toy': [None, 'Batmobile', 'Joker']})

>>> df
    age  born  name  toy
0     5.0  NaT  Alfred  None
1     6.0 1939-05-27  Batman  Batmobile
2   NaN  1940-04-25    Joker

>>> df.isna()
     age  born  name  toy
0   False  True  False  True
1   False  False  False  False
2   True  False  False  False
```

Show which entries in a Series are NA.

```python
>>> ser = pd.Series([5, 6, np.NaN])

>>> ser
0  5.0
1  6.0
```

(continues on next page)
pandas.DataFrame.isnull

DataFrame.isnull()
Detect missing values.

Return a boolean same-sized object indicating if the values are NA. NA values, such as None or numpy.NaN, gets mapped to True values. Everything else gets mapped to False values. Characters such as empty strings '' or numpy.inf are not considered NA values (unless you set pandas.options.mode.use_inf_as_na = True).

Returns DataFrame
Mask of bool values for each element in DataFrame that indicates whether an element is not an NA value.

See also:

DataFrame.isnull alias of isna
DataFrame.notna boolean inverse of isna
DataFrame.dropna omit axes labels with missing values
isna top-level isna

Examples

Show which entries in a DataFrame are NA.

>>> df = pd.DataFrame({'age': [5, 6, np.nan],
... 'born': [pd.NaT, pd.Timestamp('1939-05-27'),
... pd.Timestamp('1940-04-25')],
... 'name': ['Alfred', 'Batman', ''],
... 'toy': [None, 'Batmobile', 'Joker']})

>>> df
   age   born      name    toy
0  5.0  NaT  Alfred    None
1  6.0 1939-05-27  Batman  Batmobile
2  NaN 1940-04-25   Joker    None

>>> df.isna()
   age   born      name    toy
0 False  True  False   True
1 False  False  False   False
2 False  False  False   False

34.4. DataFrame 1815
Show which entries in a Series are NA.

```python
>>> ser = pd.Series([5, 6, np.NaN])
>>> ser
0   5.0
1   6.0
2   NaN
dtype: float64

>>> ser.isna()
0   False
1   False
2   True
dtype: bool
```

**pandas.DataFrame.items**

DataFrame.items()

Iterator over (column name, Series) pairs.

See also:

- **iterrows** Iterate over DataFrame rows as (index, Series) pairs.
- **itertuples** Iterate over DataFrame rows as namedtuples of the values.

**pandas.DataFrame.iteritems**

DataFrame.iteritems()

Iterator over (column name, Series) pairs.

See also:

- **iterrows** Iterate over DataFrame rows as (index, Series) pairs.
- **itertuples** Iterate over DataFrame rows as namedtuples of the values.

**pandas.DataFrame.iterrows**

DataFrame.iterrows()

Iterate over DataFrame rows as (index, Series) pairs.

Returns it : generator

A generator that iterates over the rows of the frame.

See also:

- **itertuples** Iterate over DataFrame rows as namedtuples of the values.
- **iteritems** Iterate over (column name, Series) pairs.
Notes

1. Because `iterrows` returns a Series for each row, it does **not** preserve dtypes across the rows (dtypes are preserved across columns for DataFrames). For example,

```python
>>> df = pd.DataFrame([[1, 1.5]], columns=['int', 'float'])
>>> row = next(df.iterrows())[1]
>>> row
int  1.0
float 1.5
Name: 0, dtype: float64
>>> print(row['int'].dtype)
float64
>>> print(df['int'].dtype)
int64
```

To preserve dtypes while iterating over the rows, it is better to use `itertuples()` which returns namedtuples of the values and which is generally faster than `iterrows`.

2. You should **never modify** something you are iterating over. This is not guaranteed to work in all cases. Depending on the data types, the iterator returns a copy and not a view, and writing to it will have no effect.

**pandas.DataFrame.itertuples**

DataFrame.**itertuples**(index=True, name='Pandas')

Iterate over DataFrame rows as namedtuples, with index value as first element of the tuple.

**Parameters**

- **index**: boolean, default True
  
  If True, return the index as the first element of the tuple.

- **name**: string, default “Pandas”
  
  The name of the returned namedtuples or None to return regular tuples.

**See also:**

- `iterrows` Iterate over DataFrame rows as (index, Series) pairs.
- `iteritems` Iterate over (column name, Series) pairs.

**Notes**

The column names will be renamed to positional names if they are invalid Python identifiers, repeated, or start with an underscore. With a large number of columns (>255), regular tuples are returned.

**Examples**

```python
>>> df = pd.DataFrame({'col1': [1, 2], 'col2': [0.1, 0.2]},
                   index=['a', 'b'])
>>> df
 a  col1  col2
0  1    1.0  0.1
1  2    2.0  0.2
```

(continues on next page)
pandas.DataFrame.join

DataFrame.join(other, on=None, how='left', lsuffix='__', rsuffix='__', sort=False)

Join columns with other DataFrame either on index or on a key column. Efficiently Join multiple DataFrame objects by index at once by passing a list.

Parameters other : DataFrame, Series with name field set, or list of DataFrame

Index should be similar to one of the columns in this one. If a Series is passed, its name attribute must be set, and that will be used as the column name in the resulting joined DataFrame

on : name, tuple/list of names, or array-like

Column or index level name(s) in the caller to join on the index in other, otherwise joins index-on-index. If multiple values given, the other DataFrame must have a MultiIndex. Can pass an array as the join key if it is not already contained in the calling DataFrame. Like an Excel VLOOKUP operation

how : {'left', 'right', 'outer', 'inner'}, default: 'left'

How to handle the operation of the two objects.

• left: use calling frame’s index (or column if on is specified)
• right: use other frame’s index
• outer: form union of calling frame’s index (or column if on is specified) with other frame’s index, and sort it lexicographically
• inner: form intersection of calling frame’s index (or column if on is specified) with other frame’s index, preserving the order of the calling’s one

lsuffix : string

Suffix to use from left frame’s overlapping columns

rsuffix : string

Suffix to use from right frame’s overlapping columns

sort : boolean, default False

Order result DataFrame lexicographically by the join key. If False, the order of the join key depends on the join type (how keyword)

Returns

joined [DataFrame]

See also:

DataFrame.merge For column(s)-on-column(s) operations
Notes

on, lsuffix, and rsuffix options are not supported when passing a list of DataFrame objects
Support for specifying index levels as the on parameter was added in version 0.23.0

Examples

```python
>>> caller = pd.DataFrame({'key': ['K0', 'K1', 'K2', 'K3', 'K4', 'K5'],
... 'A': ['A0', 'A1', 'A2', 'A3', 'A4', 'A5']})
```

```text
A key
0 A0 K0
1 A1 K1
2 A2 K2
3 A3 K3
4 A4 K4
5 A5 K5
```

```python
>>> other = pd.DataFrame({'key': ['K0', 'K1', 'K2'],
... 'B': ['B0', 'B1', 'B2']})
```

```text
B key
0 B0 K0
1 B1 K1
2 B2 K2
```

Join DataFrames using their indexes.

```python
>>> caller.join(other, lsuffix='_caller', rsuffix='_other')
```

```text
A key_caller B key_other
0 A0 K0 B0 K0
1 A1 K1 B1 K1
2 A2 K2 B2 K2
3 A3 NaN NaN
4 A4 NaN NaN
5 A5 NaN NaN
```

If we want to join using the key columns, we need to set key to be the index in both caller and other. The joined DataFrame will have key as its index.

```python
>>> caller.set_index('key').join(other.set_index('key'))
```

```text
A B
key
K0 A0 B0
K1 A1 B1
K2 A2 B2
K3 A3 NaN
K4 A4 NaN
K5 A5 NaN
```
Another option to join using the key columns is to use the on parameter. DataFrame.join always uses other’s index but we can use any column in the caller. This method preserves the original caller’s index in the result.

```python
>>> caller.join(other.set_index('key'), on='key')
```

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>key</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>A0</td>
<td>K0</td>
<td>B0</td>
</tr>
<tr>
<td>1</td>
<td>A1</td>
<td>K1</td>
<td>B1</td>
</tr>
<tr>
<td>2</td>
<td>A2</td>
<td>K2</td>
<td>B2</td>
</tr>
<tr>
<td>3</td>
<td>A3</td>
<td>K3</td>
<td>NaN</td>
</tr>
<tr>
<td>4</td>
<td>A4</td>
<td>K4</td>
<td>NaN</td>
</tr>
<tr>
<td>5</td>
<td>A5</td>
<td>K5</td>
<td>NaN</td>
</tr>
</tbody>
</table>

**pandas.DataFrame.keys**

*DataFrame.keys()*

Get the ‘info axis’ (see Indexing for more)

This is index for Series, columns for DataFrame and major_axis for Panel.

**pandas.DataFrame.kurt**

*DataFrame.kurt((axis=None, skipna=None, level=None, numeric_only=None, **kwargs))*

Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0). Normalized by N-1

**Parameters**

- `axis` ([index (0), columns (1)])
- `skipna` : boolean, default True
  - Exclude NA/null values when computing the result.
- `level` : int or level name, default None
  - If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series
- `numeric_only` : boolean, default None
  - Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

- `kurt` [Series or DataFrame (if level specified)]

**pandas.DataFrame.kurtosis**

*DataFrame.kurtosis((axis=None, skipna=None, level=None, numeric_only=None, **kwargs))*

Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0). Normalized by N-1

**Parameters**

- `axis` ([index (0), columns (1)])
skipna : boolean, default True
    Exclude NA/null values when computing the result.

level : int or level name, default None
    If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing
    into a Series

numeric_only : boolean, default None
    Include only float, int, boolean columns. If None, will attempt to use everything,
    then use only numeric data. Not implemented for Series.

Returns

kurt [Series or DataFrame (if level specified)]

pandas.DataFrame.last

DataFrame .last (offset)
    Convenience method for subsetting final periods of time series data based on a date offset.

Parameters

offset [string, DateOffset, dateutil.relativedelta]

Returns

subset [type of caller]

Raises TypeError
    If the index is not a DatetimeIndex

See also:

first Select initial periods of time series based on a date offset

at_time Select values at a particular time of the day

between_time Select values between particular times of the day

Examples

```python
>>> i = pd.date_range('2018-04-09', periods=4, freq='2D')
>>> ts = pd.DataFrame({'A': [1,2,3,4]}, index=i)
>>> ts
   A
2018-04-09  1
2018-04-11  2
2018-04-13  3
2018-04-15  4
```

Get the rows for the last 3 days:

```python
>>> ts.last('3D')
   A
2018-04-13  3
2018-04-15  4
```
Notice the data for 3 last calendar days were returned, not the last 3 observed days in the dataset, and therefore data for 2018-04-11 was not returned.

```python
pandas.DataFrame.last_valid_index

DataFrame.last_valid_index()
Return index for last non-NA/null value.

Returns
scalar [type of index]
```

**Notes**

If all elements are non-NA/null, returns None. Also returns None for empty NDFrame.

```python
pandas.DataFrame.le

DataFrame.le(other, axis='columns', level=None)
Wrapper for flexible comparison methods le
```

```python
pandas.DataFrame.lookup

DataFrame.lookup(row_labels, col_labels)
Label-based “fancy indexing” function for DataFrame. Given equal-length arrays of row and column labels, return an array of the values corresponding to each (row, col) pair.

Parameters

- **row_labels**: sequence
  The row labels to use for lookup

- **col_labels**: sequence
  The column labels to use for lookup

Notes

Akin to:

```python
result = []
for row, col in zip(row_labels, col_labels):
    result.append(df.get_value(row, col))
```

**Examples**

values [ndarray] The found values
pandas.DataFrame.lt

DataFrame.lt(others, axis='columns', level=None)
Wrapper for flexible comparison methods lt

pandas.DataFrame.mad

DataFrame.mad(axis=None, skipna=None, level=None)
Return the mean absolute deviation of the values for the requested axis

Parameters

axis [{index (0), columns (1)}]
skipna : boolean, default True
Exclude NA/null values when computing the result.
level : int or level name, default None
If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series
numeric_only : boolean, default None
Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns

mad [Series or DataFrame (if level specified)]

pandas.DataFrame.mask

DataFrame.mask(condition, other=nan, inplace=False, axis=None, level=None, errors='raise', try_cast=False, raise_on_error=None)
Return an object of same shape as self and whose corresponding entries are from self where cond is False and otherwise are from other.

Parameters cond : boolean NDFrame, array-like, or callable
Where cond is False, keep the original value. Where True, replace with corresponding value from other. If cond is callable, it is computed on the NDFrame and should return boolean NDFrame or array. The callable must not change input NDFrame (though pandas doesn’t check it).

New in version 0.18.1: A callable can be used as cond.

other : scalar, NDFrame, or callable
Entries where cond is True are replaced with corresponding value from other. If other is callable, it is computed on the NDFrame and should return scalar or NDFrame. The callable must not change input NDFrame (though pandas doesn’t check it).

New in version 0.18.1: A callable can be used as other.

inplace : boolean, default False
Whether to perform the operation in place on the data
axis  [alignment axis if needed, default None]
level  [alignment level if needed, default None]

errors : str, {'raise', 'ignore'}, default ‘raise’
  • raise : allow exceptions to be raised
  • ignore : suppress exceptions. On error return original object

Note that currently this parameter won’t affect the results and will always coerce to a suitable dtype.

try_cast : boolean, default False
  try to cast the result back to the input type (if possible),

raise_on_error : boolean, default True
  Whether to raise on invalid data types (e.g. trying to where on strings)

Deprecated since version 0.21.0.

Returns
wh [same type as caller]

See also:

DataFrame.where()

Notes

The mask method is an application of the if-then idiom. For each element in the calling DataFrame, if cond is False the element is used; otherwise the corresponding element from the DataFrame other is used.

The signature for DataFrame.where() differs from numpy.where(). Roughly df1.where(m, df2) is equivalent to np.where(m, df1, df2).

For further details and examples see the mask documentation in indexing.

Examples

```python
>>> s = pd.Series(range(5))
>>> s.where(s > 0)
0    NaN
1    1.0
2    2.0
3    3.0
4    4.0
```

```python
>>> s.mask(s > 0)
0    0.0
1    NaN
2    NaN
3    NaN
4    NaN
```
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
>>> s.where(s > 1, 10)
0    10.0
1    10.0
2     2.0
3     3.0
4     4.0
Name: 0, dtype: float64
```  
```python
>>> df = pd.DataFrame(np.arange(10).reshape(-1, 2), columns=['A', 'B'])
>>> m = df % 3 == 0
>>> df.where(m, -df)
   A  B
0  0  -1
1  1   3
2  2  -5
3  3  -7
4  4   9
```  
```python
>>> df.where(m, -df) == np.where(m, df, -df)
   A   B
0 True True
1 True True
2 True True
3 True True
4 True True
```  
```python
>>> df.where(m, -df) == df.mask(~m, -df)
   A   B
0 True True
1 True True
2 True True
3 True True
4 True True
```  
```python
pandas.DataFrame.max
```

DataFrame.max (axis=None, skipna=None, level=None, numeric_only=None, **kwars)

This method returns the maximum of the values in the object. If you want the index of the maximum, use idxmax. This is the equivalent of the numpy.ndarray method argmax.

Parameters

- **axis** [{index (0), columns (1)}]
- **skipna** : boolean, default True
  Exclude NA/null values when computing the result.
- **level** : int or level name, default None
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series
- **numeric_only** : boolean, default None
  Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns

- **max** [Series or DataFrame (if level specified)]

34.4. DataFrame 1825
**pandas.DataFrame.mean**

**DataFrame.mean**(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)

Return the mean of the values for the requested axis

**Parameters**
- **axis** [{index (0), columns (1)}]
- **skipna**: boolean, default True
  Exclude NA/null values when computing the result.
- **level**: int or level name, default None
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series
- **numeric_only**: boolean, default None
  Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**
- **mean** [Series or DataFrame (if level specified)]

**pandas.DataFrame.median**

**DataFrame.median**(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)

Return the median of the values for the requested axis

**Parameters**
- **axis** [{index (0), columns (1)}]
- **skipna**: boolean, default True
  Exclude NA/null values when computing the result.
- **level**: int or level name, default None
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series
- **numeric_only**: boolean, default None
  Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**
- **median** [Series or DataFrame (if level specified)]

**pandas.DataFrame.melt**

**DataFrame.melt**(id_vars=None, value_vars=None, var_name=None, value_name='value', col_level=None)

“Unpivots” a DataFrame from wide format to long format, optionally leaving identifier variables set.
This function is useful to massage a DataFrame into a format where one or more columns are identifier variables (id_vars), while all other columns, considered measured variables (value_vars), are “unpivoted” to the row axis, leaving just two non-identifier columns, ‘variable’ and ‘value’.

New in version 0.20.0.

**Parameters**

- **frame** [DataFrame]
  - **id_vars**: tuple, list, or ndarray, optional
    - Column(s) to use as identifier variables.
  - **value_vars**: tuple, list, or ndarray, optional
    - Column(s) to unpivot. If not specified, uses all columns that are not set as id_vars.
  - **var_name**: scalar
    - Name to use for the ‘variable’ column. If None it uses frame.columns.name or ‘variable’.
  - **value_name**: scalar, default ‘value’
    - Name to use for the ‘value’ column.
  - **col_level**: int or string, optional
    - If columns are a MultiIndex then use this level to melt.

**See also:**

melt, pivot_table, DataFrame.pivot

**Examples**

```python
>>> import pandas as pd
>>> df = pd.DataFrame({
    'A': {0: 'a', 1: 'b', 2: 'c'},
    'B': {0: 1, 1: 3, 2: 5},
    'C': {0: 2, 1: 4, 2: 6}
})
```

```python
>>> df
   A  B  C
0  a  1  2
1  b  3  4
2  c  5  6
```

```python
>>> df.melt(id_vars=['A'], value_vars=['B'])
   A  variable  value
0  a            B  1
1  b            B  3
2  c            B  5
```

```python
>>> df.melt(id_vars=['A'], value_vars=['B', 'C'])
   A  variable  value
0  a            B  1
1  b            B  3
2  c            B  5
3  a            C  2
4  b            C  4
5  c            C  6
```
The names of ‘variable’ and ‘value’ columns can be customized:

```python
>>> df.melt(id_vars=['A'], value_vars=['B'],
   ... var_name='myVarname', value_name='myValname')
   A   myVarname   myValname
0  a          B       1
1  b          B       3
2  c          B       5
```

If you have multi-index columns:

```python
>>> df.columns = [list('ABC'), list('DEF')]
>>> df
   A   B   C
0  a  1   2
1  b  3   4
2  c  5   6

>>> df.melt(col_level=0, id_vars=['A'], value_vars=['B'])
   A   variable   value
0  a     B       1
1  b     B       3
2  c     B       5

>>> df.melt(id_vars=[('A', 'D')], value_vars=[('B', 'E')])
   (A, D)   variable_0   variable_1   value
0  a       B         E           1
1  b       B         E           3
2  c       B         E           5
```

**pandas.DataFrame.memory_usage**

DataFrame.memory_usage(index=True, deep=False)

Return the memory usage of each column in bytes.

The memory usage can optionally include the contribution of the index and elements of object dtype.

This value is displayed in DataFrame.info by default. This can be suppressed by setting pandas.options.display.memory_usage to False.

Parameters index : bool, default True

Specifies whether to include the memory usage of the DataFrame’s index in returned Series. If index=True the memory usage of the index the first item in the output.

deep : bool, default False

If True, introspect the data deeply by interrogating object dtypes for system-level memory consumption, and include it in the returned values.

Returns sizes : Series

A Series whose index is the original column names and whose values is the memory usage of each column in bytes.
**numpy.ndarray.nbytes**  Total bytes consumed by the elements of an ndarray.

**Series.memory_usage**  Bytes consumed by a Series.

**pandas.Categorical**  Memory-efficient array for string values with many repeated values.

**DataFrame.info**  Concise summary of a DataFrame.

### Examples

```python
>>> dtypes = ['int64', 'float64', 'complex128', 'object', 'bool']
>>> data = dict((t, np.ones(shape=5000).astype(t))
... for t in dtypes)
>>> df = pd.DataFrame(data)
>>> df.head()
int64  float64  complex128  object  bool
0  1  1.0  (1+0j)  1  True
1  1  1.0  (1+0j)  1  True
2  1  1.0  (1+0j)  1  True
3  1  1.0  (1+0j)  1  True
4  1  1.0  (1+0j)  1  True
```

```python
>>> df.memory_usage()
Index  80
int64  40000
float64  40000
complex128  80000
object  40000
bool  5000
dtype: int64
```

```python
>>> df.memory_usage(index=False)
int64  40000
float64  40000
complex128  80000
object  40000
bool  5000
dtype: int64
```

The memory footprint of `object` dtype columns is ignored by default:

```python
>>> df.memory_usage(deep=True)
Index  80
int64  40000
float64  40000
complex128  80000
object  160000
bool  5000
dtype: int64
```

Use a Categorical for efficient storage of an object-dtype column with many repeated values.

```python
>>> df['object'].astype('category').memory_usage(deep=True)
5168
```
**pandas.DataFrame.merge**

`DataFrame.merge(right, how='inner', on=None, left_on=None, right_on=None, left_index=False, right_index=False, sort=False, suffixes=('_x', '_y'), copy=True, indicator=False, validate=None)`

Merge DataFrame objects by performing a database-style join operation by columns or indexes.

If joining columns on columns, the DataFrame indexes will be ignored. Otherwise if joining indexes on indexes or indexes on a column or columns, the index will be passed on.

**Parameters**

- **right** [DataFrame]
- **how** : {'left', 'right', 'outer', 'inner'}, default 'inner'
  - left: use only keys from left frame, similar to a SQL left outer join; preserve key order
  - right: use only keys from right frame, similar to a SQL right outer join; preserve key order
  - outer: use union of keys from both frames, similar to a SQL full outer join; sort keys lexicographically
  - inner: use intersection of keys from both frames, similar to a SQL inner join; preserve the order of the left keys
- **on** : label or list
  - Column or index level names to join on. These must be found in both DataFrames. If on is None and not merging on indexes then this defaults to the intersection of the columns in both DataFrames.
- **left_on** : label or list, or array-like
  - Column or index level names to join on in the left DataFrame. Can also be an array or list of arrays of the length of the left DataFrame. These arrays are treated as if they are columns.
- **right_on** : label or list, or array-like
  - Column or index level names to join on in the right DataFrame. Can also be an array or list of arrays of the length of the right DataFrame. These arrays are treated as if they are columns.
- **left_index** : boolean, default False
  - Use the index from the left DataFrame as the join key(s). If it is a MultiIndex, the number of keys in the other DataFrame (either the index or a number of columns) must match the number of levels
- **right_index** : boolean, default False
  - Use the index from the right DataFrame as the join key. Same caveats as left_index
- **sort** : boolean, default False
  - Sort the join keys lexicographically in the result DataFrame. If False, the order of the join keys depends on the join type (how keyword)
- **suffixes** : 2-length sequence (tuple, list, ...)  
  - Suffix to apply to overlapping column names in the left and right side, respectively
copy : boolean, default True
    If False, do not copy data unnecessarily

indicator : boolean or string, default False
    If True, adds a column to output DataFrame called “_merge” with information on the source of each row. If string, column with information on source of each row will be added to output DataFrame, and column will be named value of string. Information column is Categorical-type and takes on a value of “left_only” for observations whose merge key only appears in ‘left’ DataFrame, “right_only” for observations whose merge key only appears in ‘right’ DataFrame, and “both” if the observation’s merge key is found in both.

validate : string, default None
    If specified, checks if merge is of specified type.
    • “one_to_one” or “1:1”: check if merge keys are unique in both left and right datasets.
    • “one_to_many” or “1:m”: check if merge keys are unique in left dataset.
    • “many_to_one” or “m:1”: check if merge keys are unique in right dataset.
    • “many_to_many” or “m:m”: allowed, but does not result in checks.

    New in version 0.21.0.

Returns merged : DataFrame
    The output type will the be same as ‘left’, if it is a subclass of DataFrame.

See also:
merge_ordered, merge_asof, DataFrame.join

Notes

Support for specifying index levels as the on, left_on, and right_on parameters was added in version 0.23.0

Examples

```
>>> A
       lkey value
0       foo    1
1       bar    2
2       baz    3
3       foo    4

>>> B
       rkey value
0       foo    5
1       bar    6
2       qux    7

>>> A.merge(B, left_on='lkey', right_on='rkey', how='outer')
       lkey value_x   rkey value_y
0       foo        1       foo        5
1       foo        4       foo        5
2       bar        2       bar        6
3       bar        2       bar        8
4       baz        3       NaN        NaN
5       NaN        NaN       qux        7
```
pandas.DataFrame.min

**DataFrame.min** (axis=None, skipna=None, level=None, numeric_only=None, **kwargs)

This method returns the minimum of the values in the object. If you want the index of the minimum, use *idxmin*. This is the equivalent of the `numpy.ndarray` method `argmin`.

**Parameters**

- **axis**: [{index (0), columns (1)}]
- **skipna**: boolean, default True
  
  Exclude NA/null values when computing the result.
- **level**: int or level name, default None
  
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series
- **numeric_only**: boolean, default None
  
  Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

- **min**: [Series or DataFrame (if level specified)]

pandas.DataFrame.mod

**DataFrame.mod** (other, axis=’columns’, level=None, fill_value=None)

Modulo of dataframe and other, element-wise (binary operator `mod`).

Equivalent to `dataframe % other`, but with support to substitute a fill_value for missing data in one of the inputs.

**Parameters**

- **other**: [Series, DataFrame, or constant]
- **axis**: {0, 1, ‘index’, ‘columns’}
  
  For Series input, axis to match Series index on
- **level**: int or name
  
  Broadcast across a level, matching Index values on the passed MultiIndex level
- **fill_value**: None or float value, default None
  
  Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing

**Returns**

- **result**: [DataFrame]

See also:

- `DataFrame.rmod`
Notes

Mismatched indices will be unioned together

Examples

None

pandas.DataFrame.mode

**DataFrame.mode**(axis=0, numeric_only=False)

Gets the mode(s) of each element along the axis selected. Adds a row for each mode per label, fills in gaps with nan.

Note that there could be multiple values returned for the selected axis (when more than one item share the maximum frequency), which is the reason why a dataframe is returned. If you want to impute missing values with the mode in a dataframe `df`, you can just do this: `df.fillna(df.mode().iloc[0])`

**Parameters**

- **axis**: {0 or ‘index’, 1 or ‘columns’}, default 0
  - 0 or ‘index’: get mode of each column
  - 1 or ‘columns’: get mode of each row
- **numeric_only**: boolean, default False
  - if True, only apply to numeric columns

**Returns**

- **modes** [DataFrame (sorted)]

**Examples**

```python
>>> df = pd.DataFrame({'A': [1, 2, 1, 2, 1, 2, 3]})
>>> df.mode()
   A
0  1
1  2
```

pandas.DataFrame.mul

**DataFrame.mul**(other, axis=’columns’, level=None, fill_value=None)

Multiplication of dataframe and other, element-wise (binary operator `*`).

Equivalent to `dataframe * other`, but with support to substitute a fill_value for missing data in one of the inputs.

**Parameters**

- **other** [Series, DataFrame, or constant]
- **axis** : {0, 1, ‘index’, ‘columns’}
  - For Series input, axis to match Series index on
level : int or name
    Broadcast across a level, matching Index values on the passed MultiIndex level

fill_value : None or float value, default None
    Fill existing missing (NaN) values, and any new element needed for successful
    DataFrame alignment, with this value before computation. If data in both corre-
    sponding DataFrame locations is missing the result will be missing

Returns
    result [DataFrame]

See also:
    DataFrame.rmul

Notes

Mismatched indices will be unioned together

Examples

None

pandas.DataFrame.multiply

DataFrame.multiply(other, axis='columns', level=None, fill_value=None)
    Multiplication of dataframe and other, element-wise (binary operator mul).
    Equivalent to dataframe * other, but with support to substitute a fill_value for missing data in one
    of the inputs.

Parameters
    other [Series, DataFrame, or constant]
    axis : {0, 1, ‘index’, ‘columns’}
        For Series input, axis to match Series index on
    level : int or name
        Broadcast across a level, matching Index values on the passed MultiIndex level
    fill_value : None or float value, default None
        Fill existing missing (NaN) values, and any new element needed for successful
        DataFrame alignment, with this value before computation. If data in both corre-
        sponding DataFrame locations is missing the result will be missing

Returns
    result [DataFrame]

See also:
    DataFrame.rmul
Notes

Mismatched indices will be unioned together

Examples

None

pandas.DataFrame.ne

DataFrame.ne(other, axis='columns', level=None)
Wrapper for flexible comparison methods ne

pandas.DataFrame.nlargest

DataFrame.nlargest(n, columns, keep='first')
Return the first n rows ordered by columns in descending order.

Return the first n rows with the largest values in columns, in descending order. The columns that are not specified are returned as well, but not used for ordering.

This method is equivalent to df.sort_values(columns, ascending=False).head(n), but more performant.

Parameters

n : int
    Number of rows to return.

columns : label or list of labels
    Column label(s) to order by.

keep : {'first', 'last'}, default 'first'
    Where there are duplicate values:
    • first : prioritize the first occurrence(s)
    • last : prioritize the last occurrence(s)

Returns

DataFrame
    The first n rows ordered by the given columns in descending order.

See also:

DataFrame.nsmallest Return the first n rows ordered by columns in ascending order.

DataFrame.sort_values Sort DataFrame by the values

DataFrame.head Return the first n rows without re-ordering.

Notes

This function cannot be used with all column types. For example, when specifying columns with object or category dtypes, TypeError is raised.
Examples

```python
>>> df = pd.DataFrame({'a': [1, 10, 8, 10, -1],
...                   'b': list('abdce'),
...                   'c': [1.0, 2.0, np.nan, 3.0, 4.0]})
```

```python
df
```

In the following example, we will use `nlargest` to select the three rows having the largest values in column “a”.

```python
>>> df.nlargest(3, 'a')
```

When using `keep='last'`, ties are resolved in reverse order:

```python
>>> df.nlargest(3, 'a', keep='last')
```

To order by the largest values in column “a” and then “c”, we can specify multiple columns like in the next example.

```python
>>> df.nlargest(3, ['a', 'c'])
```

Attempting to use `nlargest` on non-numeric dtypes will raise a `TypeError`:

```python
>>> df.nlargest(3, 'b')
```

```
1836 Chapter 34. API Reference
```
Mask of bool values for each element in DataFrame that indicates whether an element is not an NA value.

See also:

DataFrame.notnull alias of notna
DataFrame.isna boolean inverse of notna
DataFrame.dropna omit axes labels with missing values
notna top-level notna

Examples

Show which entries in a DataFrame are not NA.

```python
def = pd.DataFrame({'age': [5, 6, np.NaN],
                            pd.Timestamp('1940-04-25')],
                   'name': ['Alfred', 'Batman', ''],
                   'toy': [None, 'Batmobile', 'Joker']})

def
age  born  name  toy
0  5.0   NaT  Alfred  None
1  6.0  1939-05-27  Batman  Batmobile
2  NaN  1940-04-25  Joker

def.notna()
age  born  name  toy
0  True  False  True  False
1  True  True  True  True
2  False  True  True  True
```

Show which entries in a Series are not NA.

```python
ser = pd.Series([5, 6, np.NaN])

er
0  5.0
1  6.0
2  NaN
dtype: float64

er.notna()
0  True
1  True
2  False
dtype: bool
```

pandas.DataFrame.notnull

DataFrame.notnull()

Detect existing (non-missing) values.

Return a boolean same-sized object indicating if the values are not NA. Non-missing values get mapped to True. Characters such as empty strings '' or numpy.inf are not considered NA values (unless you set
pandas.options.mode.use_inf_as_na = True). NA values, such as None or numpy.NaN, get mapped to False values.

**Returns DataFrame**

Mask of bool values for each element in DataFrame that indicates whether an element is not an NA value.

**See also:**

- DataFrame.notnull alias of notna
- DataFrame.isna boolean inverse of notna
- DataFrame.dropna omit axes labels with missing values
- notna top-level notna

**Examples**

Show which entries in a DataFrame are not NA.

```python
>>> df = pd.DataFrame({'age': [5, 6, np.NaN],
...                     'born': [pd.NaT, pd.Timestamp('1939-05-27'),
...                              pd.Timestamp('1940-04-25')],
...                     'name': ['Alfred', 'Batman', ''],
...                     'toy': [None, 'Batmobile', 'Joker']})
>>> df
          age     born      name    toy
0      5.00  NaT  Alfred   None
1      6.00 1939-05-27  Batman  Batmobile
2      NaN 1940-04-25    Joker

>>> df.notna()
          age     born      name    toy
0      True  False     True  False
1      True  True     True     True
2     False  True     True     True
```

Show which entries in a Series are not NA.

```python
>>> ser = pd.Series([5, 6, np.NaN])
>>> ser
0  5.0
1  6.0
2  NaN
dtype: float64

>>> ser.notna()
0   True
1   True
2  False
dtype: bool
**pandas.DataFrame.nsmallest**

**DataFrame.nsmallest** *(n, columns, keep='first')*

Get the rows of a DataFrame sorted by the *n* smallest values of *columns*.

**Parameters**

- **n**: int
  
  Number of items to retrieve

- **columns**: list or str
  
  Column name or names to order by

- **keep**: {'first', 'last'}, default 'first'
  
  Where there are duplicate values: - *first*: take the first occurrence. - *last*: take the last occurrence.

**Returns**

- DataFrame

**Examples**

```python
>>> df = pd.DataFrame({'a': [1, 10, 8, 11, -1],
...                    'b': list('abdce'),
...                    'c': [1.0, 2.0, np.nan, 3.0, 4.0]})
>>> df.nsmallest(3, 'a')
   a  b  c
0  1  a  1
1  8  d  NaN
2 -1 e  4
```

**pandas.DataFrame.nunique**

**DataFrame.nunique** *(axis=0, dropna=True)*

Return Series with number of distinct observations over requested axis.

New in version 0.20.0.

**Parameters**

- **axis** [{0 or 'index', 1 or 'columns'}, default 0]

- **dropna**: boolean, default True
  
  Don’t include NaN in the counts.

**Returns**

- **nunique**: [Series]

**Examples**

```python
>>> df = pd.DataFrame({'A': [1, 2, 3], 'B': [1, 1, 1]})
>>> df.nunique()
A    3
B    1
```

34.4. **DataFrame**
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
>>> df.nunique(axis=1)
0  1
1  2
2  2
```

**pandas.DataFrame.pct_change**

**DataFrame.pct_change**(periods=1, fill_method='pad', limit=None, freq=None, **kwargs)

Percentage change between the current and a prior element.

Computes the percentage change from the immediately previous row by default. This is useful in comparing the percentage of change in a time series of elements.

**Parameters**

- **periods**: int, default 1
  Periods to shift for forming percent change.

- **fill_method**: str, default ‘pad’
  How to handle NAs before computing percent changes.

- **limit**: int, default None
  The number of consecutive NAs to fill before stopping.

- **freq**: DateOffset, timedelta, or offset alias string, optional
  Increment to use from time series API (e.g. ‘M’ or BDay()).

- **kwargs**
  Additional keyword arguments are passed into DataFrame.shift or Series.shift.

**Returns**

- **chg**: Series or DataFrame
  The same type as the calling object.

**See also**

- **Series.diff**  
  Compute the difference of two elements in a Series.

- **DataFrame.diff**  
  Compute the difference of two elements in a DataFrame.

- **Series.shift**  
  Shift the index by some number of periods.

- **DataFrame.shift**  
  Shift the index by some number of periods.

**Examples**

**Series**

```python
>>> s = pd.Series([90, 91, 85])
>>> s
0  90
1  91
2  85
dtype: int64
```
See the percentage change in a Series where filling NAs with last valid observation forward to next valid.

```python
>>> s = pd.Series([90, 91, None, 85])
>>> s
0     90.0
1     91.0
2    NaN
3     85.0
dtype: float64
```

```python
>>> s.pct_change(fill_method='ffill')
0     NaN
1  0.011111
2  0.000000
3 -0.065934
dtype: float64
```

**DataFrame**

Percentage change in French franc, Deutsche Mark, and Italian lira from 1980-01-01 to 1980-03-01.

```python
>>> df
   FR    GR   IT
1980-01-01  4.0405  1.7246  804.74
1980-02-01  4.0963  1.7482  810.01
1980-03-01  4.3149  1.8519  860.13
```

```python
>>> df.pct_change()
   FR    GR    IT
1980-01-01 NaN  NaN   NaN
1980-02-01 0.013810 0.013684 0.006549
1980-03-01 0.053365 0.059318 0.061876
```

Percentage of change in GOOG and APPL stock volume. Shows computing the percentage change between columns.

```python
>>> df = pd.DataFrame({'2016': [1769950, 30586265], '2015': [1500923, 40912316]}, index=['2015', '2016'])
>>> df
     2015  2016
2015  1500923  30586265
2016   40912316
```

(continues on next page)
... '2014': [1371819, 41403351]},
... index=['GOOG', 'APPL'])

>>> df
    2016  2015  2014
GOOG   1769950  1500923  1371819
APPL    30586265  40912316  41403351

>>> df.pct_change(axis='columns')
    2016  2015  2014
GOOG    NaN -0.151997 -0.086016
APPL    NaN   0.337604   0.012002

pandas.DataFrame.pipe

DataFrame.pipe(func, *args, **kwargs)
Apply func(self, *args, **kwargs)

Parameters

func : function
    function to apply to the NDFrame. args, and kwargs are passed into func. Alternatively a (callable, data_keyword) tuple where data_keyword is a string indicating the keyword of callable that expects the NDFrame.

args : iterable, optional
    positional arguments passed into func.

kwargs : mapping, optional
    a dictionary of keyword arguments passed into func.

Returns

object [the return type of func.]

See also:
pandas.DataFrame.apply, pandas.DataFrame.applymap, pandas.Series.map

Notes

Use .pipe when chaining together functions that expect Series, DataFrames or GroupBy objects. Instead of writing

```python
>>> f(g(h(df), arg1=a), arg2=b, arg3=c)
```

You can write

```python
>>> (df.pipe(h)
...     .pipe(g, arg1=a)
...     .pipe(f, arg2=b, arg3=c)
... )
```

If you have a function that takes the data as (say) the second argument, pass a tuple indicating which keyword expects the data. For example, suppose f takes its data as arg2:
pandas.DataFrame.pivot

DataFrame.pivot(index=None, columns=None, values=None)

Return reshaped DataFrame organized by given index / column values.

Reshape data (produce a “pivot” table) based on column values. Uses unique values from specified index / columns to form axes of the resulting DataFrame. This function does not support data aggregation, multiple values will result in a MultiIndex in the columns. See the User Guide for more on reshaping.

**Parameters**

- **index**: string or object, optional
  Column to use to make new frame’s index. If None, uses existing index.

- **columns**: string or object
  Column to use to make new frame’s columns.

- **values**: string, object or a list of the previous, optional
  Column(s) to use for populating new frame’s values. If not specified, all remaining columns will be used and the result will have hierarchically indexed columns.

| Changed in version 0.23.0: Also accept list of column names.

**Returns**

DataFrame

Returns reshaped DataFrame.

**Raises**

ValueError:

When there are any index, columns combinations with multiple values.

DataFrame.pivot_table when you need to aggregate.

See also:

- **DataFrame.pivot_table**: generalization of pivot that can handle duplicate values for one index/column pair.

- **DataFrame.unstack**: pivot based on the index values instead of a column.

**Notes**

For finer-tuned control, see hierarchical indexing documentation along with the related stack/unstack methods.

**Examples**

```python
>>> df = pd.DataFrame({'foo': ['one', 'one', 'one', 'two', 'two',
...   'two'],
...   'bar': ['A', 'B', 'C', 'A', 'B', 'C'],
...   'baz': [1, 2, 3, 4, 5, 6],
```

(continues on next page)
... `zoo`: ["x", "y", "z", "q", "w", "t"]}}

```python
>>> df
      foo  bar  baz  zoo
     0    one  A    1  x
     1    one  B    2  y
     2    one  C    3  z
     3    two  A    4  q
     4    two  B    5  w
     5    two  C    6  t
```

```python
>>> df.pivot(index='foo', columns='bar', values='baz')
    bar  A  B  C
  foo  
  one  1  2  3
  two  4  5  6
```

```python
>>> df.pivot(index='foo', columns='bar')['baz']
    bar  A  B  C
  foo  
  one  1  2  3
  two  4  5  6
```

```python
>>> df.pivot(index='foo', columns='bar', values=['baz', 'zoo'])
   baz  zoo
    bar  A  B  C  A  B  C
  foo  
  one  1  2  3  x  y  z
  two  4  5  6  q  w  t
```

A ValueError is raised if there are any duplicates.

```python
>>> df = pd.DataFrame({"foo": ["one", "one", "two", "two"],
...                     "bar": ["A", "A", "B", "C"],
...                     "baz": [1, 2, 3, 4]})
```

```python
>>> df
     foo  bar  baz
    0    one  A    1
    1    one  A    2
    2    two  B    3
    3    two  C    4
```

Notice that the first two rows are the same for our index and columns arguments.

```python
>>> df.pivot(index='foo', columns='bar', values='baz')
Traceback (most recent call last):
...
ValueError: Index contains duplicate entries, cannot reshape
```

**pandas.DataFrame.pivot_table**

Dataframe.pivot_table(values=None, index=None, columns=None, aggfunc='mean', fill_value=None, margins=False, dropna=True, margins_name='All')

Create a spreadsheet-style pivot table as a DataFrame. The levels in the pivot table will be stored in MultiIndex objects (hierarchical indexes) on the index and columns of the result DataFrame.
Parameters

values [column to aggregate, optional]

index : column, Grouper, array, or list of the previous

If an array is passed, it must be the same length as the data. The list can contain any of the other types (except list). Keys to group by on the pivot table index. If an array is passed, it is being used as the same manner as column values.

columns : column, Grouper, array, or list of the previous

If an array is passed, it must be the same length as the data. The list can contain any of the other types (except list). Keys to group by on the pivot table column. If an array is passed, it is being used as the same manner as column values.

aggfunc : function, list of functions, dict, default numpy.mean

If list of functions passed, the resulting pivot table will have hierarchical columns whose top level are the function names (inferred from the function objects themselves) If dict is passed, the key is column to aggregate and value is function or list of functions

fill_value : scalar, default None

Value to replace missing values with

margins : boolean, default False

Add all row / columns (e.g. for subtotal / grand totals)

dropna : boolean, default True

Do not include columns whose entries are all NaN

margins_name : string, default ‘All’

Name of the row / column that will contain the totals when margins is True.

Returns

table [DataFrame]

See also:

DataFrame.pivot pivot without aggregation that can handle non-numeric data

Examples

```python
code_snippet
```
3  foo  two small 3
4  foo  two small 3
5  bar  one large 4
6  bar  one small 5
7  bar  two small 6
8  bar  two large 7

```
>>> table = pivot_table(df, values='D', index=['A', 'B'],
                     columns=['C'], aggfunc=np.sum)
```

```
>>> table
   C     large small
 A B
bar one  4.0   5.0
    two  7.0   6.0
foo one  4.0   1.0
    two  NaN   6.0
```

```
>>> table = pivot_table(df, values='D', index=['A', 'B'],
                     columns=['C'], aggfunc=np.sum)
```

```
>>> table
   C     large small
 A B
bar one  4.0   5.0
    two  7.0   6.0
foo one  4.0   1.0
    two  NaN   6.0
```

```
>>> table = pivot_table(df, values=['D', 'E'], index=['A', 'C'],
                      aggfunc={'D': np.mean,
                               'E': [min, max, np.mean]})
```

```
>>> table
     D   E
     mean max median min
 A C
bar large 5.500000 16 14.5 13
  small 5.500000 15 14.5 14
foo large 2.000000 10 9.5  9
  small 2.333333 12 11.0  8
```

### pandas.DataFrame.plot

`DataFrame.plot(x=None, y=None, kind='line', ax=None, subplots=False, sharex=None, sharey=False, layout=None, figsize=None, use_index=True, title=None, grid=None, legend=True, style=None, logx=False, logy=False, loglog=False, xticks=None, yticks=None, xlim=None, ylim=None, rot=None, fontsize=None, colormap=None, table=False, yerr=None, xerr=None, secondary_y=False, sort_columns=False, **kwds)`

Make plots of DataFrame using matplotlib / pylab.

New in version 0.17.0: Each plot kind has a corresponding method on the `DataFrame.plot` accessor: `df.plot(kind='line')` is equivalent to `df.plot.line()`.

**Parameters**

- **data** [DataFrame]
x [label or position, default None]
y: label, position or list of label, positions, default None
   Allows plotting of one column versus another

kind : str
   • ‘line’: line plot (default)
   • ‘bar’: vertical bar plot
   • ‘barh’: horizontal bar plot
   • ‘hist’: histogram
   • ‘box’: boxplot
   • ‘kde’: Kernel Density Estimation plot
   • ‘density’: same as ‘kde’
   • ‘area’: area plot
   • ‘pie’: pie plot
   • ‘scatter’: scatter plot
   • ‘hexbin’: hexbin plot

ax [matplotlib axes object, default None]

subplots : boolean, default False
   Make separate subplots for each column

sharex : boolean, default True if ax is None else False
   In case subplots=True, share x axis and set some x axis labels to invisible; defaults
to True if ax is None otherwise False if an ax is passed in; Be aware, that passing
in both an ax and sharex=True will alter all x axis labels for all axis in a figure!

sharey : boolean, default False
   In case subplots=True, share y axis and set some y axis labels to invisible

layout : tuple (optional)
   (rows, columns) for the layout of subplots

figsize [a tuple (width, height) in inches]

use_index : boolean, default True
   Use index as ticks for x axis

title : string or list
   Title to use for the plot. If a string is passed, print the string at the top of the
   figure. If a list is passed and subplots is True, print each item in the list above the
   corresponding subplot.

grid : boolean, default None (matlab style default)
   Axis grid lines

legend : False/True/’reverse’
Place legend on axis subplots

**style**: list or dict

  matplotlib line style per column

**logx**: boolean, default False

  Use log scaling on x axis

**logy**: boolean, default False

  Use log scaling on y axis

**loglog**: boolean, default False

  Use log scaling on both x and y axes

**xticks**: sequence

  Values to use for the xticks

**yticks**: sequence

  Values to use for the yticks

**xlim** [2-tuple/list]

**ylim** [2-tuple/list]

**rot**: int, default None

  Rotation for ticks (xticks for vertical, yticks for horizontal plots)

**fontsize**: int, default None

  Font size for xticks and yticks

**colormap**: str or matplotlib colormap object, default None

  Colormap to select colors from. If string, load colormap with that name from matplotlib.

**colorbar**: boolean, optional

  If True, plot colorbar (only relevant for 'scatter' and 'hexbin' plots)

**position**: float

  Specify relative alignments for bar plot layout. From 0 (left/bottom-end) to 1 (right/top-end). Default is 0.5 (center)

**table**: boolean, Series or DataFrame, default False

  If True, draw a table using the data in the DataFrame and the data will be transposed to meet matplotlib’s default layout. If a Series or DataFrame is passed, use passed data to draw a table.

**yerr**: DataFrame, Series, array-like, dict and str

  See Plotting with Error Bars for detail.

**xerr** [same types as yerr.]

**stacked**: boolean, default False in line and bar plots, and True in area plot. If True, create stacked plot.
sort_columns : boolean, default False
    Sort column names to determine plot ordering

secondary_y : boolean or sequence, default False
    Whether to plot on the secondary y-axis If a list/tuple, which columns to plot on secondary y-axis

mark_right : boolean, default True
    When using a secondary_y axis, automatically mark the column labels with “(right)” in the legend

**kwds** : keywords
    Options to pass to matplotlib plotting method

Returns

axes [matplotlib.axes.Axes or numpy.ndarray of them]

Notes

• See matplotlib documentation online for more on this subject

• If kind = ‘bar’ or ‘barh’, you can specify relative alignments for bar plot layout by position keyword. From 0 (left/bottom-end) to 1 (right/top-end). Default is 0.5 (center)

• If kind = ‘scatter’ and the argument c is the name of a dataframe column, the values of that column are used to color each point.

• If kind = ‘hexbin’, you can control the size of the bins with the gridsize argument. By default, a histogram of the counts around each (x, y) point is computed. You can specify alternative aggregations by passing values to the C and reduce_C_function arguments. C specifies the value at each (x, y) point and reduce_C_function is a function of one argument that reduces all the values in a bin to a single number (e.g. mean, max, sum, std).

pandas.DataFrame.pop

DataFrame.pop(item)
    Return item and drop from frame. Raise KeyError if not found.

Parameters item : str
    Column label to be popped

Returns

popped [Series]

Examples

```python
>>> df = pd.DataFrame([('falcon', 'bird', 389.0),
...                     ('parrot', 'bird', 24.0),
...                     ('lion', 'mammal', 80.5),
...                     ('monkey', 'mammal', np.nan)],
...                   columns=('name', 'class', 'max_speed'))
```
>>> df
   name   class  max_speed
0  falcon   bird      389.0
1  parrot   bird       24.0
2   lion  mammal       80.5
3  monkey  mammal      NaN

>>> df.pop('class')
0   bird
1   bird
2  mammal
3  mammal
Name: class, dtype: object

>>> df
   name  max_speed
0  falcon      389.0
1  parrot      24.0
2   lion       80.5
3  monkey      NaN

pandas.DataFrame.pow

Dataframe .pow (other, axis='columns', level=None, fill_value=None)
Exponential power of dataframe and other, element-wise (binary operator pow).
Equivalent to dataframe ** other, but with support to substitute a fill_value for missing data in
one of the inputs.

Parameters

other  [Series, DataFrame, or constant]
axis  : {0, 1, ‘index’, ‘columns’}
       For Series input, axis to match Series index on
level  : int or name
        Broadcast across a level, matching Index values on the passed MultiIndex level
fill_value  : None or float value, default None
              Fill existing missing (NaN) values, and any new element needed for successful
              DataFrame alignment, with this value before computation. If data in both corre-
              sponding DataFrame locations is missing the result will be missing

Returns

result  [DataFrame]

See also:

Dataframe.rpow

Notes

Mismatched indices will be unioned together
Examples

None

**pandas.DataFrame.prod**

```python
df = pd.DataFrame(np.random.randn(10, 2), columns=list('ab'))
df.prod()  # equivalent
```

**Returns**

```
prod [Series or DataFrame (if level specified)]
```

**Examples**

By default, the product of an empty or all-NA Series is 1

```python
>>> pd.Series([]).prod()
1.0
```

This can be controlled with the `min_count` parameter

```python
>>> pd.Series([]).prod(min_count=1)
nan
```

Thanks to the `skipna` parameter, `min_count` handles all-NA and empty series identically.

```python
>>> pd.Series([np.nan]).prod()
1.0
```

```python
>>> pd.Series([np.nan]).prod(min_count=1)
nan
```
pandas.DataFrame.product

DataFrame.product(\texttt{axis=None, skipna=None, level=None, numeric\_only=None, min\_count=0, **kwargs})

Return the product of the values for the requested axis

Parameters

- \texttt{axis} [[index (0), columns (1)]]
- \texttt{skipna} : boolean, default True
  
  Exclude NA/null values when computing the result.
- \texttt{level} : int or level name, default None
  
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series
- \texttt{numeric\_only} : boolean, default None
  
  Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.
- \texttt{min\_count} : int, default 0
  
  The required number of valid values to perform the operation. If fewer than \texttt{min\_count} non-NA values are present the result will be NA.

New in version 0.22.0: Added with the default being 0. This means the sum of an all-NA or empty Series is 0, and the product of an all-NA or empty Series is 1.

Returns

- \texttt{prod} [Series or DataFrame (if level specified)]

Examples

By default, the product of an empty or all-NA Series is 1

\begin{verbatim}
>>> pd.Series([]).prod()
1.0
\end{verbatim}

This can be controlled with the \texttt{min\_count} parameter

\begin{verbatim}
>>> pd.Series([]).prod(min\_count=1)
nan
\end{verbatim}

Thanks to the \texttt{skipna} parameter, \texttt{min\_count} handles all-NA and empty series identically.

\begin{verbatim}
>>> pd.Series([np.nan]).prod()
1.0
\end{verbatim}

\begin{verbatim}
>>> pd.Series([np.nan]).prod(min\_count=1)
nan
\end{verbatim}
**pandas.DataFrame.quantile**

DataFrame.quantile *(q=0.5, axis=0, numeric_only=True, interpolation='linear'*

Return values at the given quantile over requested axis, a la numpy.percentile.

**Parameters**

- **q**: float or array-like, default 0.5 (50% quantile)
  
  0 <= q <= 1, the quantile(s) to compute

- **axis**: {0, 1, ‘index’, ‘columns’} (default 0)
  
  0 or ‘index’ for row-wise, 1 or ‘columns’ for column-wise

- **numeric_only**: boolean, default True
  
  If False, the quantile of datetime and timedelta data will be computed as well

  
  New in version 0.18.0.
  
  This optional parameter specifies the interpolation method to use, when the desired quantile lies between two data points i and j:

  - linear: \( i + (j - i) \times \text{fraction} \), where fraction is the fractional part of the index surrounded by i and j.
  - lower: i.
  - higher: j.
  - nearest: i or j whichever is nearest.
  - midpoint: \((i + j) / 2\).

**Returns**

- **quantiles**: Series or DataFrame

  - If q is an array, a DataFrame will be returned where the index is q, the columns are the columns of self, and the values are the quantiles.
  - If q is a float, a Series will be returned where the index is the columns of self and the values are the quantiles.

**See also:**

- pandas.core.window.Rolling.quantile

**Examples**

```python
>>> df = pd.DataFrame(np.array([[1, 1], [2, 10], [3, 100], [4, 100]]),
                     columns=['a', 'b'])
>>> df.quantile(.1)
   a   b
0  1.3  3.7
dtype: float64
>>> df.quantile([.1, .5])
   a   b
0.1 1.3  3.7
0.5 2.5 55.0
```

Specifying numeric_only=False will also compute the quantile of datetime and timedelta data.
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
>>> df = pd.DataFrame({'A': [1, 2],
                     'B': [pd.Timestamp('2010'),
                           pd.Timestamp('2011')],
                     'C': [pd.Timedelta('1 days'),
                           pd.Timedelta('2 days')]})
>>> df.quantile(0.5, numeric_only=False)
A    1.5
B 2010-07-02 12:00:00
C   1 days 12:00:00
Name: 0.5, dtype: object
```

### pandas.DataFrame.query

`DataFrame.query(expr, inplace=False, **kwargs)`

Query the columns of a frame with a boolean expression.

**Parameters**

- **expr**: string
  - The query string to evaluate. You can refer to variables in the environment by prefixing them with an `@` character like `@a` + `b`.

- **inplace**: bool
  - Whether the query should modify the data in place or return a modified copy
    - New in version 0.18.0.

- **kwargs**: dict
  - See the documentation for `pandas.eval()` for complete details on the keyword arguments accepted by `DataFrame.query()`.

**Returns**

- `q` [DataFrame]

**See also**

`pandas.eval`, `DataFrame.eval`

**Notes**

The result of the evaluation of this expression is first passed to `DataFrame.loc` and if that fails because of a multidimensional key (e.g., a DataFrame) then the result will be passed to `DataFrame.__getitem__()`.

This method uses the top-level `pandas.eval()` function to evaluate the passed query.

The `query()` method uses a slightly modified Python syntax by default. For example, the `&` and `|` (bitwise) operators have the precedence of their boolean cousins, `and` and `or`. This is syntactically valid Python, however the semantics are different.

You can change the semantics of the expression by passing the keyword argument `parser='python'`. This enforces the same semantics as evaluation in Python space. Likewise, you can pass `engine='python'` to evaluate an expression using Python itself as a backend. This is not recommended as it is inefficient compared to using `numexpr` as the engine.

The `DataFrame.index` and `DataFrame.columns` attributes of the `DataFrame` instance are placed in the query namespace by default, which allows you to treat both the index and columns of
the frame as a column in the frame. The identifier `index` is used for the frame index; you can also use the name of the index to identify it in a query. Please note that Python keywords may not be used as identifiers.

For further details and examples see the `query` documentation in `indexing`.

**Examples**

```python
>>> from numpy.random import randn
>>> from pandas import DataFrame
>>> df = pd.DataFrame(randn(10, 2), columns=list('ab'))
>>> df.query('a > b')
>>> df[df.a > df.b]  # same result as the previous expression
```

### pandas.DataFrame.radd

`DataFrame.radd(other, axis='columns', level=None, fill_value=None)`

Addition of dataframe and other, element-wise (binary operator `radd`). Equivalent to `other + dataframe`, but with support to substitute a `fill_value` for missing data in one of the inputs.

**Parameters**

- `other` [Series, DataFrame, or constant]
- `axis` : {0, 1, ‘index’, ‘columns’}
  - For Series input, axis to match Series index on
- `level` : int or name
  - Broadcast across a level, matching Index values on the passed MultiIndex level
- `fill_value` : None or float value, default None
  - Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing

**Returns**

- `result` [DataFrame]

**See also:**

`DataFrame.add`

**Notes**

Mismatched indices will be unioned together

**Examples**
```python
>>> a = pd.DataFrame([1, 1, 1, np.nan], index=['a', 'b', 'c', 'd'],
...                   columns=['one'])
>>> a
one
a 1.0
b 1.0
c 1.0
NaN

>>> b = pd.DataFrame(dict(one=[1, np.nan, 1, np.nan],
...                        two=[np.nan, 2, np.nan, 2]),
...                   index=['a', 'b', 'd', 'e'])
>>> b
one two
a 1.0 NaN
b NaN 2.0
d 1.0 NaN
e NaN 2.0

>>> a.add(b, fill_value=0)
one two
a 2.0 NaN
b 1.0 2.0
c 1.0 NaN
d 1.0 NaN
e NaN 2.0
```

**pandas.DataFrame.rank**

`DataFrame.rank(axis=0, method='average', numeric_only=None, na_option='keep', ascending=True, pct=False)`

Compute numerical data ranks (1 through n) along axis. Equal values are assigned a rank that is the average of the ranks of those values.

**Parameters**

- **axis**: {0 or ‘index’, 1 or ‘columns’}, default 0
  
  index to direct ranking

- **method**: {'average', 'min', 'max', 'first', 'dense'}
  
  - average: average rank of group
  - min: lowest rank in group
  - max: highest rank in group
  - first: ranks assigned in order they appear in the array
  - dense: like ‘min’, but rank always increases by 1 between groups

- **numeric_only**: boolean, default None
  
  Include only float, int, boolean data. Valid only for DataFrame or Panel objects

- **na_option**: {'keep', 'top', 'bottom'}
  
  - keep: leave NA values where they are
  - top: smallest rank if ascending
  - bottom: smallest rank if descending

- **ascending**: boolean, default True
  
  Direction to rank. True (default) means ascending order; False means descending order.
False for ranks by high (1) to low (N)

**pct** : boolean, default False
Computes percentage rank of data

**Returns**

**ranks** [same type as caller]

**pandas.DataFrame.rdiv**

DataFrame.rdiv(other, axis='columns', level=None, fill_value=None)
Floating division of dataframe and other, element-wise (binary operator \texttt{rtruediv}).
Equivalent to other / dataframe, but with support to substitute a fill_value for missing data in one of the inputs.

**Parameters**

- **other** [Series, DataFrame, or constant]
- **axis** : {0, 1, ‘index’, ‘columns’}
  For Series input, axis to match Series index on
- **level** : int or name
  Broadcast across a level, matching Index values on the passed MultiIndex level
- **fill_value** : None or float value, default None
  Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing

**Returns**

**result** [DataFrame]

**See also:**

DataFrame.truediv

**Notes**

Mismatched indices will be unioned together

**Examples**

None

**pandas.DataFrame.reindex**

DataFrame.reindex(labels=None, index=None, columns=None, axis=None, method=None, copy=True, level=None, fill_value=None, limit=None, tolerance=None)
Conform DataFrame to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index. A new object is produced unless the new index is equivalent to the current one and copy=False
Parameters labels : array-like, optional

New labels / index to conform the axis specified by ‘axis’ to.

index, columns : array-like, optional (should be specified using keywords)

New labels / index to conform to. Preferably an Index object to avoid duplicating data.

axis : int or str, optional

Axis to target. Can be either the axis name (‘index’, ‘columns’) or number (0, 1).


method to use for filling holes in reindexed DataFrame. Please note: this is only applicable to DataFrames/Series with a monotonically increasing/decreasing index.

• default: don’t fill gaps
• pad / ffill: propagate last valid observation forward to next valid
• backfill / bfill: use next valid observation to fill gap
• nearest: use nearest valid observations to fill gap

copy : boolean, default True

Return a new object, even if the passed indexes are the same

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

fill_value : scalar, default np.NaN

Value to use for missing values. Defaults to NaN, but can be any “compatible” value

limit : int, default None

Maximum number of consecutive elements to forward or backward fill

tolerance : optional

Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations most satisfy the equation

\[
\text{abs(index[indexer] - target)} \leq \text{tolerance}
\]

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index’s type.

New in version 0.21.0: (list-like tolerance)

Returns

reindexed [DataFrame]

Examples

DataFrame.reindex supports two calling conventions

• (index=index_labels, columns=column_labels, ...)

Chapter 34. API Reference
• (labels, axis=('index', 'columns'), ...)  

We highly recommend using keyword arguments to clarify your intent.

Create a dataframe with some fictional data.

```python
>>> index = ['Firefox', 'Chrome', 'Safari', 'IE10', 'Konqueror']
>>> df = pd.DataFrame({...
  'http_status': [200, 200, 404, 404, 301],
  'response_time': [0.04, 0.02, 0.07, 0.08, 1.0]},
  index=index)
>>> df
   http_status  response_time
Firefox      200          0.04
Chrome       200          0.02
Safari       404          0.07
IE10         404          0.08
Konqueror    301          1.00
```

Create a new index and reindex the dataframe. By default values in the new index that do not have corresponding records in the dataframe are assigned NaN.

```python
>>> new_index= ['Safari', 'Iceweasel', 'Comodo Dragon', 'IE10', 'Chrome']
>>> df.reindex(new_index)
   http_status  response_time
Safari       404.0        0.07
Iceweasel    NaN          NaN
Comodo Dragon NaN          NaN
IE10         404.0        0.08
Chrome       200.0        0.02
```

We can fill in the missing values by passing a value to the keyword `fill_value`. Because the index is not monotonically increasing or decreasing, we cannot use arguments to the keyword `method` to fill the NaN values.

```python
>>> df.reindex(new_index, fill_value=0)
   http_status  response_time
Safari       404          0.07
Iceweasel    0            0.00
Comodo Dragon 0          0.00
IE10         404          0.08
Chrome       200          0.02
```

```python
>>> df.reindex(new_index, fill_value='missing')
   http_status  response_time
Safari       404          0.07
Iceweasel    missing     missing
Comodo Dragon missing     missing
IE10         404          0.08
Chrome       200          0.02
```

We can also reindex the columns.

```python
>>> df.reindex(columns=['http_status', 'user_agent'])
   http_status  user_agent
Firefox      200          NaN
Chrome       200          NaN
```

(continues on next page)
Safari 404 NaN
IE10 404 NaN
Konqueror 301 NaN

Or we can use “axis-style” keyword arguments

```python
>>> df.reindex(["http_status", 'user_agent'], axis="columns")
```

<table>
<thead>
<tr>
<th></th>
<th>http_status</th>
<th>user_agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firefox</td>
<td>200</td>
<td>NaN</td>
</tr>
<tr>
<td>Chrome</td>
<td>200</td>
<td>NaN</td>
</tr>
<tr>
<td>Safari</td>
<td>404</td>
<td>NaN</td>
</tr>
<tr>
<td>IE10</td>
<td>404</td>
<td>NaN</td>
</tr>
<tr>
<td>Konqueror</td>
<td>301</td>
<td>NaN</td>
</tr>
</tbody>
</table>

To further illustrate the filling functionality in `reindex`, we will create a dataframe with a monotonically increasing index (for example, a sequence of dates).

```python
>>> date_index = pd.date_range('1/1/2010', periods=6, freq='D')
>>> df2 = pd.DataFrame({"prices": [100, 101, np.nan, 100, 89, 88]},
                     index=date_index)
>>> df2
```

<table>
<thead>
<tr>
<th></th>
<th>prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-01-01</td>
<td>100</td>
</tr>
<tr>
<td>2010-01-02</td>
<td>101</td>
</tr>
<tr>
<td>2010-01-03</td>
<td>NaN</td>
</tr>
<tr>
<td>2010-01-04</td>
<td>100</td>
</tr>
<tr>
<td>2010-01-05</td>
<td>89</td>
</tr>
<tr>
<td>2010-01-06</td>
<td>88</td>
</tr>
</tbody>
</table>

Suppose we decide to expand the dataframe to cover a wider date range.

```python
>>> date_index2 = pd.date_range('12/29/2009', periods=10, freq='D')
>>> df2.reindex(date_index2)
```

<table>
<thead>
<tr>
<th></th>
<th>prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-12-29</td>
<td>NaN</td>
</tr>
<tr>
<td>2009-12-30</td>
<td>NaN</td>
</tr>
<tr>
<td>2009-12-31</td>
<td>NaN</td>
</tr>
<tr>
<td>2010-01-01</td>
<td>100</td>
</tr>
<tr>
<td>2010-01-02</td>
<td>101</td>
</tr>
<tr>
<td>2010-01-03</td>
<td>NaN</td>
</tr>
<tr>
<td>2010-01-04</td>
<td>100</td>
</tr>
<tr>
<td>2010-01-05</td>
<td>89</td>
</tr>
<tr>
<td>2010-01-06</td>
<td>88</td>
</tr>
</tbody>
</table>

The index entries that did not have a value in the original data frame (for example, ‘2009-12-29’) are by default filled with NaN. If desired, we can fill in the missing values using one of several options.

For example, to backpropagate the last valid value to fill the NaN values, pass `bfill` as an argument to the `method` keyword.

```python
>>> df2.reindex(date_index2, method='bfill')
```

<table>
<thead>
<tr>
<th></th>
<th>prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-12-29</td>
<td>100</td>
</tr>
<tr>
<td>2009-12-30</td>
<td>100</td>
</tr>
<tr>
<td>2009-12-31</td>
<td>100</td>
</tr>
<tr>
<td>2010-01-01</td>
<td>100</td>
</tr>
</tbody>
</table>

(continues on next page)
Please note that the NaN value present in the original dataframe (at index value 2010-01-03) will not be filled by any of the value propagation schemes. This is because filling while reindexing does not look at dataframe values, but only compares the original and desired indexes. If you do want to fill in the NaN values present in the original dataframe, use the `fillna()` method.

See the user guide for more.

### pandas.DataFrame.reindex_axis

`DataFrame.reindex_axis(labels, axis=0, method=None, level=None, copy=True, limit=None, fill_value=np.nan)`

Conform input object to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index. A new object is produced unless the new index is equivalent to the current one and copy=False

**Parameters**

- **labels**: array-like
  
  New labels / index to conform to. Preferably an Index object to avoid duplicating data

- **axis**: [(0 or ‘index’, 1 or ‘columns’)]

- **method**: {None, ‘backfill’/’bfill’, ‘pad’/’ffill’, ‘nearest’}, optional
  
  Method to use for filling holes in reindexed DataFrame:
  
  - default: don’t fill gaps
  - pad / ffill: propagate last valid observation forward to next valid
  - backfill / bfill: use next valid observation to fill gap
  - nearest: use nearest valid observations to fill gap

- **copy**: boolean, default True
  
  Return a new object, even if the passed indexes are the same

- **level**: int or name
  
  Broadcast across a level, matching Index values on the passed MultiIndex level

- **limit**: int, default None
  
  Maximum number of consecutive elements to forward or backward fill

- **tolerance**: optional
  
  Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations most satisfy the equation \( \text{abs(index[indexer] - target)} \leq \text{tolerance} \).

  Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list,
tuple, array, Series, and must be the same size as the index and its dtype must
exactly match the index’s type.

New in version 0.21.0: (list-like tolerance)

Returns

reindexed [DataFrame]

See also:

reindex, reindex_like

Examples

```python
gp = df.reindex_axis(['A', 'B', 'C'], axis=1)
```

pandas.DataFrame.reindex_like

DataFrame.reindex_like (other, method=None, copy=True, limit=None, tolerance=None)

Return an object with matching indices to myself.

Parameters

other [Object]

method [string or None]

copy [boolean, default True]

limit : int, default None

Maximum number of consecutive labels to fill for inexact matches.

tolerance : optional

Maximum distance between labels of the other object and this object for inexact
matches. Can be list-like.

New in version 0.21.0: (list-like tolerance)

Returns

reindexed [same as input]

Notes

Like calling s.reindex(index=other.index, columns=other.columns, method=…)

pandas.DataFrame.rename

DataFrame.rename (mapper=None, index=None, columns=None, axis=None, copy=True, inplace=False, level=None)

Alter axes labels.

Function / dict values must be unique (1-to-1). Labels not contained in a dict / Series will be left as-is.
Extra labels listed don’t throw an error.

See the user guide for more.
Parameters mapper, index, columns: dict-like or function, optional

dict-like or functions transformations to apply to that axis’ values. Use either mapper and axis to specify the axis to target with mapper, or index and columns.

axis: int or str, optional

Axis to target with mapper. Can be either the axis name (‘index’, ‘columns’) or number (0, 1). The default is ‘index’.

copy: boolean, default True

Also copy underlying data

inplace: boolean, default False

Whether to return a new DataFrame. If True then value of copy is ignored.

level: int or level name, default None

In case of a MultiIndex, only rename labels in the specified level.

Returns

renamed [DataFrame]

See also:

pandas.DataFrame.rename_axis

Examples

DataFrame.rename supports two calling conventions

• (index=index_mapper, columns=columns_mapper, ...)
• (mapper, axis={'index', 'columns'}, ...)

We highly recommend using keyword arguments to clarify your intent.

```
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
>>> df.rename(index=str, columns={"A": "a", "B": "c"})
   a  c
0  1  4
1  2  5
2  3  6

>>> df.rename(index=str, columns={"A": "a", "C": "c"})
   a  B
0  1  4
1  2  5
2  3  6

Using axis-style parameters

```
```
>>> df.rename(str.lower, axis='columns')
   a  b
0  1  4
1  2  5
2  3  6
```
```python
>>> df.rename({1: 2, 2: 4}, axis='index')
   A  B
0  1  4
2  2  5
4  3  6
```

**pandas.DataFrame.rename_axis**

`DataFrame.rename_axis(mapper, axis=0, copy=True, inplace=False)`

Alter the name of the index or columns.

**Parameters**

- **mapper**: scalar, list-like, optional
  - Value to set as the axis name attribute.
- **axis**: {0 or ‘index’, 1 or ‘columns’}, default 0
  - The index or the name of the axis.
- **copy**: boolean, default True
  - Also copy underlying data.
- **inplace**: boolean, default False
  - Modifies the object directly, instead of creating a new Series or DataFrame.

**Returns**

- **renamed**: Series, DataFrame, or None
  - The same type as the caller or None if `inplace` is True.

**See also:**

- `pandas.Series.rename` Alter Series index labels or name
- `pandas.DataFrame.rename` Alter DataFrame index labels or name
- `pandas.Index.rename` Set new names on index

**Notes**

Prior to version 0.21.0, `rename_axis` could also be used to change the axis *labels* by passing a mapping or scalar. This behavior is deprecated and will be removed in a future version. Use `rename` instead.

**Examples**

**Series**

```python
>>> s = pd.Series([1, 2, 3])
>>> s.rename_axis("foo")
foo
0  1
1  2
2  3
dtype: int64
```

**DataFrame**
>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
>> df.rename_axis("foo")
    A  B
foo
0  1  4
1  2  5
2  3  6

>> df.rename_axis("bar", axis="columns")
    bar  A  B
0    1  4
1    2  5
2    3  6

pandas.DataFrame.reorder_levels

DataFrame.reorder_levels(order, axis=0)
Rearrange index levels using input order. May not drop or duplicate levels

Parameters

order : list of int or list of str
    List representing new level order. Reference level by number (position) or by key (label).

axis : int
    Where to reorder levels.

Returns
type of caller (new object)

pandas.DataFrame.replace

DataFrame.replace(to_replace=None, value=None, inplace=False, limit=None, regex=False, method='pad')
Replace values given in to_replace with value.

Values of the DataFrame are replaced with other values dynamically. This differs from updating with .loc or .iloc, which require you to specify a location to update with some value.

Parameters
to_replace : str, regex, list, dict, Series, int, float, or None
    How to find the values that will be replaced.

• numeric, str or regex:
  – numeric: numeric values equal to to_replace will be replaced with value
  – str: string exactly matching to_replace will be replaced with value
  – regex: regexes matching to_replace will be replaced with value

• list of str, regex, or numeric:
  – First, if to_replace and value are both lists, they must be the same length.
  – Second, if regex=True then all of the strings in both lists will be interpreted as regexes otherwise they will match directly. This doesn’t matter
much for value since there are only a few possible substitution regexes you can use.

- str, regex and numeric rules apply as above.

- dict:

  - Dicts can be used to specify different replacement values for different existing values. For example, {'a': 'b', 'y': 'z'} replaces the value 'a' with 'b' and 'y' with 'z'. To use a dict in this way the value parameter should be None.

  - For a DataFrame a dict can specify that different values should be replaced in different columns. For example, {'a': 1, 'b': 'z'} looks for the value 1 in column 'a' and the value 'z' in column 'b' and replaces these values with whatever is specified in value. The value parameter should not be None in this case. You can treat this as a special case of passing two lists except that you are specifying the column to search in.

  - For a DataFrame nested dictionaries, e.g., {'a': {'b': np.nan}}, are read as follows: look in column 'a' for the value 'b' and replace it with NaN. The value parameter should be None to use a nested dict in this way. You can nest regular expressions as well. Note that column names (the top-level dictionary keys in a nested dictionary) cannot be regular expressions.

- None:

  - This means that the regex argument must be a string, compiled regular expression, or list, dict, ndarray or Series of such elements. If value is also None then this must be a nested dictionary or Series.

See the examples section for examples of each of these.

value : scalar, dict, list, str, regex, default None

Value to replace any values matching to_replace with. For a DataFrame a dict of values can be used to specify which value to use for each column (columns not in the dict will not be filled). Regular expressions, strings and lists or dicts of such objects are also allowed.

inplace : boolean, default False

If True, in place. Note: this will modify any other views on this object (e.g. a column from a DataFrame). Returns the caller if this is True.

limit : int, default None

Maximum size gap to forward or backward fill.

regex : bool or same types as to_replace, default False

Whether to interpret to_replace and/or value as regular expressions. If this is True then to_replace must be a string. Alternatively, this could be a regular expression or a list, dict, or array of regular expressions in which case to_replace must be None.

method : {'pad', ‘ffill’, ‘bfill’, None}

The method to use when for replacement, when to_replace is a scalar, list or tuple and value is None.

Changed in version 0.23.0: Added to DataFrame.

Returns DataFrame
Object after replacement.

**Raises** `AssertionError`

- If `regex` is not a `bool` and `to_replace` is not `None`.

**TypeError**

- If `to_replace` is a `dict` and `value` is not a `list`, `dict`, `ndarray`, or `Series`

- If `to_replace` is `None` and `regex` is not compilable into a regular expression or is a list, `dict`, `ndarray`, or `Series`.

- When replacing multiple `bool` or `datetime64` objects and the arguments to `to_replace` does not match the type of the value being replaced

**ValueError**

- If a `list` or an `ndarray` is passed to `to_replace` and `value` but they are not the same length.

See also:

- `DataFrame.fillna` Fill NA values
- `DataFrame.where` Replace values based on boolean condition
- `Series.str.replace` Simple string replacement.

**Notes**

- Regex substitution is performed under the hood with `re.sub`. The rules for substitution for `re.sub` are the same.

- Regular expressions will only substitute on strings, meaning you cannot provide, for example, a regular expression matching floating point numbers and expect the columns in your frame that have a numeric dtype to be matched. However, if those floating point numbers are strings, then you can do this.

- This method has a lot of options. You are encouraged to experiment and play with this method to gain intuition about how it works.

- When dict is used as the `to_replace` value, it is like key(s) in the dict are the `to_replace` part and value(s) in the dict are the `value` parameter.

**Examples**

**Scalar `to_replace` and `value`**

```python
>>> s = pd.Series([0, 1, 2, 3, 4])
>>> s.replace(0, 5)
0    5
1    1
2    2
3    3
4    4
dtype: int64
```
>>> df = pd.DataFrame({'A': [0, 1, 2, 3, 4],
...                   'B': [5, 6, 7, 8, 9],
...                   'C': ['a', 'b', 'c', 'd', 'e']})

>>> df.replace(0, 5)
   A  B  C
0  5  5  a
1  1  6  b
2  2  7  c
3  3  8  d
4  4  9  e

List-like ‘to_replace’

>>> df.replace([0, 1, 2, 3], 4)
   A  B  C
0  4  5  a
1  4  6  b
2  4  7  c
3  4  8  d
4  4  9  e

>>> df.replace([0, 1, 2, 3], [4, 3, 2, 1])
   A  B  C
0  4  5  a
1  3  6  b
2  2  7  c
3  1  8  d
4  4  9  e

>>> s.replace([1, 2], method='bfill')
    0
0   0
1   3
2   3
3   3
4   4
dtype: int64

dict-like ‘to_replace’

>>> df.replace({0: 10, 1: 100})
   A  B  C
0  10  5  a
1  100 6  b
2  2  7  c
3  3  8  d
4  4  9  e

>>> df.replace({'A': 0, 'B': 5}, 100)
   A  B  C
0  100 100  a
1   1  6  b
2   2  7  c
3   3  8  d
4   4  9  e
Regular expression ‘to_replace’

Note that when replacing multiple bool or datetime64 objects, the data types in the to_replace parameter must match the data type of the value being replaced:

This raises a TypeError because one of the dict keys is not of the correct type for replacement.

Compare the behavior of s.replace({'a': None}) and s.replace('a', None) to understand the peculiarities of the to_replace parameter:
When one uses a dict as the `to_replace` value, it is like the value(s) in the dict are equal to the `value` parameter. `s.replace({'a': None})` is equivalent to `s.replace(to_replace={'a': None}, value=None, method=None):

```python
>>> s.replace({'a': None})
0     10
1    None
2     3
3     b
4    None
dtype: object
```

When `value=None` and `to_replace` is a scalar, list or tuple, `replace` uses the method parameter (default ‘pad’) to do the replacement. So this is why the ‘a’ values are being replaced by 10 in rows 1 and 2 and ‘b’ in row 4 in this case. The command `s.replace('a', None)` is actually equivalent to `s.replace(to_replace='a', value=None, method='pad'):

```python
>>> s.replace('a', None)
0    10
1    10
2    10
3     b
4     b
dtype: object
```

### pandas.DataFrame.resample

`DataFrame.resample()` is a convenience method for frequency conversion and resampling of time series. Object must have a datetime-like index (DatetimeIndex, PeriodIndex, or TimedeltaIndex), or pass datetime-like values to the `on` or `level` keyword.

**Parameters**

- **rule**: string
  
  the offset string or object representing target conversion

- **axis** [int, optional, default 0]

- **closed** : {'right', 'left'}
  
  Which side of bin interval is closed. The default is ‘left’ for all frequency offsets except for ‘M’, ‘A’, ‘Q’, ‘BM’, ‘BA’, ‘BQ’, and ‘W’ which all have a default of ‘right’.

- **label** : {'right', 'left'}
  
  Which bin edge label to label bucket with. The default is ‘left’ for all frequency offsets except for ‘M’, ‘A’, ‘Q’, ‘BM’, ‘BA’, ‘BQ’, and ‘W’ which all have a default of ‘right’.

- **convention** : {'start', 'end', 's', 'e'}
  
  For PeriodIndex only, controls whether to use the start or end of `rule`
kind: {'timestamp', 'period'}, optional

Pass ‘timestamp’ to convert the resulting index to a DateTimeIndex or ‘period’ to convert it to a PeriodIndex. By default the input representation is retained.

loffset : timedelta

Adjust the resampled time labels

base : int, default 0

For frequencies that evenly subdivide 1 day, the “origin” of the aggregated intervals. For example, for ‘5min’ frequency, base could range from 0 through 4. Defaults to 0

on : string, optional

For a DataFrame, column to use instead of index for resampling. Column must be datetime-like.

New in version 0.19.0.

level : string or int, optional

For a MultiIndex, level (name or number) to use for resampling. Level must be datetime-like.

New in version 0.19.0.

Returns

Resampler object

See also:

groupby  Group by mapping, function, label, or list of labels.

Notes

See the user guide for more.

To learn more about the offset strings, please see this link.

Examples

Start by creating a series with 9 one minute timestamps.

```python
>>> index = pd.date_range('1/1/2000', periods=9, freq='T')
>>> series = pd.Series(range(9), index=index)
>>> series
2000-01-01 00:00:00    0
2000-01-01 00:01:00    1
2000-01-01 00:02:00    2
2000-01-01 00:03:00    3
2000-01-01 00:04:00    4
2000-01-01 00:05:00    5
2000-01-01 00:06:00    6
2000-01-01 00:07:00    7
```

(continues on next page)
2000-01-01 00:00:00 8
Freq: T, dtype: int64

Downsample the series into 3 minute bins and sum the values of the timestamps falling into a bin.

```python
>>> series.resample('3T').sum()
2000-01-01 00:00:00 3  
2000-01-01 00:03:00 12 
2000-01-01 00:06:00 21 
Freq: 3T, dtype: int64
```

Downsample the series into 3 minute bins as above, but label each bin using the right edge instead of the left. Please note that the value in the bucket used as the label is not included in the bucket, which it labels. For example, in the original series the bucket 2000-01-01 00:03:00 contains the value 3, but the summed value in the resampled bucket with the label 2000-01-01 00:03:00 does not include 3 (if it did, the summed value would be 6, not 3). To include this value close the right side of the bin interval as illustrated in the example below this one.

```python
>>> series.resample('3T', label='right').sum()
2000-01-01 00:03:00 3  
2000-01-01 00:06:00 12 
2000-01-01 00:09:00 21 
Freq: 3T, dtype: int64
```

Downsample the series into 3 minute bins as above, but close the right side of the bin interval.

```python
>>> series.resample('3T', label='right', closed='right').sum()
2000-01-01 00:00:00 0  
2000-01-01 00:03:00 6  
2000-01-01 00:06:00 15 
2000-01-01 00:09:00 15 
Freq: 3T, dtype: int64
```

Upsample the series into 30 second bins.

```python
>>> series.resample('30S').asfreq()[0:5] #select first 5 rows
2000-01-01 00:00:00 0.0  
2000-01-01 00:00:30 NaN 
2000-01-01 00:01:00 1.0  
2000-01-01 00:01:30 NaN 
2000-01-01 00:02:00 2.0  
Freq: 30S, dtype: float64
```

Upsample the series into 30 second bins and fill the NaN values using the pad method.

```python
>>> series.resample('30S').pad()[0:5]  
2000-01-01 00:00:00 0  
2000-01-01 00:00:30 0  
2000-01-01 00:01:00 1  
2000-01-01 00:01:30 1  
2000-01-01 00:02:00 2  
Freq: 30S, dtype: int64
```

Upsample the series into 30 second bins and fill the NaN values using the bfill method.
Pass a custom function via apply

```python
>>> def custom_resampler(array_like):
...     return np.sum(array_like)+5
```

```python
>>> series.resample('3T').apply(custom_resampler)
    2000-01-01 00:00:00    8
    2000-01-01 00:03:00   17
    2000-01-01 00:06:00   26
Freq: 3T, dtype: int64
```

For a Series with a PeriodIndex, the keyword `convention` can be used to control whether to use the start or end of `rule`.

```python
>>> s = pd.Series([1, 2], index=pd.period_range('2012-01-01', freq='A', periods=2))
```

```python
>>> s
2012    1
2013    2
Freq: A-DEC, dtype: int64
```

Resample by month using `start` `convention`. Values are assigned to the first month of the period.

```python
>>> s.resample('M', convention='start').asfreq().head()
    2012-01 1.0
    2012-02 NaN
    2012-03 NaN
    2012-04 NaN
    2012-05 NaN
Freq: M, dtype: float64
```

Resample by month using `end` `convention`. Values are assigned to the last month of the period.

```python
>>> s.resample('M', convention='end').asfreq()
    2012-12 1.0
    2013-01 NaN
    2013-02 NaN
    2013-03 NaN
    2013-04 NaN
    2013-05 NaN
    2013-06 NaN
    2013-07 NaN
    2013-08 NaN
    2013-09 NaN
    2013-10 NaN
    2013-11 NaN
    2013-12 2.0
Freq: M, dtype: float64
```
For DataFrame objects, the keyword `on` can be used to specify the column instead of the index for resampling.

```python
>>> df = pd.DataFrame(data=9*[range(4)], columns=['a', 'b', 'c', 'd'])
>>> df['time'] = pd.date_range('1/1/2000', periods=9, freq='T')
>>> df.resample('3T', on='time').sum()
         a    b    c    d
time
2000-01-01 00:00:00  0  3  6  9
2000-01-01 00:03:00  0  3  6  9
2000-01-01 00:06:00  0  3  6  9
```

For a DataFrame with MultiIndex, the keyword `level` can be used to specify on level the resampling needs to take place.

```python
>>> time = pd.date_range('1/1/2000', periods=5, freq='T')
>>> df2 = pd.DataFrame(data=10*[range(4)],
                     columns=['a', 'b', 'c', 'd'],
                     index=pd.MultiIndex.from_product([time, [1, 2]]))
>>> df2.resample('3T', level=0).sum()
         a    b    c    d
2000-01-01 00:00:00  0  6 12 18
2000-01-01 00:03:00  0  4  8 12
```

**pandas.DataFrame.reset_index**

DataFrame.reset_index(level=None, drop=False, inplace=False, col_level=0, col_fill="")

For DataFrame with multi-level index, return new DataFrame with labeling information in the columns under the index names, defaulting to ‘level_0’, ‘level_1’, etc. if any are None. For a standard index, the index name will be used (if set), otherwise a default ‘index’ or ‘level_0’ (if ‘index’ is already taken) will be used.

**Parameters**

- **level**: int, str, tuple, or list, default None
  Only remove the given levels from the index. Removes all levels by default

- **drop**: boolean, default False
  Do not try to insert index into dataframe columns. This resets the index to the default integer index.

- **inplace**: boolean, default False
  Modify the DataFrame in place (do not create a new object)

- **col_level**: int or str, default 0
  If the columns have multiple levels, determines which level the labels are inserted into. By default it is inserted into the first level.

- **col_fill**: object, default ""
  If the columns have multiple levels, determines how the other levels are named. If None then the index name is repeated.

**Returns**

- **resetted**: [DataFrame]
Examples

```python
def = pd.DataFrame([('bird', 389.0),
                   ('bird', 24.0),
                   ('mammal', 80.5),
                   ('mammal', np.nan)],
                   index=['falcon', 'parrot', 'lion', 'monkey'],
                   columns=('class', 'max_speed'))
def
```

When we reset the index, the old index is added as a column, and a new sequential index is used:

```python
def.reset_index()
def.reset_index(drop=True)
```

We can use the `drop` parameter to avoid the old index being added as a column:

```python
def.reset_index(drop=True)
```

You can also use `reset_index` with `MultiIndex`.

```python
index = pd.MultiIndex.from_tuples([('bird', 'falcon'),
                                    ('bird', 'parrot'),
                                    ('mammal', 'lion'),
                                    ('mammal', 'monkey')],
                                    names=['class', 'name'])
columns = pd.MultiIndex.from_tuples([('speed', 'max'),
                                      ('species', 'type')])
def = pd.DataFrame([(389.0, 'fly'),
                    ( 24.0, 'fly'),
                    ( 80.5, 'run'),
                    (np.nan, 'jump')],
                    index=index,
                    columns=columns)
def
```

If the index has multiple levels, we can reset a subset of them:
If we are not dropping the index, by default, it is placed in the top level. We can place it in another level:

```python
>>> df.reset_index(level='class', col_level=1)
```

<table>
<thead>
<tr>
<th>speed species</th>
<th>class</th>
<th>max</th>
<th>type</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>falcon</td>
<td>bird</td>
<td>389.0</td>
<td>fly</td>
</tr>
<tr>
<td>parrot</td>
<td>bird</td>
<td>24.0</td>
<td>fly</td>
</tr>
<tr>
<td>lion</td>
<td>mammal</td>
<td>80.5</td>
<td>run</td>
</tr>
<tr>
<td>monkey</td>
<td>mammal</td>
<td>NaN</td>
<td>jump</td>
</tr>
</tbody>
</table>

When the index is inserted under another level, we can specify under which one with the parameter `col_fill`:

```python
>>> df.reset_index(level='class', col_level=1, col_fill='species')
```

<table>
<thead>
<tr>
<th>species speed species</th>
<th>class</th>
<th>max</th>
<th>type</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>falcon</td>
<td>bird</td>
<td>389.0</td>
<td>fly</td>
</tr>
<tr>
<td>parrot</td>
<td>bird</td>
<td>24.0</td>
<td>fly</td>
</tr>
<tr>
<td>lion</td>
<td>mammal</td>
<td>80.5</td>
<td>run</td>
</tr>
<tr>
<td>monkey</td>
<td>mammal</td>
<td>NaN</td>
<td>jump</td>
</tr>
</tbody>
</table>

If we specify a nonexistent level for `col_fill`, it is created:

```python
>>> df.reset_index(level='class', col_level=1, col_fill='genus')
```

<table>
<thead>
<tr>
<th>genus speed species</th>
<th>class</th>
<th>max</th>
<th>type</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>falcon</td>
<td>bird</td>
<td>389.0</td>
<td>fly</td>
</tr>
<tr>
<td>parrot</td>
<td>bird</td>
<td>24.0</td>
<td>fly</td>
</tr>
<tr>
<td>lion</td>
<td>mammal</td>
<td>80.5</td>
<td>run</td>
</tr>
<tr>
<td>monkey</td>
<td>mammal</td>
<td>NaN</td>
<td>jump</td>
</tr>
</tbody>
</table>

**pandas.DataFrame.rfloordiv**

`DataFrame.rfloordiv(other, axis='columns', level=None, fill_value=None)`  
Integer division of dataframe and other, element-wise (binary operator `rfloordiv`).  
Equivalent to `other // dataframe`, but with support to substitute a fill_value for missing data in one of the inputs.

**Parameters**

- **other** [Series, DataFrame, or constant]  
- **axis** : {0, 1, ‘index’, ‘columns’}
  
For Series input, axis to match Series index on
**level**: int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

**fill_value**: None or float value, default None

Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing

**Returns**

result [DataFrame]

**See also:**

*DataFrame.floordiv*

**Notes**

Mismatched indices will be unioned together

**Examples**

None

**pandas.DataFrame.rmod**

```
DataFrame.rmod(other, axis='columns', level=None, fill_value=None)
```

Modulo of dataframe and other, element-wise (binary operator rmod).

Equivalent to `other % dataframe`, but with support to substitute a fill_value for missing data in one of the inputs.

**Parameters**

- **other** [Series, DataFrame, or constant]
- **axis**: {0, 1, ‘index’, ‘columns’}
  - For Series input, axis to match Series index on
- **level**: int or name
  - Broadcast across a level, matching Index values on the passed MultiIndex level
- **fill_value**: None or float value, default None
  - Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing

**Returns**

result [DataFrame]

**See also:**

*DataFrame.mod*
Notes

Mismatched indices will be unioned together

Examples

None

pandas.DataFrame.rmul

DataFrame.rmul(other, axis='columns', level=None, fill_value=None)

Multiplication of dataframe and other, element-wise (binary operator rmul).
 Equivalent to other * dataframe, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters

other [Series, DataFrame, or constant]
axis : {0, 1, ‘index’, ‘columns’}
   For Series input, axis to match Series index on
level : int or name
   Broadcast across a level, matching Index values on the passed MultiIndex level
fill_value : None or float value, default None
   Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing

Returns

result [DataFrame]

See also:

DataFrame.mul

Notes

Mismatched indices will be unioned together

Examples

None

pandas.DataFrame.rolling

DataFrame.rolling(window, min_periods=None, center=False, win_type=None, on=None, axis=0, closed=None)

Provides rolling window calculations.
New in version 0.18.0.

**Parameters**

window : int, or offset

Size of the moving window. This is the number of observations used for calculating the statistic. Each window will be a fixed size.

If its an offset then this will be the time period of each window. Each window will be a variable sized based on the observations included in the time-period. This is only valid for datetimelike indexes. This is new in 0.19.0

min_periods : int, default None

Minimum number of observations in window required to have a value (otherwise result is NA). For a window that is specified by an offset, this will default to 1.

center : boolean, default False

Set the labels at the center of the window.

win_type : string, default None

Provide a window type. If None, all points are evenly weighted. See the notes below for further information.

on : string, optional

For a DataFrame, column on which to calculate the rolling window, rather than the index

closed : string, default None

Make the interval closed on the ‘right’, ‘left’, ‘both’ or ‘neither’ endpoints. For offset-based windows, it defaults to ‘right’. For fixed windows, defaults to ‘both’. Remaining cases not implemented for fixed windows.

New in version 0.20.0.

axis [int or string, default 0]

**Returns**

a Window or Rolling sub-classed for the particular operation

**See also:**

* expanding Provides expanding transformations. 
* ewm Provides exponential weighted functions

**Notes**

By default, the result is set to the right edge of the window. This can be changed to the center of the window by setting center=True.

To learn more about the offsets & frequency strings, please see [this link](#).

The recognized win_types are:

* boxcar
* triang
* blackman
• hamming
• bartlett
• parzen
• bohman
• blackmanharris
• nuttall
• barthann
• kaiser (needs beta)
• gaussian (needs std)
• general_gaussian (needs power, width)
• slepian (needs width).

If win_type=None all points are evenly weighted. To learn more about different window types see scipy.signal window functions.

Examples

```python
>>> df = pd.DataFrame({'B': [0, 1, 2, np.nan, 4]})
>>> df
   B
0  0.0
1  1.0
2  2.0
3  NaN
4  4.0
```

Rolling sum with a window length of 2, using the ‘triang’ window type.

```python
>>> df.rolling(2, win_type='triang').sum()
   B
0  NaN
1  1.0
2  2.5
3  NaN
4  NaN
```

Rolling sum with a window length of 2, min_periods defaults to the window length.

```python
>>> df.rolling(2).sum()
   B
0  NaN
1  1.0
2  3.0
3  NaN
4  NaN
```

Same as above, but explicitly set the min_periods
A ragged (meaning not-a-regular frequency), time-indexed DataFrame

```python
>>> df = pd.DataFrame({'B': [0, 1, 2, np.nan, 4]},
                    index=[pd.Timestamp('20130101 09:00:00'),
                           pd.Timestamp('20130101 09:00:02'),
                           pd.Timestamp('20130101 09:00:03'),
                           pd.Timestamp('20130101 09:00:05'),
                           pd.Timestamp('20130101 09:00:06')])
>>> df
B
2013-01-01 09:00:00 0.0
2013-01-01 09:00:02 1.0
2013-01-01 09:00:03 2.0
2013-01-01 09:00:05 NaN
2013-01-01 09:00:06 4.0
```

Contrasting to an integer rolling window, this will roll a variable length window corresponding to the time period. The default for `min_periods` is 1.

```python
>>> df.rolling('2s').sum()
B
2013-01-01 09:00:00 0.0
2013-01-01 09:00:02 1.0
2013-01-01 09:00:03 3.0
2013-01-01 09:00:05 NaN
2013-01-01 09:00:06 4.0
```

### pandas.DataFrame.round

DataFrames have a `round` method that rounds each value to a specified number of decimal places. This method is different from the Python built-in `round` function.

#### `DataFrame.round`

`DataFrame.round(decimals=0, *args, **kwargs)`

Round a DataFrame to a variable number of decimal places.

**Parameters**

- `decimals` : int, dict, Series
  - Number of decimal places to round each column to. If an int is given, round each column to the same number of places. Otherwise dict and Series round to variable numbers of places. Column names should be in the keys if `decimals` is a dict-like, or in the index if `decimals` is a Series. Any columns not included in `decimals` will be left as is. Elements of `decimals` which are not columns of the input will be ignored.

**Returns**

DataFrame object

See also:

- `numpy.around`
- `Series.round`
Examples

>>> df = pd.DataFrame(np.random.random([3, 3]),
...                   columns=['A', 'B', 'C'], index=['first', 'second', 'third'])
>>> df
    A    B    C
first  0.028208  0.992815  0.173891
second  0.038683  0.645646  0.577595
third  0.877076  0.149370  0.491027

>>> df.round(2)
    A  B  C
first  0.03  0.99  0.17
second  0.04  0.65  0.58
third  0.88  0.15  0.49

>>> df.round({'A': 1, 'C': 2})
    A  B  C
first  0.0  0.992815  0.17
second  0.0  0.645646  0.58
third  0.9  0.149370  0.49

>>> decimals = pd.Series([1, 0, 2], index=['A', 'B', 'C'])

>>> df.round(decimals)
    A  B  C
first  0.0  1.0  0.17
second  0.0  1.0  0.58
third  0.9  0.0  0.49

pandas.DataFrame.rpow

DataFrame.rpow(other, axis='columns', level=None, fill_value=None)
Exponential power of dataframe and other, element-wise (binary operator rpow).

Equivalent to other ** dataframe, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters

    other [Series, DataFrame, or constant]

    axis : {0, 1, ‘index’, ‘columns’}

        For Series input, axis to match Series index on

    level : int or name

        Broadcast across a level, matching Index values on the passed MultiIndex level

    fill_value : None or float value, default None

        Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing

Returns

    result [DataFrame]

See also:

    DataFrame.pow
Notes

Mismatched indices will be unioned together

Examples

None

pandas.DataFrame.rsub

datetime.timedelta

Subtraction of dataframe and other, element-wise (binary operator rsub).

Equivalent to other - dataframe, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters

other [Series, DataFrame, or constant]

axis : {0, 1, ‘index’, ‘columns’}

For Series input, axis to match Series index on

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

fill_value : None or float value, default None

Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing

Returns

result [DataFrame]

See also:

datetime.timedelta

Notes

Mismatched indices will be unioned together

Examples

>>> a = pd.DataFrame([2, 1, 1, np.nan], index=['a', 'b', 'c', 'd'],
... columns=['one'])

>>> a
  one
a  2.0
b  1.0
c  1.0
d  NaN

(continues on next page)
b = pd.DataFrame(dict(one=[1, np.nan, 1, np.nan],
    ...  two=[3, 2, np.nan, 2]),
    ...  index=['a', 'b', 'd', 'e'])

a.sub(b, fill_value=0)

pandas.DataFrame.rtruediv

DataFrame.rtruediv(other, axis='columns', level=None, fill_value=None)

Floating division of dataframe and other, element-wise (binary operator rtruediv).
Equivalent to other / dataframe, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters
other [Series, DataFrame, or constant]
axis : {0, 1, ‘index’, ‘columns’}
For Series input, axis to match Series index on
level : int or name
Broadcast across a level, matching Index values on the passed MultiIndex level
fill_value : None or float value, default None
Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing

Returns
result [DataFrame]

See also:
DataFrame.truediv

Notes
Mismatched indices will be unioned together
Examples

None

pandas.DataFrame.sample

DataFrame.sample(n=None, frac=None, replace=False, weights=None, random_state=None, axis=None)

Return a random sample of items from an axis of object.

You can use random_state for reproducibility.

Parameters

- **n** : int, optional
  - Number of items from axis to return. Cannot be used with frac. Default = 1 if frac = None.
- **frac** : float, optional
  - Fraction of axis items to return. Cannot be used with n.
- **replace** : boolean, optional
  - Sample with or without replacement. Default = False.
- **weights** : str or ndarray-like, optional
  - Default ‘None’ results in equal probability weighting. If passed a Series, will align with target object on index. Index values in weights not found in sampled object will be ignored and index values in sampled object not in weights will be assigned weights of zero. If called on a DataFrame, will accept the name of a column when axis = 0. Unless weights are a Series, weights must be same length as axis being sampled. If weights do not sum to 1, they will be normalized to sum to 1. Missing values in the weights column will be treated as zero. inf and -inf values not allowed.
- **random_state** : int or numpy.random.RandomState, optional
  - Seed for the random number generator (if int), or numpy RandomState object.
- **axis** : int or string, optional
  - Axis to sample. Accepts axis number or name. Default is stat axis for given data type (0 for Series and DataFrames, 1 for Panels).

Returns

A new object of same type as caller.

Examples

Generate an example Series and DataFrame:

```python
>>> s = pd.Series(np.random.randn(50))
>>> s.head()
0  -0.038497
1   1.820773
2  -0.972766
3  -1.598270
34.4. DataFrame
```

(continues on next page)
Next extract a random sample from both of these objects...

3 random elements from the `Series`:

```python
>>> s.sample(n=3)
27 -0.994689
55 -1.049016
67 -0.224565
dtype: float64
```

And a random 10% of the `DataFrame` with replacement:

```python
>>> df.sample(frac=0.1, replace=True)
A    B    C    D
35  1.981780  0.142106  1.817165 -0.290805
49 -1.336199 -0.448634 -0.789640  0.217116
40  0.823173 -0.078816  1.009536  1.015108
15  1.421154 -0.055301 -1.922594 -0.019696
  6 -0.148339  0.832938  1.787600 -1.383767
dtype: float64
```

You can use `random state` for reproducibility:

```python
>>> df.sample(random_state=1)
A    B    C    D
37 -2.027662  0.103611  0.237496 -0.165867
43 -0.259323 -0.583426  1.516140 -0.479118
12 -1.686325 -0.579510  0.985195 -0.460286
  8  1.167946  0.429082  1.215742 -1.636041
  9  1.197475 -0.864188  1.554031 -1.505264
dtype: float64
```

### pandas.DataFrame.select

DataFrame.select(crit, axis=0)

Return data corresponding to axis labels matching criteria

Deprecated since version 0.21.0: Use `df.loc[df.index.map(crit)]` to select via labels

**Parameters**

- **crit**: function
  
  To be called on each index (label). Should return True or False

- **axis**: [int]

**Returns**

- **selection**: [type of caller]
DataFrame.select_dtypes

DataFrame.select_dtypes(include=None, exclude=None)
Return a subset of the DataFrame’s columns based on the column dtypes.

Parameters include, exclude : scalar or list-like
A selection of dtypes or strings to be included/excluded. At least one of these parameters must be supplied.

Returns subset : DataFrame
The subset of the frame including the dtypes in include and excluding the dtypes in exclude.

Raises ValueError
• If both of include and exclude are empty
• If include and exclude have overlapping elements
• If any kind of string dtype is passed in.

Notes
• To select all numeric types, use np.number or 'number'
• To select strings you must use the object dtype, but note that this will return all object dtype columns
• See the numpy dtype hierarchy
• To select datetimes, use np.datetime64, 'datetime' or 'datetime64'
• To select timedeltas, use np.timedelta64, 'timedelta' or 'timedelta64'
• To select Pandas categorical dtypes, use 'category'
• To select Pandas datetimetz dtypes, use 'datetimetz' (new in 0.20.0) or 'datetime64[ns, tz]'

Examples

```python
>>> df = pd.DataFrame({'a': [1, 2] * 3,
...                    'b': [True, False] * 3,
...                    'c': [1.0, 2.0] * 3})
>>> df
          a    b     c
0       1.0  True  1.0
1       2.0  False  2.0
2       1.0  True  1.0
3       2.0  False  2.0
4       1.0  True  1.0
5       2.0  False  2.0
>>> df.select_dtypes(include='bool')
   b
0 True
```
pandas: powerful Python data analysis toolkit, Release 0.23.2

(continued from previous page)

```python
1     False
2      True
3     False
4      True
5     False
```

```python
df.select_dtypes(include=['float64'])
```

``` MARKDOWN
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0</td>
</tr>
<tr>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>2.0</td>
</tr>
<tr>
<td>4</td>
<td>1.0</td>
</tr>
<tr>
<td>5</td>
<td>2.0</td>
</tr>
</tbody>
</table>
```

```python
df.select_dtypes(exclude=['int'])
```

``` MARKDOWN
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>True</td>
<td>1.0</td>
</tr>
<tr>
<td>1</td>
<td>False</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>True</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>False</td>
<td>2.0</td>
</tr>
<tr>
<td>4</td>
<td>True</td>
<td>1.0</td>
</tr>
<tr>
<td>5</td>
<td>False</td>
<td>2.0</td>
</tr>
</tbody>
</table>
```

**pandas.DataFrame.sem**

DataFrame.sem(axis=None, skipna=None, level=None, ddof=1, numeric_only=None, **kwargs)

Return unbiased standard error of the mean over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument.

**Parameters**

- **axis** [{index (0), columns (1)}]
- **skipna** : boolean, default True
  Exclude NA/null values. If an entire row/column is NA, the result will be NA
- **level** : int or level name, default None
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series
- **ddof** : int, default 1
  Delta Degrees of Freedom. The divisor used in calculations is N - ddof, where N represents the number of elements.
- **numeric_only** : boolean, default None
  Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

- **sem** [Series or DataFrame (if level specified)]
pandas.DataFrame.set_axis

DataFrame.set_axis(labels, axis=0, inplace=None)
Assign desired index to given axis.

Indexes for column or row labels can be changed by assigning a list-like or Index.

Changed in version 0.21.0: The signature is now labels and axis, consistent with the rest of pandas API. Previously, the axis and labels arguments were respectively the first and second positional arguments.

Parameters

- **labels**: list-like, Index
  The values for the new index.
- **axis**: {0 or ‘index’, 1 or ‘columns’}, default 0
  The axis to update. The value 0 identifies the rows, and 1 identifies the columns.
- **inplace**: boolean, default None
  Whether to return a new %(klass)s instance.

Warning: inplace=None currently falls back to to True, but in a future version, will default to False. Use inplace=True explicitly rather than relying on the default.

Returns

- **renamed**: %(klass)s or None
  An object of same type as caller if inplace=False, None otherwise.

See also:

pandas.DataFrame.rename_axis Alter the name of the index or columns.

Examples

Series

```python
>>> s = pd.Series([1, 2, 3])
>>> s
0  1
1  2
2  3
dtype: int64
```

```python
>>> s.set_axis(['a', 'b', 'c'], axis=0, inplace=False)
a  1
b  2
c  3
dtype: int64
```

The original object is not modified.

```python
>>> s
0  1
1  2
```
2 3  
dtype: int64

**DataFrame**

```python
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
```

Change the row labels.

```python
>>> df.set_axis(['a', 'b', 'c'], axis='index', inplace=False)

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>2</td>
</tr>
<tr>
<td>c</td>
<td>3</td>
</tr>
</tbody>
</table>
```

Change the column labels.

```python
>>> df.set_axis(['I', 'II'], axis='columns', inplace=False)

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
```

Now, update the labels inplace.

```python
>>> df.set_axis(['i', 'ii'], axis='columns', inplace=True)

<table>
<thead>
<tr>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
```

**pandas.DataFrame.set_index**

DataFrame.set_index *(keys, drop=True, append=False, inplace=False, verify_integrity=False)*  

Set the DataFrame index (row labels) using one or more existing columns. By default yields a new object.

**Parameters**

- **keys** [column label or list of column labels / arrays]
- **drop** : boolean, default True  
  Delete columns to be used as the new index
- **append** : boolean, default False  
  Whether to append columns to existing index
- **inplace** : boolean, default False  
  Modify the DataFrame in place (do not create a new object)
- **verify_integrity** : boolean, default False  
  Check the new index for duplicates. Otherwise defer the check until necessary. Setting to False will improve the performance of this method

**Returns**
dataframe  [DataFrame]

Examples

```python
>>> df = pd.DataFrame({'month': [1, 4, 7, 10],
... 'year': [2012, 2014, 2013, 2014],
... 'sale':[55, 40, 84, 31]})

month  sale  year
0  1      55  2012
1  4      40  2014
2  7      84  2013
3  10     31  2014

Set the index to become the ‘month’ column:

```python
>>> df.set_index('month')

sale  year
month
1  55  2012
4  40  2014
7  84  2013
10 31  2014

Create a multi-index using columns ‘year’ and ‘month’:

```python
>>> df.set_index(['year', 'month'])

sale
year  month
2012  1   55
2014  4   40
2013  7   84
2014 10  31

Create a multi-index using a set of values and a column:

```python
>>> df.set_index([[1, 2, 3, 4], 'year'])

month  sale
year
1  2012  1   55
2  2014  4   40
3  2013  7   84
4  2014 10  31
```

pandas.DataFrame.set_value

DataFrame.set_value(index, col, value, takeable=False)

Put single value at passed column and index

Deprecated since version 0.21.0: Use .at[] or .iat[] accessors instead.

Parameters

- **index**  [row label]
- **col**    [column label]
- **value**  [scalar value]
**takeable**  [interpret the index/col as indexers, default False]

**Returns**  
**frame** : DataFrame

If label pair is contained, will be reference to calling DataFrame, otherwise a new object

---

**pandas.DataFrame.shift**

DataFrame.**(periods=1, freq=None, axis=0)**

Shift index by desired number of periods with an optional time freq

**Parameters**

- **periods** : int
  Number of periods to move, can be positive or negative
- **freq** : DateOffset, timedelta, or time rule string, optional
  Increment to use from the tseries module or time rule (e.g. ‘EOM’). See Notes.
- **axis** : [(0 or ‘index’, 1 or ‘columns’)]

**Returns**

**shifted**  [DataFrame]

**Notes**

If freq is specified then the index values are shifted but the data is not realigned. That is, use freq if you would like to extend the index when shifting and preserve the original data.

---

**pandas.DataFrame.skew**

DataFrame.**(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)**

Return unbiased skew over requested axis Normalized by N-1

**Parameters**

- **axis** : [(index (0), columns (1))]
- **skipna** : boolean, default True
  Exclude NA/null values when computing the result.
- **level** : int or level name, default None
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series
- **numeric_only** : boolean, default None
  Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

**skew**  [Series or DataFrame (if level specified)]
### pandas.DataFrame.slice_shift

*DataFrame.slice_shift*(periods=1, axis=0)

Equivalent to *shift* without copying data. The shifted data will not include the dropped periods and the shifted axis will be smaller than the original.

**Parameters**
- **periods**: int
  - Number of periods to move, can be positive or negative

**Returns**
- **shifted**: [same type as caller]

**Notes**

While the *slice_shift* is faster than *shift*, you may pay for it later during alignment.

### pandas.DataFrame.sort_index

*DataFrame.sort_index*(axis=0, level=None, ascending=True, inplace=False, kind='quicksort', na_position='last', sort_remaining=True, by=None)

Sort object by labels (along an axis)

**Parameters**
- **axis**: [index, columns to direct sorting]
- **level**: int or level name or list of ints or list of level names
  - if not None, sort on values in specified index level(s)
- **ascending**: boolean, default True
  - Sort ascending vs. descending
- **inplace**: bool, default False
  - if True, perform operation in-place
- **kind**: {'quicksort', 'mergesort', 'heapsort'}, default 'quicksort'
  - Choice of sorting algorithm. See also *ndarray.np.sort* for more information. *mergesort* is the only stable algorithm. For DataFrames, this option is only applied when sorting on a single column or label.
- **na_position**: {'first', 'last'}, default 'last'
  - first puts NaNs at the beginning, last puts NaNs at the end. Not implemented for *MultiIndex*.
- **sort_remaining**: bool, default True
  - if true and sorting by level and index is multilevel, sort by other levels too (in order) after sorting by specified level

**Returns**
- **sorted_obj**: [DataFrame]
pandas.DataFrame.sort_values

DataFrame.sort_values(by, axis=0, ascending=True, inplace=False, kind='quicksort', na_position='last')

Sort by the values along either axis

Parameters by : str or list of str

Name or list of names to sort by.

• if axis is 0 or ‘index’ then by may contain index levels and/or column labels

• if axis is 1 or ‘columns’ then by may contain column levels and/or index labels

Changed in version 0.23.0: Allow specifying index or column level names.

axis : {0 or ‘index’, 1 or ‘columns’}, default 0

Axis to be sorted

ascending : bool or list of bool, default True

Sort ascending vs. descending. Specify list for multiple sort orders. If this is a list of bools, must match the length of the by.

inplace : bool, default False

if True, perform operation in-place

kind : {'quicksort', 'mergesort', 'heapsort'}, default ‘quicksort’

Choice of sorting algorithm. See also ndarray.np.sort for more information. mergesort is the only stable algorithm. For DataFrames, this option is only applied when sorting on a single column or label.

na_position : {'first', 'last'}, default ‘last’

first puts NaNs at the beginning, last puts NaNs at the end

Returns

sorted_obj [DataFrame]

Examples

```python
>>> df = pd.DataFrame({
...     'col1': ['A', 'A', 'B', np.nan, 'D', 'C'],
...     'col2': [2, 1, 9, 8, 7, 4],
...     'col3': [0, 1, 9, 4, 2, 3],
... })
>>> df
   col1  col2  col3
0    A     2     0
1    A     1     1
2    B     9     9
3  NaN    8     4
4    D     7     2
5    C     4     3
```

Sort by col1
>>> df.sort_values(by=['col1'])
  col1  col2  col3
0    A     2     0
1    A     1     1
2    B     9     9
5    C     4     3
4    D     7     2
3  NaN    8     4

Sort by multiple columns

>>> df.sort_values(by=['col1', 'col2'])
  col1  col2  col3
1    A     1     1
0    A     2     0
2    B     9     9
5    C     4     3
4    D     7     2
3  NaN    8     4

Sort Descending

>>> df.sort_values(by='col1', ascending=False)
  col1  col2  col3
4    D     7     2
5    C     4     3
2    B     9     9
0    A     2     0
1    A     1     1
3  NaN    8     4

Putting NAs first

>>> df.sort_values(by='col1', ascending=False, na_position='first')
  col1  col2  col3
3  NaN    8     4
4    D     7     2
5    C     4     3
2    B     9     9
0    A     2     0
1    A     1     1

**pandas.DataFrame.sortlevel**

DataFrame.sortlevel(level=0, axis=0, ascending=True, inplace=False, sort_remaining=True)
Sort multilevel index by chosen axis and primary level. Data will be lexicographically sorted by the
chosen level followed by the other levels (in order).

Deprecated since version 0.20.0: Use **DataFrame.sort_index()**

**Parameters**

- **level** [int]
- **axis** [{0 or 'index', 1 or 'columns'}, default 0]
- **ascending** [boolean, default True]
pandas.DataFrame.sort_values

```
inplace : boolean, default False
    Sort the DataFrame without creating a new instance
sort_remaining : boolean, default True
    Sort by the other levels too.

Returns
    sorted [DataFrame]

See also:
    DataFrame.sort_index
```

pandas.DataFrame.squeeze

```
DataFrame.squeeze (axis=None)
    Squeeze length 1 dimensions.

Parameters axis : None, integer or string axis name, optional
    The axis to squeeze if 1-sized.

New in version 0.20.0.

Returns
    scalar if 1-sized, else original object
```

pandas.DataFrame.stack

```
DataFrame.stack (level=-1, dropna=True)
    Stack the prescribed level(s) from columns to index.

Return a reshaped DataFrame or Series having a multi-level index with one or more new inner-most levels compared to the current DataFrame. The new inner-most levels are created by pivoting the columns of the current dataframe:

• if the columns have a single level, the output is a Series;
• if the columns have multiple levels, the new index level(s) is (are) taken from the prescribed level(s) and the output is a DataFrame.

The new index levels are sorted.

Parameters level : int, str, list, default -1
    Level(s) to stack from the column axis onto the index axis, defined as one index or label, or a list of indices or labels.

dropna : bool, default True
    Whether to drop rows in the resulting Frame/Series with missing values. Stacking a column level onto the index axis can create combinations of index and column values that are missing from the original dataframe. See Examples section.

Returns DataFrame or Series
    Stacked dataframe or series.

See also:
```
**DataFrame.unstack**  Unstack prescribed level(s) from index axis onto column axis.

**DataFrame.pivot**  Reshape dataframe from long format to wide format.

**DataFrame.pivot_table**  Create a spreadsheet-style pivot table as a DataFrame.

**Notes**

The function is named by analogy with a collection of books being re-organised from being side by side on a horizontal position (the columns of the dataframe) to being stacked vertically on top of each other (in the index of the dataframe).

**Examples**

**Single level columns**

```
>>> df_single_level_cols = pd.DataFrame([[0, 1], [2, 3]],
...                                       index=['cat', 'dog'],
...                                       columns=['weight', 'height'])
```

Stacking a dataframe with a single level column axis returns a Series:

```
>>> df_single_level_cols
   weight  height
cat      0       1
dog      2       3

>>> df_single_level_cols.stack()
   weight  height
cat          0       1
            height  1
dog          2       3
            height  3
dtype: int64
```

**Multi level columns: simple case**

```
>>> multicoll = pd.MultiIndex.from_tuples([('weight', 'kg'),
...                                          ('weight', 'pounds')])
```

```
>>> df_multi_level_cols1 = pd.DataFrame([[1, 2], [2, 4]],
...                                       index=['cat', 'dog'],
...                                       columns=multicoll)
```

```
>>> df_multi_level_cols1
     weight
    kg  pounds
cat  1       2
dog  2       4
```

```
>>> df_multi_level_cols1.stack()
     weight
    kg  cat  1
          dog  1
          dog  2
    pounds   cat  2
                dog  2
                dog  4
```

**Missing values**
It is common to have missing values when stacking a dataframe with multi-level columns, as the stacked dataframe typically has more values than the original dataframe. Missing values are filled with NaNs:

```python
>>> df_multi_level_cols2

weight  height
kg     m
cat  1.0  2.0
dog  3.0  4.0
```

```python
>>> df_multi_level_cols2.stack()

height  weight
kg      NaN     1.0
m       NaN     NaN
kg      NaN     3.0
m       NaN     NaN
```

### Prescribing the level(s) to be stacked

The first parameter controls which level or levels are stacked:

```python
>>> df_multi_level_cols2.stack(0)

kg     m
cat  1.0  NaN
weight  1.0  NaN
dog  3.0  NaN
```

```python
>>> df_multi_level_cols2.stack([0, 1])

cat  height  weight
kg   2.0     NaN
m    NaN     NaN
kg   4.0     NaN
m    NaN     NaN
dtype: float64
```

### Dropping missing values

Note that rows where all values are missing are dropped by default but this behaviour can be controlled via the dropna keyword parameter:

```python
>>> df_multi_level_cols3 = pd.DataFrame([[None, 1.0], [2.0, 3.0]],
            index=['cat', 'dog'],
            columns=multicol2)
```

```python
>>> df_multi_level_cols3

weight  height
kg     m
cat  NaN  1.0
dog  2.0  3.0
```

```python
>>> df_multi_level_cols3.stack(dropna=False)

height  weight
kg      NaN     NaN
m       1.0     NaN
dog  NaN     2.0
```
m 3.0 NaN
>>> df_multi_level_cols3.stack(dropna=True)

<table>
<thead>
<tr>
<th>height</th>
<th>weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>cat</td>
<td>m</td>
</tr>
<tr>
<td>dog</td>
<td>kg</td>
</tr>
<tr>
<td>m</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**pandas.DataFrame.std**

DataFrame.std (axis=None, skipna=None, level=None, ddof=1, numeric_only=None, **kwargs)

Return sample standard deviation over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument

**Parameters**

axis [index (0), columns (1)]

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

ddof : int, default 1

Delta Degrees of Freedom. The divisor used in calculations is N - ddof, where N represents the number of elements.

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

std [Series or DataFrame (if level specified)]

**pandas.DataFrame.sub**

DataFrame.sub (other, axis='columns', level=None, fill_value=None)

Subtraction of dataframe and other, element-wise (binary operator sub).

Equivalent to dataframe - other, but with support to substitute a fill_value for missing data in one of the inputs.

**Parameters**

other [Series, DataFrame, or constant]

axis : {0, 1, ‘index’, ‘columns’}

For Series input, axis to match Series index on

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level
fill_value : None or float value, default None

Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing

Returns
result [DataFrame]

See also:
DataFrame.rsub

Notes
Mismatched indices will be unioned together

Examples

```python
>>> a = pd.DataFrame([2, 1, 1, np.nan], index=['a', 'b', 'c', 'd'],
                   columns=['one'])
>>> a
   one
a  2.0
b  1.0
c  1.0
d  NaN
>>> b = pd.DataFrame(dict(one=[1, np.nan, 1, np.nan],
                        two=[3, 2, np.nan, 2]),
                   index=['a', 'b', 'd', 'e'])
>>> b
   one  two
a  1.0  3.0
b  NaN  2.0
d  1.0  NaN
e  NaN  2.0
>>> a.sub(b, fill_value=0)
   one  two
a  1.0 -3.0
b  1.0 -2.0
c  1.0  NaN
d -1.0  NaN
e  NaN -2.0
```

pandas.DataFrame.subtract

DataFrame.\texttt{subtract} (other, axis='columns', level=None, fill_value=None)
Subtraction of dataframe and other, element-wise (binary operator sub).
Equivalent to dataframe - other, but with support to substitute a fill_value for missing data in one of the inputs.

Parameters

- other [Series, DataFrame, or constant]
axis : {0, 1, ‘index’, ‘columns’}

For Series input, axis to match Series on

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

fill_value : None or float value, default None

Fill existing missing (NaN) values, and any new element needed for successful
DataFrame alignment, with this value before computation. If data in both corre-
sponding DataFrame locations is missing the result will be missing

Returns

result [DataFrame]

See also:

DataFrame.rsub

Notes

Mismatched indices will be unioned together

Examples

```python
>>> a = pd.DataFrame([2, 1, 1, np.nan], index=['a', 'b', 'c', 'd'],
...                     columns=['one'])
>>> a
   one
a  2.0
b  1.0
c  1.0
d  NaN
>>> b = pd.DataFrame(dict(one=[1, np.nan, 1, np.nan],
...                        two=[3, 2, np.nan, 2]),
...                  index=['a', 'b', 'd', 'e'])
>>> b
    one   two
a   1.0   3.0
b  NaN   2.0
d   1.0  NaN
e  NaN   2.0
>>> a.sub(b, fill_value=0)
    one   two
a   1.0  -3.0
b   1.0  -2.0
c   1.0   NaN
d  -1.0  NaN
e  NaN  -2.0
```
pandas.DataFrame.sum

DataFrame.sum(axis=None, skipna=None, level=None, numeric_only=None, min_count=0, **kwargs)

Return the sum of the values for the requested axis

Parameters

axis [{index (0), columns (1)}]

skipna : boolean, default True

Exclude NA/null values when computing the result.

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

min_count : int, default 0

The required number of valid values to perform the operation. If fewer than min_count non-NA values are present the result will be NA.

New in version 0.22.0: Added with the default being 0. This means the sum of an all-NA or empty Series is 0, and the product of an all-NA or empty Series is 1.

Returns

sum  [Series or DataFrame (if level specified)]

Examples

By default, the sum of an empty or all-NA Series is 0.

```python
>>> pd.Series([]).sum()  # min_count=0 is the default
0.0
```

This can be controlled with the min_count parameter. For example, if you’d like the sum of an empty series to be NaN, pass min_count=1.

```python
>>> pd.Series([]).sum(min_count=1)
nan
```

Thanks to the skipna parameter, min_count handles all-NA and empty series identically.

```python
>>> pd.Series([np.nan]).sum()
0.0
```

```python
>>> pd.Series([np.nan]).sum(min_count=1)
nan
```
pandas.DataFrame.swapaxes

DataFrame.swapaxes (axis1, axis2, copy=True)
Interchange axes and swap values axes appropriately

Returns

y [same as input]

pandas.DataFrame.swaplevel

DataFrame.swaplevel (i=-2, j=-1, axis=0)
Swap levels i and j in a MultiIndex on a particular axis

Parameters i, j: int, string (can be mixed)
Level of index to be swapped. Can pass level name as string.

Returns

swapped [type of caller (new object)]
.. versionchanged:: 0.18.1
The indexes i and j are now optional, and default to the two innermost levels of the index.

pandas.DataFrame.tail

DataFrame.tail(n=5)
Return the last n rows.

This function returns last n rows from the object based on position. It is useful for quickly verifying data, for example, after sorting or appending rows.

Parameters n: int, default 5
Number of rows to select.

Returns type of caller
The last n rows of the caller object.

See also:

pandas.DataFrame.head The first n rows of the caller object.

Examples

```python
>>> df = pd.DataFrame({'animal': ['alligator', 'bee', 'falcon', 'lion',
...                        'monkey', 'parrot', 'shark', 'whale', 'zebra']})
>>> df
   animal
0  alligator
1       bee
2    falcon
3      lion
```
Viewing the last 5 lines

```python
>>> df.tail()
   animal
4  monkey
5  parrot
6  shark
7  whale
8  zebra
```

Viewing the last $n$ lines (three in this case)

```python
>>> df.tail(3)
   animal
6  shark
7  whale
8  zebra
```

**pandas.DataFrame.take**

`DataFrame.take(indices, axis=0, convert=None, is_copy=True, **kwargs)`

Return the elements in the given *positional* indices along an axis.

This means that we are not indexing according to actual values in the index attribute of the object. We are indexing according to the actual position of the element in the object.

**Parameters**

- **indices**: array-like
  
  An array of ints indicating which positions to take.

- **axis**: {0 or ‘index’, 1 or ‘columns’, None}, default 0
  
  The axis on which to select elements. 0 means that we are selecting rows, 1 means that we are selecting columns.

- **convert**: bool, default True
  
  Whether to convert negative indices into positive ones. For example, -1 would map to the `len(axis)` - 1. The conversions are similar to the behavior of indexing a regular Python list.

  Deprecated since version 0.21.0: In the future, negative indices will always be converted.

- **is_copy**: bool, default True
  
  Whether to return a copy of the original object or not.

- **kwargs**
  
  For compatibility with `numpy.take()`. Has no effect on the output.

**Returns**

- **taken**: type of caller
An array-like containing the elements taken from the object.

See also:

- **DataFrame.loc** Select a subset of a DataFrame by labels.
- **DataFrame.iloc** Select a subset of a DataFrame by positions.
- **numpy.take** Take elements from an array along an axis.

### Examples

```python
>>> df = pd.DataFrame([('falcon', 'bird', 389.0),
                     ('parrot', 'bird', 24.0),
                     ('lion', 'mammal', 80.5),
                     ('monkey', 'mammal', np.nan)],
                    columns=['name', 'class', 'max_speed'],
                    index=[0, 2, 3, 1])
>>> df
   name   class  max_speed
0  falcon    bird     389.0
2  parrot    bird      24.0
3   lion  mammal      80.5
1  monkey  mammal       NaN

Take elements at positions 0 and 3 along the axis 0 (default).

Note how the actual indices selected (0 and 1) do not correspond to our selected indices 0 and 3. That's because we are selecting the 0th and 3rd rows, not rows whose indices equal 0 and 3.

```python
>>> df.take([0, 3])
   name   class  max_speed
0  falcon    bird     389.0
1  monkey  mammal       NaN
```

Take elements at indices 1 and 2 along the axis 1 (column selection).

```python
>>> df.take([1, 2], axis=1)
   class  max_speed
0   bird     389.0
2   bird      24.0
3  mammal      80.5
1  mammal       NaN
```

We may take elements using negative integers for positive indices, starting from the end of the object, just like with Python lists.

```python
>>> df.take([-1, -2])
   name   class  max_speed
1  monkey  mammal       NaN
3   lion  mammal      80.5
```

**pandas.DataFrame.to_clipboard**

*DataFrame.to_clipboard*(excel=True, sep=None, **kwargs)

Copy object to the system clipboard.
Write a text representation of object to the system clipboard. This can be pasted into Excel, for example.

**Parameters**

-excel : bool, default True
  - True, use the provided separator, writing in a csv format for allowing easy pasting into excel.
  - False, write a string representation of the object to the clipboard.

-sep : str, default ' \t '
  Field delimiter.

**kwargs

These parameters will be passed to DataFrame.to_csv.

See also:

- **DataFrame.to_csv**  Write a DataFrame to a comma-separated values (csv) file.
- **read_clipboard**  Read text from clipboard and pass to read_table.

**Notes**

Requirements for your platform.

- Linux : xclip, or xsel (with gtk or PyQt4 modules)
- Windows : none
- OS X : none

**Examples**

Copy the contents of a DataFrame to the clipboard.

```python
>>> df = pd.DataFrame([ [1, 2, 3], [4, 5, 6]], columns=['A', 'B', 'C'])
>>> df.to_clipboard(sep=',')
... # Wrote the following to the system clipboard:
... # ,A,B,C
... # 0,1,2,3
... # 1,4,5,6
```

We can omit the the index by passing the keyword **index** and setting it to false.

```python
>>> df.to_clipboard(sep=',', index=False)
... # Wrote the following to the system clipboard:
... # A,B,C
... # 1,2,3
... # 4,5,6
```
### pandas.DataFrame.to_csv

`DataFrame.to_csv(path_or_buf=None, sep=’,’, na_rep=”, float_format=None, columns=None, header=True, index=True, index_label=None, mode=’w’, encoding=None, compression=None, quoting=None, quotechar=’”’, line_terminator=’\n’, chunks=0, tupleize_cols=None, date_format=None, doublequote=True, escapechar=None, decimal=’.’)`

Write DataFrame to a comma-separated values (csv) file

**Parameters**

- **path_or_buf**: string or file handle, default None
  - File path or object, if None is provided the result is returned as a string.

- **sep**: character, default ‘,’
  - Field delimiter for the output file.

- **na_rep**: string, default “”
  - Missing data representation

- **float_format**: string, default None
  - Format string for floating point numbers

- **columns**: sequence, optional
  - Columns to write

- **header**: boolean or list of string, default True
  - Write out the column names. If a list of strings is given it is assumed to be aliases for the column names

- **index**: boolean, default True
  - Write row names (index)

- **index_label**: string or sequence, or False, default None
  - Column label for index column(s) if desired. If None is given, and header and index are True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex. If False do not print fields for index names. Use index_label=False for easier importing in R

- **mode**: str
  - Python write mode, default ‘w’

- **encoding**: string, optional
  - A string representing the encoding to use in the output file, defaults to ‘ascii’ on Python 2 and ‘utf-8’ on Python 3.

- **compression**: string, optional
  - A string representing the compression to use in the output file. Allowed values are ‘gzip’, ‘bz2’, ‘zip’, ‘xz’. This input is only used when the first argument is a filename.

- **line_terminator**: string, default ‘\n’
  - The newline character or character sequence to use in the output file

- **quoting**: optional constant from csv module
defaults to csv.QUOTE_MINIMAL. If you have set a float_format then floats are converted to strings and thus csv.QUOTE_NONNUMERIC will treat them as non-numeric.

quotechar : string (length 1), default ‘”’
character used to quote fields

doublequote : boolean, default True
Control quoting of quotechar inside a field

escapechar : string (length 1), default None
character used to escape sep and quotechar when appropriate

chunksize : int or None
rows to write at a time

tupleize_cols : boolean, default False
	Deprecated since version 0.21.0: This argument will be removed and will always write each row of the multi-index as a separate row in the CSV file.

Write MultiIndex columns as a list of tuples (if True) or in the new, expanded format, where each MultiIndex column is a row in the CSV (if False).

date_format : string, default None
Format string for datetime objects

decimal: string, default ‘.’
Character recognized as decimal separator. E.g. use ‘,’ for European data

pandas.DataFrame.to_dense

dataFrame.to_dense()
Return dense representation of NDFrame (as opposed to sparse)

pandas.DataFrame.to_dict

dataFrame.to_dict(orient='dict', into=<class 'dict'>)
Convert the DataFrame to a dictionary.
The type of the key-value pairs can be customized with the parameters (see below).

Parameters orient : str {'dict', 'list', 'series', 'split', 'records', 'index'}
Determines the type of the values of the dictionary.
• ‘dict’ (default) : dict like {column -> {index -> value}}
• ‘list’ : dict like {column -> [values]}
• ‘series’ : dict like {column -> Series(values)}
• ‘split’ : dict like {'index' -> [index], 'columns' -> [columns], 'data' -> [values]}
• ‘records’ : list like [{column -> value}, . . . , {column -> value}]
• ‘index’ : dict like {index -> {column -> value}}
Abbreviations are allowed. \textit{s} indicates \textit{series} and \textit{sp} indicates \textit{split}.

\textbf{into} : class, default dict

The collections.Mapping subclass used for all Mappings in the return value. Can be the actual class or an empty instance of the mapping type you want. If you want a collections.defaultdict, you must pass it initialized.

New in version 0.21.0.

Returns

result [collections.Mapping like \{column -> \{index -> value\}\}]

See also:

\texttt{DataFrame.from\_dict} create a DataFrame from a dictionary

\texttt{DataFrame.to\_json} convert a DataFrame to JSON format

Examples

```python
>>> df = pd.DataFrame({'col1': [1, 2],
      'col2': [0.5, 0.75]},
      index=['a', 'b'])

>>> df
   col1  col2
a   1.0  0.50
b   2.0  0.75

>>> df.to_dict()
{'col1': {'a': 1.0, 'b': 2.0}, 'col2': {'a': 0.5, 'b': 0.75}}

You can specify the return orientation.

```python
>>> df.to_dict('series')
{'col1': a 1
  b 2
      Name: col1, dtype: int64,
'col2': a 0.50
  b 0.75
      Name: col2, dtype: float64}

```python
>>> df.to_dict('split')
{'index': ['a', 'b'], 'columns': ['col1', 'col2'],
 'data': [[1.0, 0.5], [2.0, 0.75]]}

```python
>>> df.to_dict('records')
[{'col1': 1.0, 'col2': 0.5}, {'col1': 2.0, 'col2': 0.75}]

```python
>>> df.to_dict('index')
{'a': {'col1': 1.0, 'col2': 0.5}, 'b': {'col1': 2.0, 'col2': 0.75}}

You can also specify the mapping type.

```python
>>> from collections import OrderedDict, defaultdict

>>> df.to_dict('split', into=OrderedDict)
OrderedDict([
    ('col1', OrderedDict([
        ('a', 1.0), ('b', 2.0)])),
    ('col2', OrderedDict([
        ('a', 0.5), ('b', 0.75)]))])
```
If you want a `defaultdict`, you need to initialize it:

```python
>>> dd = defaultdict(list)
>>> df.to_dict('records', into=dd)

[defaultdict(<class 'list'>, {'col1': 1.0, 'col2': 0.5}),
  defaultdict(<class 'list'>, {'col1': 2.0, 'col2': 0.75})]
```

**pandas.DataFrame.to_excel**

DataFrame.to_excel(excel_writer, sheet_name='Sheet1', na_rep='', float_format=None, columns=None, header=True, index=True, index_label=None, startrow=0, startcol=0, engine=None, merge_cells=True, encoding=None, inf_rep='inf', verbose=True, freeze_panes=None)

Write DataFrame to an excel sheet

**Parameters**

- **excel_writer** : string or ExcelWriter object
  - File path or existing ExcelWriter

- **sheet_name** : string, default ‘Sheet1’
  - Name of sheet which will contain DataFrame

- **na_rep** : string, default ”
  - Missing data representation

- **float_format** : string, default None
  - Format string for floating point numbers

- **columns** : sequence, optional
  - Columns to write

- **header** : boolean or list of string, default True
  - Write out the column names. If a list of strings is given it is assumed to be aliases for the column names

- **index** : boolean, default True
  - Write row names (index)

- **index_label** : string or sequence, default None
  - Column label for index column(s) if desired. If None is given, and header and index are True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.

- **startrow** :
  - upper left cell row to dump data frame

- **startcol** :
  - upper left cell column to dump data frame

- **engine** : string, default None
  - write engine to use - you can also set this via the options io.excel.xlsx.writer, io.excel.xls.writer, and io.excel.xlsm.writer.

- **merge_cells** : boolean, default True
Write MultiIndex and Hierarchical Rows as merged cells.

**encoding**: string, default None

Encoding of the resulting Excel file. Only necessary for xlwt, other writers support unicode natively.

**inf_rep**: string, default ‘inf’

Representation for infinity (there is no native representation for infinity in Excel)

**freeze_panes**: tuple of integer (length 2), default None

Specifies the one-based bottommost row and rightmost column that is to be frozen
New in version 0.20.0.

**Notes**

If passing an existing ExcelWriter object, then the sheet will be added to the existing workbook. This can be used to save different DataFrames to one workbook:

```python
>>> writer = pd.ExcelWriter('output.xlsx')
>>> df1.to_excel(writer,'Sheet1')
>>> df2.to_excel(writer,'Sheet2')
>>> writer.save()
```

For compatibility with to_csv, to_excel serializes lists and dicts to strings before writing.

**pandas.DataFrame.to_feather**

DataFrame.to_feather (fname)

Write out the binary feather-format for DataFrames
New in version 0.20.0.

**Parameters** fname : str

String file path

**pandas.DataFrame.to_gbq**

DataFrame.to_gbq (destination_table, project_id, chunksize=None, verbose=None, reauth=False, if_exists='fail', private_key=None, auth_local_webserver=False, table_schema=None)

Write a DataFrame to a Google BigQuery table.

This function requires the pandas-gbq package.

Authentication to the Google BigQuery service is via OAuth 2.0.

- If private_key is provided, the library loads the JSON service account credentials and uses those to authenticate.
- If no private_key is provided, the library tries application default credentials.
- If application default credentials are not found or cannot be used with BigQuery, the library authenticates with user account credentials. In this case, you will be asked to grant permissions for product name ‘pandas GBQ’.
Parameters destination_table : str
    Name of table to be written, in the form ‘dataset.tablename’.

project_id : str
    Google BigQuery Account project ID.

chunksize : int, optional
    Number of rows to be inserted in each chunk from the dataframe. Set to None to load the whole dataframe at once.

reauth : bool, default False
    Force Google BigQuery to reauthenticate the user. This is useful if multiple accounts are used.

if_exists : str, default ‘fail’
    Behavior when the destination table exists. Value can be one of:
    'fail'  If table exists, do nothing.
    'replace'  If table exists, drop it, recreate it, and insert data.
    'append'  If table exists, insert data. Create if does not exist.

private_key : str, optional
    Service account private key in JSON format. Can be file path or string contents. This is useful for remote server authentication (eg. Jupyter/IPython notebook on remote host).

auth_local_webserver : bool, default False
    Use the local webserver flow instead of the console flow when getting user credentials.
    
    *New in version 0.2.0 of pandas-gbq.*

table_schema : list of dicts, optional
    List of BigQuery table fields to which according DataFrame columns conform to, e.g. [{'name': 'col1', 'type': 'STRING'},...]. If schema is not provided, it will be generated according to dtypes of DataFrame columns. See BigQuery API documentation on available names of a field.
    
    *New in version 0.3.1 of pandas-gbq.*

verbose : boolean, deprecated
    
    *Deprecated in Pandas-GBQ 0.4.0.* Use the logging module to adjust verbosity instead.

See also:

pandas_gbq.to_gbq  This function in the pandas-gbq library.
pandas.read_gbq  Read a DataFrame from Google BigQuery.
pandas.DataFrame.to_hdf

**DataFrame.to_hdf**(path_or_buf, key, **kwargs)

Write the contained data to an HDF5 file using HDFStore.

Hierarchical Data Format (HDF) is self-describing, allowing an application to interpret the structure and contents of a file with no outside information. One HDF file can hold a mix of related objects which can be accessed as a group or as individual objects.

In order to add another DataFrame or Series to an existing HDF file please use append mode and a different key.

For more information see the user guide.

**Parameters**

- **path_or_buf** : str or pandas.HDFStore
  File path or HDFStore object.

- **key** : str
  Identifier for the group in the store.

- **mode** : {'a', 'w', 'r+'}, default ‘a’
  Mode to open file:
  - ‘w’: write, a new file is created (an existing file with the same name would be deleted).
  - ‘a’: append, an existing file is opened for reading and writing, and if the file does not exist it is created.
  - ‘r+’: similar to ‘a’, but the file must already exist.

- **format** : {'fixed', 'table'}, default ‘fixed’
  Possible values:
  - ‘table’: Table format. Write as a PyTables Table structure which may perform worse but allow more flexible operations like searching / selecting subsets of the data.

- **append** : bool, default False
  For Table formats, append the input data to the existing.

- **data_columns** : list of columns or True, optional
  List of columns to create as indexed data columns for on-disk queries, or True to use all columns. By default only the axes of the object are indexed. See [Query via Data Columns](#).

- **complevel** : {0-9}, optional
  Specifies a compression level for data. A value of 0 disables compression.

  Specifies the compression library to be used. As of v0.20.2 these additional compressors for Blosc are supported (default if no compressor specified: ‘blosc:blosclz’): {‘blosc:blosclz’, ‘blosc:lz4’, ‘blosc:lz4hc’, ‘blosc:snappy’, ‘blosc:zlib’, ‘blosc:zstd’}. Specifying a compression library which is not available issues a ValueError.
fletcher32 : bool, default False
If applying compression use the fletcher32 checksum.

dropna : bool, default False
If true, ALL nan rows will not be written to store.

errors : str, default ‘strict’
Specifies how encoding and decoding errors are to be handled. See the errors argument for open() for a full list of options.

See also:

DataFrame.read_hdf Read from HDF file.

DataFrame.to_parquet Write a DataFrame to the binary parquet format.

DataFrame.to_sql Write to a sql table.

DataFrame.to_feather Write out feather-format for DataFrames.

DataFrame.to_csv Write out to a csv file.

Examples

```python
>>> df = pd.DataFrame({'A': [1, 2, 3], 'B': [4, 5, 6]},
                   index=['a', 'b', 'c'])
>>> df.to_hdf('data.h5', key='df', mode='w')
```

We can add another object to the same file:

```python
>>> s = pd.Series([1, 2, 3, 4])
>>> s.to_hdf('data.h5', key='s')
```

Reading from HDF file:

```python
>>> pd.read_hdf('data.h5', 'df')
A B
a 1 4
b 2 5
c 3 6
```

```python
>>> pd.read_hdf('data.h5', 's')
0 1
1 2
2 3
3 4
dtype: int64
```

Deleting file with data:

```python
>>> import os
>>> os.remove('data.h5')
```
pandas.DataFrame.to_html

DataFrame.to_html(buf=None, columns=None, col_space=None, header=True, index=True, na_rep='NaN', formatters=None, float_format=None, sparsify=None, index_names=True, justify=None, bold_rows=True, classes=None, escape=True, max_rows=None, max_cols=None, show_dimensions=False, notebook=False, decimal='.', border=None, table_id=None)

Render a DataFrame as an HTML table.

to_html-specific options:

bold_rows [boolean, default True] Make the row labels bold in the output

classes [str or list or tuple, default None] CSS class(es) to apply to the resulting html table

escape [boolean, default True] Convert the characters <, >, and & to HTML-safe sequences.

max_rows [int, optional] Maximum number of rows to show before truncating. If None, show all.

max_cols [int, optional] Maximum number of columns to show before truncating. If None, show all.

decimal [string, default ‘.’] Character recognized as decimal separator, e.g. ‘,’ in Europe

New in version 0.18.0.

border [int] A border=border attribute is included in the opening <table> tag. Default pd.options.html.border.

New in version 0.19.0.

table_id [str, optional] A css id is included in the opening <table> tag if specified.

New in version 0.23.0.

Parameters

buf : StringIO-like, optional
  buffer to write to

columns : sequence, optional
  the subset of columns to write; default None writes all columns

col_space : int, optional
  the minimum width of each column

header : bool, optional
  whether to print column labels, default True

index : bool, optional
  whether to print index (row) labels, default True

na_rep : string, optional
  string representation of NAN to use, default ‘NaN’

formatters : list or dict of one-parameter functions, optional
  formatter functions to apply to columns’ elements by position or name, default None. The result of each function must be a unicode string. List must be of length equal to the number of columns.

float_format : one-parameter function, optional
formatter function to apply to columns’ elements if they are floats, default None. The result of this function must be a unicode string.

**sparsify**: bool, optional
- Set to False for a DataFrame with a hierarchical index to print every multiindex key at each row, default True

**index_names**: bool, optional
- Prints the names of the indexes, default True

**line_width**: int, optional
- Width to wrap a line in characters, default no wrap

**table_id**: str, optional
- id for the `<table>` element create by `to_html`
  - New in version 0.23.0.

**justify**: str, default None
- How to justify the column labels. If None uses the option from the print configuration (controlled by `set_option`), ‘right’ out of the box. Valid values are
  - left
  - right
  - center
  - justify
  - justify-all
  - start
  - end
  - inherit
  - match-parent
  - initial
  - unset

**Returns**
- **formatted** [string (or unicode, depending on data and options)]

---

**pandas.DataFrame.to_json**

DataFrame.to_json(`path_or_buf=None, orient=None, date_format=None, double_precision=10, force_ascii=True, date_unit='ms', default_handler=None, lines=False, compression=None, index=True`)  
Convert the object to a JSON string.

Note NaN’s and None will be converted to null and datetime objects will be converted to UNIX timestamps.

**Parameters** **path_or_buf**: string or file handle, optional
- File path or object. If not specified, the result is returned as a string.
orient : string

Indication of expected JSON string format.

- Series
  - default is ‘index’
  - allowed values are: { ‘split’, ‘records’, ‘index’ }
- DataFrame
  - default is ‘columns’
  - allowed values are: { ‘split’, ‘records’, ‘index’, ‘columns’, ‘values’ }
- The format of the JSON string
  - ‘split’ : dict like { ‘index’ -> [index], ‘columns’ -> [columns], ‘data’ -> [values] }
  - ‘records’ : list like [[column -> value], ... , [column -> value]]
  - ‘index’ : dict like { index -> {column -> value} }
  - ‘columns’ : dict like { column -> {index -> value} }
  - ‘values’ : just the values array
  - ‘table’ : dict like { ‘schema’: {schema}, ‘data’: {data} } describing the data, and the data component is like orient='records'.

  Changed in version 0.20.0.

date_format : {None, ‘epoch’, ‘iso’}

Type of date conversion. ‘epoch’ = epoch milliseconds, ‘iso’ = ISO8601. The default depends on the orient. For orient='table', the default is ‘iso’. For all other orients, the default is ‘epoch’.

double_precision : int, default 10

The number of decimal places to use when encoding floating point values.

force_ascii : boolean, default True

Force encoded string to be ASCII.

date_unit : string, default ‘ms’ (milliseconds)

The time unit to encode to, governs timestamp and ISO8601 precision. One of ‘s’, ‘ms’, ‘us’, ‘ns’ for second, millisecond, microsecond, and nanosecond respectively.

default_handler : callable, default None

Handler to call if object cannot otherwise be converted to a suitable format for JSON. Should receive a single argument which is the object to convert and return a serialisable object.

lines : boolean, default False

If ‘orient’ is ‘records’ write out line delimited json format. Will throw ValueError if incorrect ‘orient’ since others are not list like.

  New in version 0.19.0.

A string representing the compression to use in the output file, only used when the first argument is a filename.

New in version 0.21.0.

`index` : boolean, default True

Whether to include the index values in the JSON string. Not including the index (`index=False`) is only supported when orient is ‘split’ or ‘table’.

New in version 0.23.0.

See also:

`pandas.read_json`

Examples

```python
>>> df = pd.DataFrame([['a', 'b'], ['c', 'd']],
                   index=['row 1', 'row 2'],
                   columns=['col 1', 'col 2'])

>>> df.to_json(orient='split')
'{"columns": ["col 1", "col 2"],
 "index": ["row 1", "row 2"],
 "data": [["a", "b"], ["c", "d"]]}'

Encoding/decoding a Dataframe using 'records' formatted JSON. Note that index labels are not preserved with this encoding.

```python
>>> df.to_json(orient='records')
'[{"col 1":"a","col 2":"b"},{"col 1":"c","col 2":"d"}]'
```

Encoding/decoding a Dataframe using 'index' formatted JSON:

```python
>>> df.to_json(orient='index')
'{"row 1":{"col 1":"a","col 2":"b"},"row 2":{"col 1":"c","col 2":"d"}}'
```

Encoding/decoding a Dataframe using 'columns' formatted JSON:

```python
>>> df.to_json(orient='columns')
'{"col 1":{"row 1":"a","row 2":"c"},"col 2":{"row 1":"b","row 2":"d"}}'
```

Encoding/decoding a Dataframe using 'values' formatted JSON:

```python
>>> df.to_json(orient='values')
'[["a","b"],["c","d"]]
```

Encoding with Table Schema

```python
>>> df.to_json(orient='table')
'{"schema": {"fields": [{"name": "index", "type": "string"},
{"name": "col 1", "type": "string"},
{"name": "col 2", "type": "string"}],
"primaryKey": "index",
"pandas_version": "0.20.0"},
"data": [["index": "row 1", "col 1": "a", "col 2": "b"],
{"index": "row 2", "col 1": "c", "col 2": "d"}]}'
```
**pandas.DataFrame.to_latex**

```python
DataFrame.to_latex(buf=None, columns=None, col_space=None, header=True, index=True, na_rep='NaN', formatters=None, float_format=None, sparse=None, index_names=True, bold_rows=False, column_format=None, longtable=None, escape=None, encoding=None, decimal='. ', multicolumn=None, multicolumn_format=None, multirow=None)
```

Render an object to a tabular environment table. You can splice this into a LaTeX document. Requires \usepackage{booktabs}.

Changed in version 0.20.2: Added to Series

to_latex-specific options:

- **bold_rows** [boolean, default False] Make the row labels bold in the output

- **column_format** [str, default None] The columns format as specified in LaTeX table format e.g. ‘rc’ for 3 columns

- **longtable** [boolean, default will be read from the pandas config module] Default: False. Use a longtable environment instead of tabular. Requires adding a \usepackage{longtable} to your LaTeX preamble.

- **escape** [boolean, default will be read from the pandas config module] Default: True. When set to False prevents from escaping latex special characters in column names.

- **encoding** [str, default None] A string representing the encoding to use in the output file, defaults to ‘ascii’ on Python 2 and ‘utf-8’ on Python 3.

- **decimal** [string, default ‘.’] Character recognized as decimal separator, e.g. ‘,’ in Europe.

  New in version 0.18.0.

- **multicolumn** [boolean, default True] Use multicolumn to enhance MultiIndex columns. The default will be read from the config module.

  New in version 0.20.0.

- **multicolumn_format** [str, default ‘l’] The alignment for multicolumns, similar to column_format. The default will be read from the config module.

  New in version 0.20.0.

- **multirow** [boolean, default False] Use multirow to enhance MultiIndex rows. Requires adding a \usepackage{multirow} to your LaTeX preamble. Will print centered labels (instead of top-aligned) across the contained rows, separating groups via clines. The default will be read from the pandas config module.

  New in version 0.20.0.

**pandas.DataFrame.to_msgpack**

```python
DataFrame.to_msgpack(path_or_buf=None, encoding='utf-8', **kwargs)
```

msgpack (serialize) object to input file path

THIS IS AN EXPERIMENTAL LIBRARY and the storage format may not be stable until a future release.

**Parameters**

- **path** : string File path, buffer-like, or None
  
  if None, return generated string

- **append** : boolean whether to append to an existing msgpack

  (default is False)
compress : type of compressor (zlib or blosc), default to None (no compression)

pandas.DataFrame.to_panel

DataFrame.to_panel()

Transform long (stacked) format (DataFrame) into wide (3D, Panel) format.

Deprecated since version 0.20.0.

Currently the index of the DataFrame must be a 2-level MultiIndex. This may be generalized later

Returns

panel [Panel]

pandas.DataFrame.to_parquet

DataFrame.to_parquet (fname, engine='auto', compression='snappy', **kwargs)

Write a DataFrame to the binary parquet format.

New in version 0.21.0.

This function writes the dataframe as a parquet file. You can choose different parquet backends, and have the option of compression. See the user guide for more details.

Parameters f{}name : str

String file path.

engine : {'auto', 'pyarrow', 'fastparquet'}, default ‘auto’

Parquet library to use. If ‘auto’, then the option io.parquet.engine is used. The default io.parquet.engine behavior is to try ‘pyarrow’, falling back to ‘fastparquet’ if ‘pyarrow’ is unavailable.

compression : {'snappy', 'gzip', 'brotli', None}, default ‘snappy’

Name of the compression to use. Use None for no compression.

**kwargs

Additional arguments passed to the parquet library. See pandas io for more details.

See also:

read_parquet Read a parquet file.

DataFrame.to_csv Write a csv file.

DataFrame.to_sql Write to a sql table.

DataFrame.to_hdf Write to hdf.

Notes

This function requires either the fastparquet or pyarrow library.
Examples

```python
>>> df = pd.DataFrame(data={'col1': [1, 2], 'col2': [3, 4]})
>>> df.to_parquet('df.parquet.gzip', compression='gzip')
>>> pd.read_parquet('df.parquet.gzip')
  col1 col2
0    1    3
1    2    4
```

**pandas.DataFrame.to_period**

`DataFrame.to_period(freq=None, axis=0, copy=True)`

Convert DataFrame from DatetimeIndex to PeriodIndex with desired frequency (inferred from index if not passed)

**Parameters**

- `freq` [string, default]
- `axis` : {0 or ‘index’, 1 or ‘columns’}, default 0
  - The axis to convert (the index by default)
- `copy` : boolean, default True
  - If False then underlying input data is not copied

**Returns**

- `ts` [TimeSeries with PeriodIndex]

**pandas.DataFrame.to_pickle**

`DataFrame.to_pickle(path, compression='infer', protocol=4)`

Pickle (serialize) object to file.

**Parameters**

- `path` : str
  - File path where the pickled object will be stored.
- `compression` : {'infer', 'gzip', 'bz2', 'zip', 'xz', None}, default ‘infer’
  - A string representing the compression to use in the output file. By default, infers from the file extension in specified path.
  - New in version 0.20.0.
- `protocol` : int
  - Int which indicates which protocol should be used by the pickler, default HIGHEST_PROTOCOL (see [R15] paragraph 12.1.2). The possible values for this parameter depend on the version of Python. For Python 2.x, possible values are 0, 1, 2. For Python>=3.0, 3 is a valid value. For Python >= 3.4, 4 is a valid value.
  - A negative value for the protocol parameter is equivalent to setting its value to HIGHEST_PROTOCOL.
  - New in version 0.21.0.

See also:
read_pickle  Load pickled pandas object (or any object) from file.

DataFrame.to_hdf  Write DataFrame to an HDF5 file.

DataFrame.to_sql  Write DataFrame to a SQL database.

DataFrame.to_parquet  Write a DataFrame to the binary parquet format.

Examples

```python
>>> original_df = pd.DataFrame({"foo": range(5), "bar": range(5, 10))
>>> original_df
   foo  bar
0   0   5
1   1   6
2   2   7
3   3   8
4   4   9

>>> original_df.to_pickle("./dummy.pkl")

>>> unpickled_df = pd.read_pickle("./dummy.pkl")

>>> unpickled_df
   foo  bar
0   0   5
1   1   6
2   2   7
3   3   8
4   4   9

>>> import os
>>> os.remove("./dummy.pkl")
```

pandas.DataFrame.to_records

DataFrame.to_records (index=True, convert_datetime64=None)
Convert DataFrame to a NumPy record array.

Index will be put in the ‘index’ field of the record array if requested.

Parameters

- **index**: boolean, default True
  Include index in resulting record array, stored in ‘index’ field.
- **convert_datetime64**: boolean, default None
  Deprecated since version 0.23.0.
  Whether to convert the index to datetime.datetime if it is a DatetimeIndex.

Returns

- **y**: [numpy.recarray]

See also:

- **DataFrame.from_records**: convert structured or record ndarray to DataFrame.
- **numpy.recarray**: ndarray that allows field access using attributes, analogous to typed columns in a spreadsheet.
### Examples

```python
>>> df = pd.DataFrame({'A': [1, 2], 'B': [0.5, 0.75]},
   index=['a', 'b'])
>>> df
   A  B
a 1  0.50
b 2  0.75
```

```python
>>> df.to_records()
rec.array([(0, 'a', 1, 0.5), (1, 'b', 2, 0.75)],
          dtype=[('index', 'O'), ('A', '<i8'), ('B', '<f8')])
```

The index can be excluded from the record array:

```python
>>> df.to_records(index=False)
rec.array([(1, 0.5), (2, 0.75)],
          dtype=[('A', '<i8'), ('B', '<f8')])
```

By default, timestamps are converted to `datetime.datetime`:

```python
>>> df.index = pd.date_range('2018-01-01 09:00', periods=2, freq='min')
>>> df
   A  B
2018-01-01 09:00:00    1  0.50
2018-01-01 09:01:00    2  0.75
```

```python
>>> df.to_records()
rec.array([(datetime.datetime(2018, 1, 1, 9, 0), 1, 0.5),
           (datetime.datetime(2018, 1, 1, 9, 1), 2, 0.75)],
          dtype=[('index', 'O'), ('A', '<i8'), ('B', '<f8')])
```

The timestamp conversion can be disabled so NumPy's `datetime64` data type is used instead:

```python
>>> df.to_records(convert_datetime64=False)
rec.array([('2018-01-01T09:00:00.000000000', 1, 0.5),
           ('2018-01-01T09:01:00.000000000', 2, 0.75)],
          dtype=[('index', '<m8[ns]'), ('A', '<i8'), ('B', '<f8')])
```

### pandas.DataFrame.to_sparse

DataFrame.to_sparse (fill_value=None, kind='block')
Convert to SparseDataFrame

**Parameters**

| fill_value | [float, default NaN] |
| kind       | ['block', 'integer'] |

**Returns**

| y | [SparseDataFrame] |
pandas.DataFrame.to_stata

DataFrame.to_stata(fname=None, convert_dates=None, write_index=True, encoding='latin-1', byteorder=None, time_stamp=None, data_label=None, variable_labels=None, version=114, convert_strl=None)

Export Stata binary dta files.

**Parameters**

- **fname**: path (string), buffer or path object
  
  string, path object (pathlib.Path or py._path.local.LocalPath) or object implementing a binary write() functions. If using a buffer then the buffer will not be automatically closed after the file data has been written.

- **convert_dates**: dict
  
  Dictionary mapping columns containing datetime types to stata internal format to use when writing the dates. Options are ‘tc’, ‘td’, ‘tm’, ‘tw’, ‘th’, ‘tq’, ‘ty’. Column can be either an integer or a name. Datetime columns that do not have a conversion type specified will be converted to ‘tc’. Raises NotImplementedError if a datetime column has timezone information.

- **write_index**: bool
  
  Write the index to Stata dataset.

- **encoding**: str
  
  Default is latin-1. Unicode is not supported.

- **byteorder**: str
  
  Can be “>”, “<”, “little”, or “big”. default is sys.byteorder.

- **time_stamp**: datetime
  
  A datetime to use as file creation date. Default is the current time.

- **data_label**: str
  
  A label for the data set. Must be 80 characters or smaller.

- **variable_labels**: dict
  
  Dictionary containing columns as keys and variable labels as values. Each label must be 80 characters or smaller.
  
  New in version 0.19.0.

- **version**: {114, 117}
  
  Version to use in the output dta file. Version 114 can be used read by Stata 10 and later. Version 117 can be read by Stata 13 or later. Version 114 limits string variables to 244 characters or fewer while 117 allows strings with lengths up to 2,000,000 characters.
  
  New in version 0.23.0.

- **convert_strl**: list, optional
  
  List of column names to convert to string columns to Stata StrL format. Only available if version is 117. Storing strings in the StrL format can produce smaller dta files if strings have more than 8 characters and values are repeated.
  
  New in version 0.23.0.

**Raises**

NotImplementedError
• If datetimes contain timezone information
• Column dtype is not representable in Stata

**ValueError**

• Columns listed in `convert_dates` are neither `datetime64[ns]` or `datetime`
• Column listed in `convert_dates` is not in DataFrame
• Categorical label contains more than 32,000 characters

New in version 0.19.0.

See also:

**pandas.read_stata** Import Stata data files

**pandas.io.stata.StataWriter** low-level writer for Stata data files

**pandas.io.stata.StataWriter117** low-level writer for version 117 files

**Examples**

```python
>>> data.to_stata('./data_file.dta')
```

Or with dates

```python
>>> data.to_stata('./date_data_file.dta', {2 : 'tw'})
```

Alternatively you can create an instance of the StataWriter class

```python
>>> writer = StataWriter('./data_file.dta', data)
>>> writer.write_file()
```

With dates:

```python
>>> writer = StataWriter('./date_data_file.dta', data, {2 : 'tw'})
>>> writer.write_file()
```

**pandas.DataFrame.to_string**

`DataFrame.to_string` *(buf=None, columns=None, col_space=None, header=True, index=True, na_rep='NaN', formatters=None, float_format=None, sparsify=None, index_names=True, justify=None, line_width=None, max_rows=None, max_cols=None, show_dimensions=False)*

Render a DataFrame to a console-friendly tabular output.

**Parameters**

- `buf` : StringIO-like, optional
  - buffer to write to

- `columns` : sequence, optional
  - the subset of columns to write; default None writes all columns

- `col_space` : int, optional
  - the minimum width of each column
header : bool, optional

Write out the column names. If a list of strings is given, it is assumed to be aliases for the column names

index : bool, optional

whether to print index (row) labels, default True

na_rep : string, optional

string representation of NaN to use, default ‘NaN’

formatters : list or dict of one-parameter functions, optional

formatter functions to apply to columns’ elements by position or name, default None. The result of each function must be a unicode string. List must be of length equal to the number of columns.

float_format : one-parameter function, optional

formatter function to apply to columns’ elements if they are floats, default None. The result of this function must be a unicode string.

sparsify : bool, optional

Set to False for a DataFrame with a hierarchical index to print every multiindex key at each row, default True

index_names : bool, optional

Prints the names of the indexes, default True

line_width : int, optional

Width to wrap a line in characters, default no wrap

table_id : str, optional

id for the <table> element create by to_html

New in version 0.23.0.

justify : str, default None

How to justify the column labels. If None uses the option from the print configuration (controlled by set_option), ‘right’ out of the box. Valid values are

• left
• right
• center
• justify
• justify-all
• start
• end
• inherit
• match-parent
• initial
• unset
Returns

formatted [string (or unicode, depending on data and options)]

pandas.DataFrame.to_timestamp

DataFrame.to_timestamp(freq=None, how='start', axis=0, copy=True)
Cast to DatetimeIndex of timestamps, at beginning of period

Parameters

freq : string, default frequency of PeriodIndex
Desired frequency

how : {'s', 'e', 'start', 'end'}
Convention for converting period to timestamp; start of period vs. end

axis : {0 or 'index', 1 or 'columns'}, default 0
The axis to convert (the index by default)

copy : boolean, default True
If false then underlying input data is not copied

Returns

df [DataFrame with DatetimeIndex]

pandas.DataFrame.to_xarray

DataFrame.to_xarray()
Return an xarray object from the pandas object.

Returns

a DataArray for a Series

a Dataset for a DataFrame

a DataArray for higher dims

Notes

See the xarray docs

Examples

```python
>>> df = pd.DataFrame({'A': [1, 1, 2],
                   'B': ['foo', 'bar', 'foo'],
                   'C': np.arange(4.,7)})
>>> df
   A  B     C
0  0 foo  4.0
1  1  bar  5.0
2  2 foo  6.0
```
>>> df.to_xarray()
<xarray.Dataset>
Dimensions: (index: 3)
Coordinates:
  * index (index) int64 0 1 2
Data variables:
  A (index) int64 1 1 2
  B (index) object 'foo' 'bar' 'foo'
  C (index) float64 4.0 5.0 6.0

>>> df = pd.DataFrame({'A': [1, 1, 2],
                     'B': ['foo', 'bar', 'foo'],
                     'C': np.arange(4., 7)}
                  ).set_index(['B', 'A'])

>>> df
     C
B A  
foo 1 4.0
bar 1 5.0
foo 2 6.0

>>> df.to_xarray()
<xarray.Dataset>
Dimensions: (A: 2, B: 2)
Coordinates:
  * B (B) object 'bar' 'foo'
  * A (A) int64 1 2
Data variables:
  C (B, A) float64 5.0 nan 4.0 6.0

>>> p = pd.Panel(np.arange(24).reshape(4, 3, 2),
               items=list('ABCD'),
               major_axis=pd.date_range('20130101', periods=3),
               minor_axis=['first', 'second'])

>>> p
<class 'pandas.core.panel.Panel'>
Dimensions: 4 (items) x 3 (major_axis) x 2 (minor_axis)
Items axis: A to D
Major_axis axis: 2013-01-01 00:00:00 to 2013-01-03 00:00:00
Minor_axis axis: first to second

>>> p.to_xarray()
<xarray.DataArray (items: 4, major_axis: 3, minor_axis: 2)>
array([[ 0,  1],
       [ 2,  3],
       [ 4,  5],
       [ 6,  7],
       [ 8,  9],
       [10, 11],
       [12, 13],
       [14, 15],
       [16, 17],
       [18, 19],
       [20, 21],
       [22, 23]])
Coordinates:
pandas.DataFrame.transform

DataFrame.transform(func, *args, **kwargs)
Call function producing a like-indexed NDFrame and return a NDFrame with the transformed values

New in version 0.20.0.

Parameters func : callable, string, dictionary, or list of string/callables
To apply to column
Accepted Combinations are:
• string function name
• function
• list of functions
• dict of column names -> functions (or list of functions)

Returns
transformed [NDFrame]

See also:
pandas.NDFrame.aggregate, pandas.NDFrame.apply

Examples

```python
>>> df = pd.DataFrame(np.random.randn(10, 3), columns=['A', 'B', 'C'],  
... index=pd.date_range('1/1/2000', periods=10))
df.iloc[3:7] = np.nan

>>> df.transform(lambda x: (x - x.mean()) / x.std())
```

```
A     B     C
2000-01-01  0.579457  1.236184  0.123424
2000-01-02  0.370357 -0.605875 -1.231325
2000-01-03  1.455756 -0.277446  0.288967
2000-01-04  NaN       NaN       NaN
2000-01-05  NaN       NaN       NaN
2000-01-06  NaN       NaN       NaN
2000-01-07  NaN       NaN       NaN
2000-01-08 -0.498658  1.274522  1.642524
2000-01-09 -0.540524 -1.012676 -0.828968
2000-01-10 -1.366388 -0.614710  0.005378
```
pandas.DataFrame.transpose

DataFrame.transpose(*args, **kwargs)
Transpose index and columns.

Reflect the DataFrame over its main diagonal by writing rows as columns and vice-versa. The property \( T \) is an accessor to the method \( \text{transpose()} \).

**Parameters**
- **copy**: bool, default False
  - If True, the underlying data is copied. Otherwise (default), no copy is made if possible.

- **args**, **kwargs
  - Additional keywords have no effect but might be accepted for compatibility with \( \text{numpy} \).

**Returns** DataFrame
- The transposed DataFrame.

**See also:**
- \( \text{numpy.transpose} \) Permute the dimensions of a given array.

**Notes**

Transposing a DataFrame with mixed dtypes will result in a homogeneous DataFrame with the \( \text{object} \) dtype. In such a case, a copy of the data is always made.

**Examples**

**Square DataFrame with homogeneous dtype**

```python
>>> d1 = {'col1': [1, 2], 'col2': [3, 4]}
>>> df1 = pd.DataFrame(data=d1)
>>> df1
   col1 col2
0    1    3
1    2    4

>>> df1_transposed = df1.T  # or df1.transpose()
>>> df1_transposed
   0  1
col1 1  2
col2 3  4
```

When the dtype is homogeneous in the original DataFrame, we get a transposed DataFrame with the same dtype:

```python
>>> df1.dtypes
col1  int64
col2  int64
dtype: object
>>> df1_transposed.dtypes
```

(continues on next page)
Non-square DataFrame with mixed dtypes

```python
>>> d2 = {'name': ['Alice', 'Bob'],
...       'score': [9.5, 8],
...       'employed': [False, True],
...       'kids': [0, 0]}
>>> df2 = pd.DataFrame(data=d2)
>>> df2
   name  score  employed  kids
0  Alice   9.5     False   0
1   Bob    8.0      True   0
```

```python
>>> df2_transposed = df2.T # or df2.transpose()
>>> df2_transposed
   0    1
name Alice  Bob
score  9.5   8
employed  False  True
kids     0     0
```

When the DataFrame has mixed dtypes, we get a transposed DataFrame with the `object` dtype:

```python
>>> df2.dtypes
name    object
score   float64
employed    bool
kids    int64
dtype: object
>>> df2_transposed.dtypes
0    object
1    object
dtype: object
```

**pandas.DataFrame.truediv**

DataFrame.truediv(other, axis='columns', level=None, fill_value=None)
Floating division of dataframe and other, element-wise (binary operator truediv).
Equivalent to dataframe / other, but with support to substitute a fill_value for missing data in one of the inputs.

**Parameters**

- **other** [Series, DataFrame, or constant]
- **axis** : {0, 1, ‘index’, ‘columns’}
  - For Series input, axis to match Series index on
- **level** : int or name
  - Broadcast across a level, matching Index values on the passed MultiIndex level
- **fill_value** : None or float value, default None
Fill existing missing (NaN) values, and any new element needed for successful DataFrame alignment, with this value before computation. If data in both corresponding DataFrame locations is missing the result will be missing.

**Returns**

result [DataFrame]

**See also:**

*DataFrame.rtruediv*

**Notes**

Mismatched indices will be unioned together.

**Examples**

None

---

**pandas.DataFrame.truncate**

*DataFrame.truncate(before=None, after=None, axis=None, copy=True)*

Truncate a Series or DataFrame before and after some index value.

This is a useful shorthand for boolean indexing based on index values above or below certain thresholds.

**Parameters**

- **before**: date, string, int
  
  Truncate all rows before this index value.

- **after**: date, string, int
  
  Truncate all rows after this index value.

- **axis**: {0 or ‘index’, 1 or ‘columns’}, optional
  
  Axis to truncate. Truncates the index (rows) by default.

- **copy**: boolean, default is True,
  
  Return a copy of the truncated section.

**Returns**

**type of caller**

The truncated Series or DataFrame.

**See also:**

*DataFrame.loc* Select a subset of a DataFrame by label.

*DataFrame.iloc* Select a subset of a DataFrame by position.

**Notes**

If the index being truncated contains only datetime values, *before* and *after* may be specified as strings instead of Timestamps.
Examples

```python
>>> df = pd.DataFrame({'A': ['a', 'b', 'c', 'd', 'e'],
...                    'B': ['f', 'g', 'h', 'i', 'j'],
...                    'C': ['k', 'l', 'm', 'n', 'o']},
...                   index=[1, 2, 3, 4, 5])
>>> df
   A  B  C
1  a  f  k
2  b  g  l
3  c  h  m
4  d  i  n
5  e  j  o
```

The columns of a DataFrame can be truncated.

```python
>>> df.truncate(before=2, after=4)
   A  B
1  a  f
2  b  g
3  c  h
4  d  i
```

For Series, only rows can be truncated.

```python
>>> df['A'].truncate(before=2, after=4)
Name: A, dtype: object
```

The index values in `truncate` can be datetimes or string dates.

```python
>>> dates = pd.date_range('2016-01-01', '2016-02-01', freq='s')
>>> df = pd.DataFrame(index=dates, data={'A': 1})
>>> df.tail()
    A
2016-01-31 23:59:56  1
2016-01-31 23:59:57  1
2016-01-31 23:59:58  1
2016-01-31 23:59:59  1
2016-02-01 00:00:00  1
```

```python
>>> df.truncate(before=pd.Timestamp('2016-01-05'),
...              after=pd.Timestamp('2016-01-10')).tail()
    A
2016-01-09 23:59:56  1
2016-01-09 23:59:57  1
2016-01-09 23:59:58  1
```

(continues on next page)
Because the index is a DatetimeIndex containing only dates, we can specify before and after as strings. They will be coerced to Timestamps before truncation.

```python
>>> df.truncate('2016-01-05', '2016-01-10').tail()
     A
2016-01-09 23:59:56 1
2016-01-09 23:59:57 1
2016-01-09 23:59:58 1
2016-01-09 23:59:59 1
2016-01-10 00:00:00 1
```

Note that `truncate` assumes a 0 value for any unspecified time component (midnight). This differs from partial string slicing, which returns any partially matching dates.

```python
>>> df.loc['2016-01-05':'2016-01-10', :].tail()
     A
2016-01-10 23:59:55 1
2016-01-10 23:59:56 1
2016-01-10 23:59:57 1
2016-01-10 23:59:58 1
2016-01-10 23:59:59 1
```

**pandas.DataFrame.tshift**

`DataFrame.tshift`(*periods=1, freq=None, axis=0*)

Shift the time index, using the index’s frequency if available.

**Parameters**

- `periods`: int
  
  Number of periods to move, can be positive or negative

- `freq`: DateOffset, timedelta, or time rule string, default None
  
  Increment to use from the tseries module or time rule (e.g. ‘EOM’)

- `axis`: int or basestring
  
  Corresponds to the axis that contains the Index

**Returns**

- `shifted` [NDFrame]

**Notes**

If `freq` is not specified then tries to use the freq or inferred_freq attributes of the index. If neither of those attributes exist, a ValueError is thrown

**pandas.DataFrame.tz_convert**

`DataFrame.tz_convert`(*tz, axis=0, level=None, copy=True*)

Convert tz-aware axis to target time zone.
**Parameters**

- **tz** [string or pytz.timezone object]
- **axis** [the axis to convert]
- **level** : int, str, default None
  - If axis ia a MultiIndex, convert a specific level. Otherwise must be None
- **copy** : boolean, default True
  - Also make a copy of the underlying data

**Raises** **TypeError**

- If the axis is tz-naive.

**pandas.DataFrame.tz_localize**

DataFrame.tz_localize (tz, axis=0, level=None, copy=True, ambiguous='raise')
Localize tz-naive TimeSeries to target time zone.

**Parameters**

- **tz** [string or pytz.timezone object]
- **axis** [the axis to localize]
- **level** : int, str, default None
  - If axis ia a MultiIndex, localize a specific level. Otherwise must be None
- **copy** : boolean, default True
  - Also make a copy of the underlying data
- **ambiguous** : ‘infer’, bool-ndarray, ‘NaT’, default ‘raise’
  - ‘infer’ will attempt to infer fall dst-transition hours based on order
  - bool-ndarray where True signifies a DST time, False designates a non-DST time (note that this flag is only applicable for ambiguous times)
  - ‘NaT’ will return NaT where there are ambiguous times
  - ‘raise’ will raise an AmbiguousTimeError if there are ambiguous times

**Raises** **TypeError**

- If the TimeSeries is tz-aware and tz is not None.

**pandas.DataFrame.unstack**

DataFrame.unstack (level=-1, fill_value=None)
Pivot a level of the (necessarily hierarchical) index labels, returning a DataFrame having a new level of column labels whose inner-most level consists of the pivoted index labels. If the index is not a MultiIndex, the output will be a Series (the analogue of stack when the columns are not a MultiIndex). The level involved will automatically get sorted.

**Parameters** **level** : int, string, or list of these, default -1 (last level)

- Level(s) of index to unstack, can pass level name
fill_value : replace NaN with this value if the unstack produces missing values

New in version 0.18.0.

Returns

unstacked [DataFrame or Series]

See also:

DataFrame.pivot Pivot a table based on column values.

DataFrame.stack Pivot a level of the column labels (inverse operation from unstack).

Examples

```python
>>> index = pd.MultiIndex.from_tuples([('one', 'a'), ('one', 'b'),
... (two', 'a'), ('two', 'b')])
>>> s = pd.Series(np.arange(1.0, 5.0), index=index)
>>> s
one a 1.0
 b 2.0
two a 3.0
 b 4.0
dtype: float64
```

```python
>>> s.unstack(level=-1)
a b
one 1.0 2.0
two 3.0 4.0
```

```python
>>> s.unstack(level=0)
one two
 a 1.0 3.0
 b 2.0 4.0
```

```python
>>> df = s.unstack(level=0)
>>> df.unstack()
one a 1.0
 b 2.0
two a 3.0
 b 4.0
dtype: float64
```

pandas.DataFrame.update

DataFrame.update(other, join='left', overwrite=True, filter_func=None, raise_conflict=False)

Modify in place using non-NA values from another DataFrame.

Aligns on indices. There is no return value.

Parameters other : DataFrame, or object coercible into a DataFrame
Should have at least one matching index/column label with the original DataFrame. If a Series is passed, its name attribute must be set, and that will be used as the column name to align with the original DataFrame.

**join** : ['left'], default 'left'

Only left join is implemented, keeping the index and columns of the original object.

**overwrite** : bool, default True

How to handle non-NA values for overlapping keys:

- True: overwrite original DataFrame’s values with values from `other`.
- False: only update values that are NA in the original DataFrame.

**filter_func** : callable(1d-array) -> boolean 1d-array, optional

Can choose to replace values other than NA. Return True for values that should be updated.

**raise_conflict** : bool, default False

If True, will raise a ValueError if the DataFrame and `other` both contain non-NA data in the same place.

**Raises** `ValueError`

When `raise_conflict` is True and there’s overlapping non-NA data.

**See also:**

dict.update  Similar method for dictionaries.

`DataFrame.merge` For column(s)-on-columns(s) operations.

**Examples**

```python
>>> df = pd.DataFrame({'A': [1, 2, 3],
... 'B': [400, 500, 600]})
>>> new_df = pd.DataFrame({'B': [4, 5, 6],
... 'C': [7, 8, 9]})
>>> df.update(new_df)
>>> df
   A  B
0  1  4
1  2  5
2  3  6
```

The DataFrame’s length does not increase as a result of the update, only values at matching index/column labels are updated.

```python
>>> df = pd.DataFrame({'A': ['a', 'b', 'c'],
... 'B': ['x', 'y', 'z']})
>>> new_df = pd.DataFrame({'B': ['d', 'e', 'f', 'g', 'h', 'i']})
>>> df.update(new_df)
>>> df
   A  B
0  a  d
```

(continues on next page)
For Series, its name attribute must be set.

```python
>>> df = pd.DataFrame({'A': ['a', 'b', 'c'],
... 'B': ['x', 'y', 'z']})
>>> new_column = pd.Series(['d', 'e'], name='B', index=[0, 2])
>>> df.update(new_column)
>>> df
        A  B
0      a  d
1      b  y
2      c  e
```

If other contains NaNs the corresponding values are not updated in the original dataframe.

```python
>>> df = pd.DataFrame({'A': [1, 2, 3],
... 'B': [400, 500, 600]})
>>> new_df = pd.DataFrame({'B': [4, np.nan, 6]})
>>> df.update(new_df)
>>> df
       A     B
0      1  4.0
1      2 500.0
2      3  6.0
```

**pandas.DataFrame.var**

DataFrame.var (axis=None, skipna=None, level=None, ddof=1, numeric_only=None, **kwargs)  
Return unbiased variance over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument

**Parameters**

- **axis** [{index (0), columns (1)}]  
- **skipna** : boolean, default True  
  Exclude NA/null values. If an entire row/column is NA, the result will be NA

- **level** : int or level name, default None  
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

- **ddof** : int, default 1
Delta Degrees of Freedom. The divisor used in calculations is N - ddof, where N represents the number of elements.

**numeric_only**: boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

**var** [Series or DataFrame (if level specified)]

**pandas.DataFrame.where**

DataFrame.where (cond, other=nan, inplace=False, axis=None, level=None, errors='raise', try_cast=False, raise_on_error=None)

Return an object of same shape as self and whose corresponding entries are from self where cond is True and otherwise are from other.

**Parameters**

**cond**: boolean NDFrame, array-like, or callable

Where cond is True, keep the original value. Where False, replace with corresponding value from other. If cond is callable, it is computed on the NDFrame and should return boolean NDFrame or array. The callable must not change input NDFrame (though pandas doesn’t check it).

New in version 0.18.1: A callable can be used as cond.

**other**: scalar, NDFrame, or callable

Entries where cond is False are replaced with corresponding value from other. If other is callable, it is computed on the NDFrame and should return scalar or NDFrame. The callable must not change input NDFrame (though pandas doesn’t check it).

New in version 0.18.1: A callable can be used as other.

**inplace**: boolean, default False

Whether to perform the operation in place on the data

**axis** [alignment axis if needed, default None]

**level** [alignment level if needed, default None]

**errors**: str, {'raise', 'ignore'}, default 'raise'

  * raise: allow exceptions to be raised
  * ignore: suppress exceptions. On error return original object

Note that currently this parameter won’t affect the results and will always coerce to a suitable dtype.

**try_cast**: boolean, default False

try to cast the result back to the input type (if possible),

**raise_on_error**: boolean, default True

Whether to raise on invalid data types (e.g. trying to where on strings)

Deprecated since version 0.21.0.
Returns

wh  [same type as caller]

See also:

DataFrame.mask()

Notes

The where method is an application of the if-then idiom. For each element in the calling DataFrame, if cond is True the element is used; otherwise the corresponding element from the DataFrame other is used.

The signature for DataFrame.where() differs from numpy.where(). Roughly df1.where(m, df2) is equivalent to np.where(m, df1, df2).

For further details and examples see the where documentation in indexing.

Examples

```python
>>> s = pd.Series(range(5))
>>> s.where(s > 0)
0   NaN
1    1.0
2    2.0
3    3.0
4    4.0

>>> s.where(s > 1, 10)
0  10.0
1  10.0
2    2.0
3    3.0
4    4.0

>>> df = pd.DataFrame(np.arange(10).reshape(-1, 2), columns=['A', 'B'])
>>> m = df % 3 == 0
>>> df.where(m, -df)
     A   B
0    0 -1
1   -2  3
2   -4 -5
3    6 -7
4   -8  9
>>> df.where(m, -df) == np.where(m, df, -df)
     A   B
0 True True
```
1  True  True
2  True  True
3  True  True
4  True  True

```python
>>> df.where(m, -df) == df.mask(~m, -df)
   A  B
0  True True
1  True True
2  True True
3  True True
4  True True
```

**pandas.DataFrame.xs**

DataFrame.xs(key, axis=0, level=None, drop_level=True)

Returns a cross-section (row(s) or column(s)) from the Series/DataFrame. Defaults to cross-section on the rows (axis=0).

**Parameters**

- **key** : object
  
  Some label contained in the index, or partially in a MultiIndex

- **axis** : int, default 0
  
  Axis to retrieve cross-section on

- **level** : object, defaults to first n levels (n=1 or len(key))
  
  In case of a key partially contained in a MultiIndex, indicate which levels are used. Levels can be referred by label or position.

- **drop_level** : boolean, default True
  
  If False, returns object with same levels as self.

**Returns**

xs  [Series or DataFrame]

**Notes**

xs is only for getting, not setting values.

MultiIndex Slicers is a generic way to get/set values on any level or levels. It is a superset of xs functionality, see MultiIndex Slicers

**Examples**

```python
>>> df
   A  B  C
a  4  5  2
b  4  0  9
c  9  7  3

>>> df.xs('a')
   A  B  C
a  4  5  2
```

(continues on next page)
34.4.2 Attributes and underlying data

Axes

| **DataFrame.index** | The index (row labels) of the DataFrame. |
| **DataFrame.columns** | The column labels of the DataFrame. |

| **DataFrame.dtypes** | Return the dtypes in the DataFrame. |
| **DataFrame.ftypes** | Return the ftypes (indication of sparse/dense and dtype) in DataFrame. |

| **DataFrame.get_dtypes_counts()** | Return counts of unique dtypes in this object. |
| **DataFrame.get_ftype_counts()** | (DEPRECATED) Return counts of unique ftypes in this object. |

| **DataFrame.select_dtypes([include, exclude])** | Return a subset of the DataFrame’s columns based on the column dtypes. |
| **DataFrame.values** | Return a Numpy representation of the DataFrame. |
| **DataFrame.get_values()** | Return an ndarray after converting sparse values to dense. |

| **DataFrame.axes** | Return a list representing the axes of the DataFrame. |
| **DataFrame.ndim** | Return an int representing the number of axes / array dimensions. |

Continued on next page
Table 63 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame.size</td>
<td>Return an int representing the number of elements in this object.</td>
</tr>
<tr>
<td>DataFrame.shape</td>
<td>Return a tuple representing the dimensionality of the DataFrame.</td>
</tr>
<tr>
<td>DataFrame.memory_usage</td>
<td>Return the memory usage of each column in bytes.</td>
</tr>
<tr>
<td>DataFrame.empty</td>
<td>Indicator whether DataFrame is empty.</td>
</tr>
<tr>
<td>DataFrame.is_copy</td>
<td></td>
</tr>
</tbody>
</table>

### 34.4.2.1 pandas.DataFrame.is_copy

DataFrame.is_copy

### 34.4.3 Conversion

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame.astype</td>
<td>Cast a pandas object to a specified dtype dtype.</td>
</tr>
<tr>
<td>DataFrame.convert_objects</td>
<td>(DEPRECATED) Attempt to infer better dtype for object columns.</td>
</tr>
<tr>
<td>DataFrame.infer_objects</td>
<td>Attempt to infer better dtypes for object columns.</td>
</tr>
<tr>
<td>DataFrame.copy</td>
<td>Make a copy of this object’s indices and data.</td>
</tr>
<tr>
<td>DataFrame.isna</td>
<td>Detect missing values.</td>
</tr>
<tr>
<td>DataFrame.notna</td>
<td>Detect existing (non-missing) values.</td>
</tr>
<tr>
<td>DataFrame.bool</td>
<td>Return the bool of a single element PandasObject.</td>
</tr>
</tbody>
</table>

### 34.4.4 Indexing, iteration

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame.head</td>
<td>Return the first n rows.</td>
</tr>
<tr>
<td>DataFrame.at</td>
<td>Access a single value for a row/column label pair.</td>
</tr>
<tr>
<td>DataFrame.iat</td>
<td>Access a single value for a row/column pair by integer position.</td>
</tr>
<tr>
<td>DataFrame.loc</td>
<td>Access a group of rows and columns by label(s) or a boolean array.</td>
</tr>
<tr>
<td>DataFrame.iloc</td>
<td>Purely integer-location based indexing for selection by position.</td>
</tr>
<tr>
<td>DataFrame.insert</td>
<td>Insert column into DataFrame at specified location.</td>
</tr>
<tr>
<td>DataFrame.insert</td>
<td>Insert column into DataFrame at specified location.</td>
</tr>
<tr>
<td>DataFrame.<strong>iter</strong></td>
<td>Iterate over info axis</td>
</tr>
<tr>
<td>DataFrame.items</td>
<td>Iterator over (column name, Series) pairs.</td>
</tr>
<tr>
<td>DataFrame.keys</td>
<td>Get the ‘info axis’ (see Indexing for more)</td>
</tr>
<tr>
<td>DataFrame.iteritems</td>
<td>Iterator over (column name, Series) pairs.</td>
</tr>
<tr>
<td>DataFrame.iterrows</td>
<td>Iterate over DataFrame rows as (index, Series) pairs.</td>
</tr>
<tr>
<td>DataFrame.itertuples</td>
<td>Iterate over DataFrame rows as namedtuples, with index value as first element of the tuple.</td>
</tr>
<tr>
<td>DataFrame.lookup</td>
<td>Label-based “fancy indexing” function for DataFrame.</td>
</tr>
<tr>
<td>DataFrame.pop</td>
<td>Return item and drop from frame.</td>
</tr>
<tr>
<td>DataFrame.tail</td>
<td>Return the last n rows.</td>
</tr>
<tr>
<td>DataFrame.xs</td>
<td>Returns a cross-section (row(s) or column(s)) from the Series/DataFrame.</td>
</tr>
</tbody>
</table>

Continued on next page
Table 65 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame.get</td>
<td>Get item from object for given key (DataFrame column, Panel slice, etc.).</td>
</tr>
<tr>
<td>DataFrame.isin</td>
<td>Return boolean DataFrame showing whether each element in the DataFrame is contained in values.</td>
</tr>
<tr>
<td>DataFrame.where</td>
<td>Return an object of same shape as self and whose corresponding entries are from self where cond is True and otherwise are from other.</td>
</tr>
<tr>
<td>DataFrame.mask</td>
<td>Return an object of same shape as self and whose corresponding entries are from self where cond is False and otherwise are from other.</td>
</tr>
<tr>
<td>DataFrame.query</td>
<td>Query the columns of a frame with a boolean expression.</td>
</tr>
</tbody>
</table>

34.4.4.1 pandas.DataFrame.__iter__

DataFrame.__iter__()
Iterate over infor axis

For more information on .at, .iat, .loc, and .iloc, see the indexing documentation.

34.4.5 Binary operator functions

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame.add</td>
<td>Addition of dataframe and other, element-wise (binary operator add).</td>
</tr>
<tr>
<td>DataFrame.sub</td>
<td>Subtraction of dataframe and other, element-wise (binary operator sub).</td>
</tr>
<tr>
<td>DataFrame.mul</td>
<td>Multiplication of dataframe and other, element-wise (binary operator mul).</td>
</tr>
<tr>
<td>DataFrame.div</td>
<td>Floating division of dataframe and other, element-wise (binary operator truediv).</td>
</tr>
<tr>
<td>DataFrame.truediv</td>
<td>Floating division of dataframe and other, element-wise (binary operator truediv).</td>
</tr>
<tr>
<td>DataFrame.floordiv</td>
<td>Integer division of dataframe and other, element-wise (binary operator floordiv).</td>
</tr>
<tr>
<td>DataFrame.mod</td>
<td>Modulo of dataframe and other, element-wise (binary operator mod).</td>
</tr>
<tr>
<td>DataFrame.pow</td>
<td>Exponential power of dataframe and other, element-wise (binary operator pow).</td>
</tr>
<tr>
<td>DataFrame.dot</td>
<td>Matrix multiplication with DataFrame or Series objects.</td>
</tr>
<tr>
<td>DataFrame.radd</td>
<td>Addition of dataframe and other, element-wise (binary operator radd).</td>
</tr>
<tr>
<td>DataFrame.rsub</td>
<td>Subtraction of dataframe and other, element-wise (binary operator rsub).</td>
</tr>
<tr>
<td>DataFrame.rmul</td>
<td>Multiplication of dataframe and other, element-wise (binary operator rmul).</td>
</tr>
<tr>
<td>DataFrame.rdiv</td>
<td>Floating division of dataframe and other, element-wise (binary operator rtruediv).</td>
</tr>
<tr>
<td>DataFrame.rtruediv</td>
<td>Floating division of dataframe and other, element-wise (binary operator rtruediv).</td>
</tr>
</tbody>
</table>

Continued on next page
Table 66 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame.rfloordiv(other[, axis, level, ...])</td>
<td>Integer division of dataframe and other, element-wise (binary operator r\text{floor}div).</td>
</tr>
<tr>
<td>DataFrame.rmod(other[, axis, level, fill_value])</td>
<td>Modulo of dataframe and other, element-wise (binary operator r\text{mod}).</td>
</tr>
<tr>
<td>DataFrame.rpow(other[, axis, level, fill_value])</td>
<td>Exponential power of dataframe and other, element-wise (binary operator r\text{pow}).</td>
</tr>
<tr>
<td>DataFrame.lt(other[, axis, level])</td>
<td>Wrapper for flexible comparison methods lt</td>
</tr>
<tr>
<td>DataFrame.gt(other[, axis, level])</td>
<td>Wrapper for flexible comparison methods gt</td>
</tr>
<tr>
<td>DataFrame.le(other[, axis, level])</td>
<td>Wrapper for flexible comparison methods le</td>
</tr>
<tr>
<td>DataFrame.ge(other[, axis, level])</td>
<td>Wrapper for flexible comparison methods ge</td>
</tr>
<tr>
<td>DataFrame.ne(other[, axis, level])</td>
<td>Wrapper for flexible comparison methods ne</td>
</tr>
<tr>
<td>DataFrame.combine(other, func[, fill_value, ...])</td>
<td>Add two DataFrame objects and do not propagate NaN values, so if for a (column, time) one frame is missing a value, it will default to the other frame’s value (which might be NaN as well)</td>
</tr>
<tr>
<td>DataFrame.combine_first(other)</td>
<td>Combine two DataFrame objects and default to non-null values in frame calling the method.</td>
</tr>
</tbody>
</table>

### 34.4.6 Function application, GroupBy & Window

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame.apply(func[, axis, broadcast, ...])</td>
<td>Apply a function along an axis of the DataFrame.</td>
</tr>
<tr>
<td>DataFrame.applymap(func)</td>
<td>Apply a function to a dataframe elementwise.</td>
</tr>
<tr>
<td>DataFrame.pipe(func, *args, **kwargs)</td>
<td>Apply func(self, *args, **kwargs)</td>
</tr>
<tr>
<td>DataFrame.agg(func[, axis])</td>
<td>Aggregate using one or more operations over the specified axis.</td>
</tr>
<tr>
<td>DataFrame.aggregate(func[, axis])</td>
<td>Aggregate using one or more operations over the specified axis.</td>
</tr>
<tr>
<td>DataFrame.transform(func, *args, **kwargs)</td>
<td>Call function producing a like-indexed NDFrame and return a NDFrame with the transformed values</td>
</tr>
<tr>
<td>DataFrame.groupby([by, axis, level, ...])</td>
<td>Group series using mapper (dict or key function, apply given function to group, return result as series) or by a series of columns.</td>
</tr>
<tr>
<td>DataFrame.rolling(window[, min_periods, ...])</td>
<td>Provides rolling window calculations.</td>
</tr>
<tr>
<td>DataFrame.expanding([min_periods, center, axis])</td>
<td>Provides expanding transformations.</td>
</tr>
<tr>
<td>DataFrame.ewm([com, span, halflife, alpha, ...])</td>
<td>Provides exponential weighted functions</td>
</tr>
</tbody>
</table>

### 34.4.7 Computations / Descriptive Stats

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame.abs()</td>
<td>Return a Series/DataFrame with absolute numeric value of each element.</td>
</tr>
<tr>
<td>DataFrame.all([axis, bool_only, skipna, level])</td>
<td>Return whether all elements are True, potentially over an axis.</td>
</tr>
<tr>
<td>DataFrame.any([axis, bool_only, skipna, level])</td>
<td>Return whether any element is True over requested axis.</td>
</tr>
<tr>
<td>DataFrame.clip([lower, upper, axis, inplace])</td>
<td>Trim values at input threshold(s).</td>
</tr>
<tr>
<td>DataFrame.clip_lower(threshold[, axis, inplace])</td>
<td>Return copy of the input with values below a threshold truncated.</td>
</tr>
</tbody>
</table>

Continued on next page
Table 68 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>DataFrame.clip_upper</code></td>
<td>Return copy of input with values above given value(s) truncated.</td>
</tr>
<tr>
<td><code>DataFrame.compound</code></td>
<td>Return the compound percentage of the values for the requested axis</td>
</tr>
<tr>
<td><code>DataFrame.corr</code></td>
<td>Compute pairwise correlation of columns, excluding NA/null values.</td>
</tr>
<tr>
<td><code>DataFrame.corrwith</code></td>
<td>Compute pairwise correlation between rows or columns of two DataFrame objects.</td>
</tr>
<tr>
<td><code>DataFrame.count</code></td>
<td>Count non-NA cells for each column or row.</td>
</tr>
<tr>
<td><code>DataFrame.cov</code></td>
<td>Compute pairwise covariance of columns, excluding NA/null values.</td>
</tr>
<tr>
<td><code>DataFrame.cummax</code></td>
<td>Return cumulative maximum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>DataFrame.cummin</code></td>
<td>Return cumulative minimum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>DataFrame.cumprod</code></td>
<td>Return cumulative product over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>DataFrame.cumsum</code></td>
<td>Return cumulative sum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>DataFrame.describe</code></td>
<td>Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset’s distribution, excluding NaN values.</td>
</tr>
<tr>
<td><code>DataFrame.diff</code></td>
<td>First discrete difference of element.</td>
</tr>
<tr>
<td><code>DataFrame.eval</code></td>
<td>Evaluate a string describing operations on DataFrame columns.</td>
</tr>
<tr>
<td><code>DataFrame.kurt</code></td>
<td>Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0).</td>
</tr>
<tr>
<td><code>DataFrame.kurtosis</code></td>
<td>Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0).</td>
</tr>
<tr>
<td><code>DataFrame.mad</code></td>
<td>Return the mean absolute deviation of the values for the requested axis</td>
</tr>
<tr>
<td><code>DataFrame.max</code></td>
<td>This method returns the maximum of the values in the object.</td>
</tr>
<tr>
<td><code>DataFrame.mean</code></td>
<td>Return the mean of the values for the requested axis.</td>
</tr>
<tr>
<td><code>DataFrame.median</code></td>
<td>Return the median of the values for the requested axis.</td>
</tr>
<tr>
<td><code>DataFrame.min</code></td>
<td>This method returns the minimum of the values in the object.</td>
</tr>
<tr>
<td><code>DataFrame.mode</code></td>
<td>Gets the mode(s) of each element along the axis selected.</td>
</tr>
<tr>
<td><code>DataFrame.pct_change</code></td>
<td>Percentage change between the current and a prior element.</td>
</tr>
<tr>
<td><code>DataFrame.prod</code></td>
<td>Return the product of the values for the requested axis.</td>
</tr>
<tr>
<td><code>DataFrame.product</code></td>
<td>Return the product of the values for the requested axis.</td>
</tr>
<tr>
<td><code>DataFrame.quantile</code></td>
<td>Return values at the given quantile over requested axis, a la numpy.percentile.</td>
</tr>
<tr>
<td><code>DataFrame.rank</code></td>
<td>Compute numerical data ranks (1 through n) along axis.</td>
</tr>
<tr>
<td><code>DataFrame.round</code></td>
<td>Round a DataFrame to a variable number of decimal places.</td>
</tr>
</tbody>
</table>
### 34.4.8 Reindexing / Selection / Label manipulation

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>DataFrame.add_prefix</code></td>
<td>Prefix labels with string <code>prefix</code>.</td>
</tr>
<tr>
<td><code>DataFrame.add_suffix</code></td>
<td>Suffix labels with string <code>suffix</code>.</td>
</tr>
<tr>
<td><code>DataFrame.align</code></td>
<td>Align two objects on their axes with the specified join method for each axis</td>
</tr>
<tr>
<td><code>DataFrame.at_time</code></td>
<td>Select values at particular time of day (e.g., 9:00-9:30 AM).</td>
</tr>
<tr>
<td><code>DataFrame.between_time</code></td>
<td>Select values between particular times of the day (e.g., 9:00-9:30 AM).</td>
</tr>
<tr>
<td><code>DataFrame.drop</code></td>
<td>Drop specified labels from rows or columns.</td>
</tr>
<tr>
<td><code>DataFrame.drop_duplicates</code></td>
<td>Return DataFrame with duplicate rows removed, optionally only considering</td>
</tr>
<tr>
<td></td>
<td>certain columns.</td>
</tr>
<tr>
<td><code>DataFrame.duplicated</code></td>
<td>Return boolean Series denoting duplicate rows, optionally only considering</td>
</tr>
<tr>
<td></td>
<td>certain columns.</td>
</tr>
<tr>
<td><code>DataFrame.equals</code></td>
<td>Determines if two NDFrame objects contain the same elements.</td>
</tr>
<tr>
<td><code>DataFrame.filter</code></td>
<td>Subset rows or columns of dataframe according to labels in the specified</td>
</tr>
<tr>
<td></td>
<td>index.</td>
</tr>
<tr>
<td><code>DataFrame.first</code></td>
<td>Convenience method for subsetting initial periods of time series data based</td>
</tr>
<tr>
<td></td>
<td>on a date offset.</td>
</tr>
<tr>
<td><code>DataFrame.head</code></td>
<td>Return the first n rows.</td>
</tr>
<tr>
<td><code>DataFrame.idxmax</code></td>
<td>Return index of first occurrence of maximum over requested axis.</td>
</tr>
<tr>
<td><code>DataFrame.idxmin</code></td>
<td>Return index of first occurrence of minimum over requested axis.</td>
</tr>
<tr>
<td><code>DataFrame.last</code></td>
<td>Convenience method for subsetting final periods of time series data based</td>
</tr>
<tr>
<td></td>
<td>on a date offset.</td>
</tr>
<tr>
<td><code>DataFrame.reindex</code></td>
<td>Conform DataFrame to new index with optional filling logic, placing NA/NaN</td>
</tr>
<tr>
<td></td>
<td>in locations having no value in the previous index.</td>
</tr>
<tr>
<td><code>DataFrame.reindex_axis</code></td>
<td>Conform input object to new index with optional filling logic, placing NA/N</td>
</tr>
<tr>
<td></td>
<td>NaN in locations having no value in the previous index.</td>
</tr>
<tr>
<td><code>DataFrame.rename</code></td>
<td>Alter axes labels.</td>
</tr>
<tr>
<td><code>DataFrame.rename_axis</code></td>
<td>Alter the name of the index or columns.</td>
</tr>
</tbody>
</table>

Continued on next page
### 34.4.9 Missing data handling

- **DataFrame.dropna**(axis, how, thresh, ...) Remove missing values.
- **DataFrame.fillna**(value, method, axis, ...) Fill NA/NaN values using the specified method.
- **DataFrame.replace**(to_replace, value, ...) Replace values given in to_replace with value.
- **DataFrame.interpolate**(method, axis, limit, ...) Interpolate values according to different methods.

### 34.4.10 Reshaping, sorting, transposing

- **DataFrame.pivot**(index, columns, values) Return reshaped DataFrame organized by given index / column values.
- **DataFrame.pivot_table**(values, index, ...) Create a spreadsheet-style pivot table as a DataFrame.
- **DataFrame.reorder_levels**(order[, axis]) Rearrange index levels using input order.
- **DataFrame.sort_values**(by[, axis, ascending, ...]) Sort by the values along either axis.
- **DataFrame.sort_index**(axis[, level, ...]) Sort object by labels (along an axis).
- **DataFrame.nlargest**(n, columns[, keep]) Return the first n rows ordered by columns in descending order.
- **DataFrame.nsmallest**(n, columns[, keep]) Get the rows of a DataFrame sorted by the n smallest values of columns.
- **DataFrame.swaplevel**(i, j, axis) Swap levels i and j in a MultiIndex on a particular axis.
- **DataFrame.stack**(level, dropna) Stack the prescribed level(s) from columns to index.
- **DataFrame.unstack**(level, fill_value) Pivot a level of the (necessarily hierarchical) index labels, returning a DataFrame having a new level of column labels whose inner-most level consists of the pivoted index labels.
- **DataFrame.swapaxes**(axis1, axis2[, copy]) Interchange axes and swap values axes appropriately.
- **DataFrame.melt**(id_vars, value_vars, ...) “Un pivots” a DataFrame from wide format to long format, optionally leaving identifier variables set.
- **DataFrame.squeeze**(axis) Squeeze length 1 dimensions.
- **DataFrame.to_panel**() (DEPRECATED) Transform long (stacked) format (DataFrame) into wide (3D, Panel) format.
Table 71 – continued from previous page

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame.to_xarray()</td>
<td>Return an xarray object from the pandas object.</td>
</tr>
<tr>
<td>DataFrame.T</td>
<td>Transpose index and columns.</td>
</tr>
<tr>
<td>DataFrame.transpose(*args, **kwargs)</td>
<td>Transpose index and columns.</td>
</tr>
</tbody>
</table>

### 34.4.11 Combining / joining / merging

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame.append(other[, ignore_index, ...])</td>
<td>Append rows of other to the end of this frame, returning a new object.</td>
</tr>
<tr>
<td>DataFrame.assign(**kwargs)</td>
<td>Assign new columns to a DataFrame, returning a new object (a copy) with the new columns added to the original ones.</td>
</tr>
<tr>
<td>DataFrame.join(other[, on, how, lsuffix, ...])</td>
<td>Join columns with other DataFrame either on index or on a key column.</td>
</tr>
<tr>
<td>DataFrame.merge(right[, how, on, left_on, ...])</td>
<td>Merge DataFrame objects by performing a database-style join operation by columns or indexes.</td>
</tr>
<tr>
<td>DataFrame.update(other[, join, overwrite, ...])</td>
<td>Modify in place using non-NA values from another DataFrame.</td>
</tr>
</tbody>
</table>

### 34.4.12 Time series-related

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame.asfreq(freq[, method, how, ...])</td>
<td>Convert TimeSeries to specified frequency.</td>
</tr>
<tr>
<td>DataFrame.asof(where[, subset])</td>
<td>The last row without any NaN is taken (or the last row without NaN considering only the subset of columns in the case of a DataFrame)</td>
</tr>
<tr>
<td>DataFrame.shift([periods, freq, axis])</td>
<td>Shift index by desired number of periods with an optional time freq.</td>
</tr>
<tr>
<td>DataFrame.slice_shift([periods, axis])</td>
<td>Equivalent to shift without copying data.</td>
</tr>
<tr>
<td>DataFrame.tshift([periods, freq, axis])</td>
<td>Shift the time index, using the index’s frequency if available.</td>
</tr>
<tr>
<td>DataFrame.first_valid_index()</td>
<td>Return index for first non-NA/null value.</td>
</tr>
<tr>
<td>DataFrame.last_valid_index()</td>
<td>Return index for last non-NA/null value.</td>
</tr>
<tr>
<td>DataFrame.resample(rule[, how, axis, ...])</td>
<td>Convenience method for frequency conversion and resampling of time series.</td>
</tr>
<tr>
<td>DataFrame.to_period([freq, axis, copy])</td>
<td>Convert DataFrame from DatetimeIndex to PeriodIndex with desired frequency (inferred from index if not passed)</td>
</tr>
<tr>
<td>DataFrame.to_timestamp([freq, how, axis, copy])</td>
<td>Cast to DatetimeIndex of timestamps, at beginning of period</td>
</tr>
<tr>
<td>DataFrame.tz_convert(tz[, axis, level, copy])</td>
<td>Convert tz-aware axis to target time zone.</td>
</tr>
<tr>
<td>DataFrame.tz_localize(tz[, axis, level, ...])</td>
<td>Localize tz-naive TimeSeries to target time zone.</td>
</tr>
</tbody>
</table>

### 34.4.13 Plotting

DataFrame.plot is both a callable method and a namespace attribute for specific plotting methods of the form DataFrame.plot.<kind>.

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame.plot([x, y, kind, ax, ....])</td>
<td>DataFrame plotting accessor and method</td>
</tr>
</tbody>
</table>
DataFrame.plot.area([x, y])  
Area plot

Parameters x, y : label or position, optional
Coordinates for each point.

**kwds : optional
Additional keyword arguments are documented in pandas.DataFrame.plot().

Returns axes : matplotlib.axes.Axes or numpy.ndarray of them

34.4.13.2 pandas.DataFrame.plot.bar

DataFrame.plot.bar(x=None, y=None, **kwds)

Vertical bar plot.

A bar plot is a plot that presents categorical data with rectangular bars with lengths proportional to the values that they represent. A bar plot shows comparisons among discrete categories. One axis of the plot shows the specific categories being compared, and the other axis represents a measured value.

Parameters x : label or position, optional
 Allows plotting of one column versus another. If not specified, the index of the DataFrame is used.

y : label or position, optional
 Allows plotting of one column versus another. If not specified, all numerical columns are used.

**kwds
Additional keyword arguments are documented in pandas.DataFrame.plot().

Returns axes : matplotlib.axes.Axes or numpy.ndarray of them
An ndarray is returned with one `matplotlib.axes.Axes` per column when `subplots=True`.

See also:

- `pandas.DataFrame.plot.barh` Horizontal bar plot.
- `pandas.DataFrame.plot` Make plots of a DataFrame.
- `matplotlib.pyplot.bar` Make a bar plot with matplotlib.

Examples

Basic plot.

```python
>>> df = pd.DataFrame({'lab': ['A', 'B', 'C'], 'val':[10, 30, 20]})
>>> ax = df.plot.bar(x='lab', y='val', rot=0)
```

Plot a whole dataframe to a bar plot. Each column is assigned a distinct color, and each row is nested in a group along the horizontal axis.

```python
>>> speed = [0.1, 17.5, 40, 48, 52, 69, 88]
>>> lifespan = [2, 8, 70, 1.5, 25, 12, 28]
>>> index = ['snail', 'pig', 'elephant', ...
'rabbit', 'giraffe', 'coyote', 'horse']
>>> df = pd.DataFrame({'speed': speed,
... 'lifespan': lifespan}, index=index)
>>> ax = df.plot.bar(rot=0)
```

Instead of nesting, the figure can be split by column with `subplots=True`. In this case, a `numpy.ndarray` of `matplotlib.axes.Axes` are returned.

```python
>>> axes = df.plot.bar(rot=0, subplots=True)
>>> axes[1].legend(loc=2)
```

Plot a single column.

```python
>>> ax = df.plot.bar(y='speed', rot=0)
```

Plot only selected categories for the DataFrame.

```python
>>> ax = df.plot.bar(x='lifespan', rot=0)
```

### 34.4.13.3 pandas.DataFrame.plot.barh

DataFrame.plot.barh(x=None, y=None, **kwds)

Make a horizontal bar plot.

A horizontal bar plot is a plot that presents quantitative data with rectangular bars with lengths proportional to the values that they represent. A bar plot shows comparisons among discrete categories. One axis of the plot shows the specific categories being compared, and the other axis represents a measured value.

**Parameters**

- `x`: label or position, default DataFrame.index
  - Column to be used for categories.
- `y`: label or position, default All numeric columns in dataframe
Columns to be plotted from the DataFrame.

**kwds**

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

Returns

`axes` [matplotlib.axes.Axes or numpy.ndarray of them.]

See also:

- `pandas.DataFrame.plot.bar` Vertical bar plot.
- `pandas.DataFrame.plot` Make plots of DataFrame using matplotlib.
- `matplotlib.axes.Axes.bar` Plot a vertical bar plot using matplotlib.

Examples

Basic example

```python
>>> df = pd.DataFrame({'lab': ['A', 'B', 'C'], 'val':[10, 30, 20]})
>>> ax = df.plot.barh(x='lab', y='val')
```

Plot a whole DataFrame to a horizontal bar plot

```python
>>> speed = [0.1, 17.5, 40, 48, 52, 69, 88]
>>> lifespan = [2, 8, 70, 1.5, 25, 12, 28]
>>> index = ['snail', 'pig', 'elephant', 'rabbit', 'giraffe', 'coyote', 'horse']
>>> df = pd.DataFrame({'speed': speed, 'lifespan': lifespan}, index=index)
>>> ax = df.plot.barh()
```

Plot a column of the DataFrame to a horizontal bar plot

```python
>>> speed = [0.1, 17.5, 40, 48, 52, 69, 88]
>>> lifespan = [2, 8, 70, 1.5, 25, 12, 28]
>>> index = ['snail', 'pig', 'elephant', 'rabbit', 'giraffe', 'coyote', 'horse']
>>> df = pd.DataFrame({'speed': speed, 'lifespan': lifespan}, index=index)
>>> ax = df.plot.barh(y='speed')
```

Plot DataFrame versus the desired column

```python
>>> speed = [0.1, 17.5, 40, 48, 52, 69, 88]
>>> lifespan = [2, 8, 70, 1.5, 25, 12, 28]
>>> index = ['snail', 'pig', 'elephant', 'rabbit', 'giraffe', 'coyote', 'horse']
>>> df = pd.DataFrame({'speed': speed, 'lifespan': lifespan}, index=index)
>>> ax = df.plot.barh(x='lifespan')
```
34.4.13.4 pandas.DataFrame.plot.box

DataFrame.plot.box(by=None, **kwds)
Make a box plot of the DataFrame columns.

A box plot is a method for graphically depicting groups of numerical data through their quartiles. The box extends from the Q1 to Q3 quartile values of the data, with a line at the median (Q2). The whiskers extend from the edges of box to show the range of the data. The position of the whiskers is set by default to 1.5*IQR (IQR = Q3 - Q1) from the edges of the box. Outlier points are those past the end of the whiskers.

For further details see Wikipedia’s entry for boxplot.

A consideration when using this chart is that the box and the whiskers can overlap, which is very common when plotting small sets of data.

**Parameters**

- **by** : string or sequence
  Column in the DataFrame to group by.

- **kwds** : optional
  Additional keywords are documented in pandas.DataFrame.plot().

**Returns**

axes [matplotlib.axes.Axes or numpy.ndarray of them]

See also:

- pandas.DataFrame.boxplot Another method to draw a box plot.
- pandas.Series.plot.box Draw a box plot from a Series object.
- matplotlib.pyplot.boxplot Draw a box plot in matplotlib.

Examples

Draw a box plot from a DataFrame with four columns of randomly generated data.

```python
>>> data = np.random.randn(25, 4)
>>> df = pd.DataFrame(data, columns=list('ABCD'))
>>> ax = df.plot.box()
```

34.4.13.5 pandas.DataFrame.plot.density

DataFrame.plot.density(bw_method=None, ind=None, **kwds)
Generate Kernel Density Estimate plot using Gaussian kernels.

In statistics, kernel density estimation (KDE) is a non-parametric way to estimate the probability density function (PDF) of a random variable. This function uses Gaussian kernels and includes automatic bandwidth determination.

**Parameters**

- **bw_method** : str, scalar or callable, optional
  The method used to calculate the estimator bandwidth. This can be ‘scott’, ‘silverman’, a scalar constant or a callable. If None (default), ‘scott’ is used. See scipy.stats.gaussian_kde for more information.

- **ind** : NumPy array or integer, optional
Evaluation points for the estimated PDF. If None (default), 1000 equally spaced points are used. If ind is a NumPy array, the KDE is evaluated at the points passed. If ind is an integer, ind number of equally spaced points are used.

**kwds**: optional

Additional keyword arguments are documented in `pandas.DataFrame.plot()`.

Returns

axes : [matplotlib.axes.Axes or numpy.ndarray of them]

See also:

- `scipy.stats.gaussian_kde` Representation of a kernel-density estimate using Gaussian kernels. This is the function used internally to estimate the PDF.
- `Series.plot.kde` Generate a KDE plot for a Series.

Examples

Given several Series of points randomly sampled from unknown distributions, estimate their PDFs using KDE with automatic bandwidth determination and plot the results, evaluating them at 1000 equally spaced points (default):

```python
>>> df = pd.DataFrame({
...     'x': [1, 2, 2.5, 3, 3.5, 4, 5],
...     'y': [4, 4, 4.5, 5, 5.5, 6, 6],
... })
>>> ax = df.plot.kde()
```

A scalar bandwidth can be specified. Using a small bandwidth value can lead to overfitting, while using a large bandwidth value may result in underfitting:

```python
>>> ax = df.plot.kde(bw_method=0.3)

>>> ax = df.plot.kde(bw_method=3)
```

Finally, the ind parameter determines the evaluation points for the plot of the estimated PDF:

```python
>>> ax = df.plot.kde(ind=[1, 2, 3, 4, 5, 6])
```

34.4.13.6 pandas.DataFrame.plot.hexbin

`DataFrame.plot.hexbin(x, y, C=None, reduce_C_function=None, gridsize=None, **kwds)`

Generate a hexagonal binning plot.

Generate a hexagonal binning plot of x versus y. If C is None (the default), this is a histogram of the number of occurrences of the observations at \((x[i], y[i])\).

If C is specified, specifies values at given coordinates \((x[i], y[i])\). These values are accumulated for each hexagonal bin and then reduced according to \(reduce_C_function\), having as default the NumPy's mean function \(\text{numpy.mean}()\). (If C is specified, it must also be a 1-D sequence of the same length as x and y, or a column label.)

**Parameters**

- **x** : int or str
The column label or position for x points.

\texttt{y} : int or str

The column label or position for y points.

\texttt{C} : int or str, optional

The column label or position for the value of (x, y) point.

\texttt{reduce\_C\_function} : callable, default \texttt{np.mean}

Function of one argument that reduces all the values in a bin to a single number (e.g. \texttt{np.mean}, \texttt{np.max}, \texttt{np.sum}, \texttt{np.std}).

\texttt{gridsize} : int or tuple of (int, int), default 100

The number of hexagons in the x-direction. The corresponding number of hexagons in the y-direction is chosen in a way that the hexagons are approximately regular. Alternatively, gridsize can be a tuple with two elements specifying the number of hexagons in the x-direction and the y-direction.

\**kwds\**

Additional keyword arguments are documented in \texttt{pandas.DataFrame.plot}.

Returns \texttt{matplotlib.AxesSubplot}

The \texttt{matplotlib.Axes} on which the hexbin is plotted.

See also:

\texttt{Dataframe.plot} Make plots of a DataFrame.

\texttt{matplotlib.pyplot.hexbin} hexagonal binning plot using \texttt{matplotlib}, the \texttt{matplotlib} function that is used under the hood.

Examples

The following examples are generated with random data from a normal distribution.

```python
>>> n = 10000
>>> df = pd.DataFrame({'x': np.random.randn(n),
...                     'y': np.random.randn(n)})
>>> ax = df.plot.hexbin(x='x', y='y', gridsize=20)
```

The next example uses \texttt{C} and \texttt{np.sum} as \texttt{reduce\_C\_function}. Note that ‘observations’ values ranges from 1 to 5 but the result plot shows values up to more than 25. This is because of the \texttt{reduce\_C\_function}.

```python
>>> n = 500
>>> df = pd.DataFrame({
...                     'coord_x': np.random.uniform(-3, 3, size=n),
...                     'coord_y': np.random.uniform(30, 50, size=n),
...                     'observations': np.random.randint(1,5, size=n)
...                     })
>>> ax = df.plot.hexbin(x='coord_x', y='coord_y',
...                      C='observations',
...                      reduce_C_function=np.sum,
...                      )
```
34.4.13.7 pandas.DataFrame.plot.hist

DataFrame.plot.hist(by=None, bins=10, **kwds)

Draw one histogram of the DataFrame’s columns.

A histogram is a representation of the distribution of data. This function groups the values of all given Series in the DataFrame into bins and draws all bins in one matplotlib.axes.Axes. This is useful when the DataFrame’s Series are in a similar scale.

Parameters:
- **by**: str or sequence, optional
  - Column in the DataFrame to group by.
- **bins**: int, default 10
  - Number of histogram bins to be used.
- **kwds**: Additional keyword arguments are documented in pandas.DataFrame.plot().

Returns:
- **axes**: [matplotlib.AxesSubplot histogram.]

See also:
- DataFrame.hist: Draw histograms per DataFrame’s Series.
- Series.hist: Draw a histogram with Series’ data.

Examples

When we draw a dice 6000 times, we expect to get each value around 1000 times. But when we draw two dices and sum the result, the distribution is going to be quite different. A histogram illustrates those distributions.

```python
>>> df = pd.DataFrame(
...     np.random.randint(1, 7, 6000),
...     columns=['one'])
>>> df['two'] = df['one'] + np.random.randint(1, 7, 6000)
>>> ax = df.plot.hist(bins=12, alpha=0.5)
```

34.4.13.8 pandas.DataFrame.plot.kde

DataFrame.plot.kde(bw_method=None, ind=None, **kwds)

Generate Kernel Density Estimate plot using Gaussian kernels.

In statistics, kernel density estimation (KDE) is a non-parametric way to estimate the probability density function (PDF) of a random variable. This function uses Gaussian kernels and includes automatic bandwidth determination.

Parameters:
- **bw_method**: str, scalar or callable, optional
The method used to calculate the estimator bandwidth. This can be ‘scott’, ‘silverman’, a scalar constant or a callable. If None (default), ‘scott’ is used. See scipy.stats.gaussian_kde for more information.

**ind** : NumPy array or integer, optional
   Evaluation points for the estimated PDF. If None (default), 1000 equally spaced points are used. If ind is a NumPy array, the KDE is evaluated at the points passed. If ind is an integer, ind number of equally spaced points are used.

**kwds** : optional
   Additional keyword arguments are documented in pandas.DataFrame.plot().

Returns
axes  [matplotlib.axes.Axes or numpy.ndarray of them]

See also:
scipy.stats.gaussian_kde  Representation of a kernel-density estimate using Gaussian kernels. This is the function used internally to estimate the PDF.

Series.plot.kde  Generate a KDE plot for a Series.

Examples

Given several Series of points randomly sampled from unknown distributions, estimate their PDFs using KDE with automatic bandwidth determination and plot the results, evaluating them at 1000 equally spaced points (default):

```python
>>> df = pd.DataFrame({
...     'x': [1, 2, 2.5, 3, 3.5, 4, 5],
...     'y': [4, 4, 4.5, 5, 5.5, 6, 6],
... })
>>> ax = df.plot.kde()
```

A scalar bandwidth can be specified. Using a small bandwidth value can lead to overfitting, while using a large bandwidth value may result in underfitting:

```python
>>> ax = df.plot.kde(bw_method=0.3)

>>> ax = df.plot.kde(bw_method=3)
```

Finally, the ind parameter determines the evaluation points for the plot of the estimated PDF:

```python
>>> ax = df.plot.kde(ind=[1, 2, 3, 4, 5, 6])
```

34.4.13.9 pandas.DataFrame.plot.line

DataFrame.plot.line(x=None, y=None, **kwds)
   Plot DataFrame columns as lines.

   This function is useful to plot lines using DataFrame’s values as coordinates.

   Parameters x : int or str, optional
Columns to use for the horizontal axis. Either the location or the label of the columns to be used. By default, it will use the DataFrame indices.

**y**: int, str, or list of them, optional

The values to be plotted. Either the location or the label of the columns to be used. By default, it will use the remaining DataFrame numeric columns.

**kwds**

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

**Returns**

`axes`: `matplotlib.axes.Axes` or `numpy.ndarray`

Returns an ndarray when `subplots=True`.

**See also:**

- `matplotlib.pyplot.plot` | Plot y versus x as lines and/or markers.

**Examples**

The following example shows the populations for some animals over the years.

```python
don = pd.DataFrame({
    'pig': [20, 18, 489, 675, 1776],
    'horse': [4, 25, 281, 600, 1900]
don.plot.line()
```

An example with subplots, so an array of axes is returned.

```python
don.plot.line(subplots=True)
```

The following example shows the relationship between both populations.

```python
don.plot.line(x='pig', y='horse')
```

**34.4.13.10 pandas.DataFrame.plot.pie**

DataFrame.plot.pie(y=None, **kwds)

Generate a pie plot.

A pie plot is a proportional representation of the numerical data in a column. This function wraps `matplotlib.pyplot.pie()` for the specified column. If no column reference is passed and `subplots=True` a pie plot is drawn for each numerical column independently.

**Parameters**

- **y**: int or label, optional
  - Label or position of the column to plot. If not provided, `subplots=True` argument must be passed.

**kwds**

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

**Returns**

- `axes`: `matplotlib.axes.Axes` or `numpy.ndarray` of them.
A NumPy array is returned when `subplots` is True.

See also:

* `Series.plot.pie` Generate a pie plot for a Series.
* `DataFrame.plot` Make plots of a DataFrame.

Examples

In the example below we have a DataFrame with the information about planet’s mass and radius. We pass the ‘mass’ column to the pie function to get a pie plot.

```python
>>> df = pd.DataFrame({'mass': [0.330, 4.87, 5.97],
...                   'radius': [2439.7, 6051.8, 6378.1]},
...                   index=['Mercury', 'Venus', 'Earth'])
>>> plot = df.plot.pie(y='mass', figsize=(5, 5))

>>> plot = df.plot.pie(subplots=True, figsize=(6, 3))
```

### 34.4.13.11 pandas.DataFrame.plot.scatter

DataFrame.plot.

```python
scatter(x, y, s=None, c=None, **kwds)
```

Create a scatter plot with varying marker point size and color.

The coordinates of each point are defined by two dataframe columns and filled circles are used to represent each point. This kind of plot is useful to see complex correlations between two variables. Points could be for instance natural 2D coordinates like longitude and latitude in a map or, in general, any pair of metrics that can be plotted against each other.

**Parameters**

- **x**: int or str
  The column name or column position to be used as horizontal coordinates for each point.

- **y**: int or str
  The column name or column position to be used as vertical coordinates for each point.

- **s**: scalar or array_like, optional
  The size of each point. Possible values are:
  - A single scalar so all points have the same size.
  - A sequence of scalars, which will be used for each point’s size recursively. For instance, when passing [2,14] all points size will be either 2 or 14, alternatively.

- **c**: str, int or array_like, optional
  The color of each point. Possible values are:
  - A single color string referred to by name, RGB or RGBA code, for instance ‘red’ or ‘#a98d19’.
  - A sequence of color strings referred to by name, RGB or RGBA code, which will be used for each point’s color recursively. For instance ['green','yellow'] all points will be filled in green or yellow, alternatively.
• A column name or position whose values will be used to color the marker points according to a colormap.

**kwds**

Keyword arguments to pass on to `pandas.DataFrame.plot()`.

Returns

axes  [matplotlib.axes.Axes or numpy.ndarray of them]

See also:

`matplotlib.pyplot.scatter` scatter plot using multiple input data formats.

Examples

Let’s see how to draw a scatter plot using coordinates from the values in a DataFrame’s columns.

```python
>>> df = pd.DataFrame([ [5.1, 3.5, 0], [4.9, 3.0, 0], [7.0, 3.2, 1],
... [6.4, 3.2, 1], [5.9, 3.0, 2] ],
... columns=['length', 'width', 'species'])
>>> ax1 = df.plot.scatter(x='length',
... y='width',
... c='DarkBlue')
```

And now with the color determined by a column as well.

```python
>>> ax2 = df.plot.scatter(x='length',
... y='width',
... c='species',
... colormap='viridis')
```

`DataFrame.boxplot`([column, by, ax, . . . ]) Make a box plot from DataFrame columns.

`DataFrame.hist`([column, by, grid, . . . ]) Make a histogram of the DataFrame’s.

34.4.14 Serialization / IO / Conversion

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>DataFrame.from_csv</code>([path[, header, sep, . . . ]])</td>
<td>(DEPRECATED) Read CSV file.</td>
</tr>
<tr>
<td><code>DataFrame.from_dict</code>(data[, orient, dtype, . . .])</td>
<td>Construct DataFrame from dict of array-like or dicts.</td>
</tr>
<tr>
<td><code>DataFrame.from_items</code>(items[, columns, orient])</td>
<td>(DEPRECATED) Construct a dataframe from a list of tuples</td>
</tr>
<tr>
<td><code>DataFrame.from_records</code>(data[, index, . . .])</td>
<td>Convert structured or record ndarray to DataFrame</td>
</tr>
<tr>
<td><code>DataFrame.info</code>([verbose, buf, max_cols, . . .])</td>
<td>Print a concise summary of a DataFrame.</td>
</tr>
<tr>
<td><code>DataFrame.to_parquet</code>(fname[, engine, . . .])</td>
<td>Write a DataFrame to the binary parquet format.</td>
</tr>
<tr>
<td><code>DataFrame.to_pickle</code>(path[, compression, . . .])</td>
<td>Pickle (serialize) object to file.</td>
</tr>
<tr>
<td><code>DataFrame.to_csv</code>([path_or_buf, sep, na_rep, . . .])</td>
<td>Write DataFrame to a comma-separated values (csv) file</td>
</tr>
<tr>
<td><code>DataFrame.to_hdf</code>(path_or_buf, key, **kwargs)</td>
<td>Write the contained data to an HDF5 file using HDFS-store.</td>
</tr>
<tr>
<td><code>DataFrame.to_sql</code>(name, con[, schema, . . .])</td>
<td>Write records stored in a DataFrame to a SQL database.</td>
</tr>
<tr>
<td><code>DataFrame.to_dict</code>([orient, into])</td>
<td>Convert the DataFrame to a dictionary.</td>
</tr>
<tr>
<td><code>DataFrame.to_excel</code>(excel_writer[, . . .])</td>
<td>Write DataFrame to an excel sheet</td>
</tr>
</tbody>
</table>
Table 77 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrame.to_json([path_or_buf, orient, ...])</td>
<td>Convert the object to a JSON string.</td>
</tr>
<tr>
<td>DataFrame.to_html([buf, columns, col_space, ...])</td>
<td>Render a DataFrame as an HTML table.</td>
</tr>
<tr>
<td>DataFrame.to_feather(fname)</td>
<td>Write out the binary feather-format for DataFrames.</td>
</tr>
<tr>
<td>DataFrame.to_latex([buf, columns, ...])</td>
<td>Render an object to a tabular environment table.</td>
</tr>
<tr>
<td>DataFrame.to_stata(fname[, convert_dates, ...])</td>
<td>Export Stata binary dta files.</td>
</tr>
<tr>
<td>DataFrame.to_msgpack([path_or_buf, encoding])</td>
<td>msgpack (serialize) object to input file path</td>
</tr>
<tr>
<td>DataFrame.to_gbq(destination_table, project_id)</td>
<td>Write a DataFrame to a Google BigQuery table.</td>
</tr>
<tr>
<td>DataFrame.to_records([index, convert_datetime64])</td>
<td>Convert DataFrame to a NumPy record array.</td>
</tr>
<tr>
<td>DataFrame.to_sparse([fill_value, kind])</td>
<td>Convert to SparseDataFrame</td>
</tr>
<tr>
<td>DataFrame.to_dense()</td>
<td>Return dense representation of NDFrame (as opposed to sparse)</td>
</tr>
<tr>
<td>DataFrame.to_string([buf, columns, ...])</td>
<td>Render a DataFrame to a console-friendly tabular output.</td>
</tr>
<tr>
<td>DataFrame.style</td>
<td>Property returning a Styler object containing methods for building a styled HTML representation for the DataFrame.</td>
</tr>
</tbody>
</table>

34.4.15 Sparse

SparseDataFrame.to_coo() Return the contents of the frame as a sparse SciPy COO matrix.

34.4.15.1 pandas.SparseDataFrame.to_coo

SparseDataFrame.to_coo() Return the contents of the frame as a sparse SciPy COO matrix.

New in version 0.20.0.

Returns coo_matrix : scipy.sparse.spmatrix

If the caller is heterogeneous and contains booleans or objects, the result will be of dtype=object. See Notes.

Notes

The dtype will be the lowest-common-denominator type (implicit upcasting); that is to say if the dtypes (even of numeric types) are mixed, the one that accommodates all will be chosen.

e.g. If the dtypes are float16 and float32, dtype will be upcast to float32. By numpy.find_common_type convention, mixing int64 and and uint64 will result in a float64 dtype.
34.5 Panel

34.5.1 Constructor

```
Panel([data, items, major_axis, minor_axis, ...])  (DEPRECATED) Represents wide format panel data, stored as 3-dimensional array
```

34.5.1.1 pandas.Panel

```
class pandas.Panel(data=None, items=None, major_axis=None, minor_axis=None, copy=False, dtype=None)
```

Represents wide format panel data, stored as 3-dimensional array

Deprecated since version 0.20.0: The recommended way to represent 3-D data are with a MultiIndex on a DataFrame via the `to_frame()` method or with the xarray package. Pandas provides a `to_xarray()` method to automate this conversion.

**Parameters**

- **data**: ndarray (items x major x minor), or dict of DataFrames
- **items** [Index or array-like] axis=0
- **major_axis** [Index or array-like] axis=1
- **minor_axis** [Index or array-like] axis=2
- **dtype** [dtype, default None] Data type to force, otherwise infer
- **copy** [boolean, default False] Copy data from inputs. Only affects DataFrame / 2d ndarray input

**Attributes**

- **at**  Access a single value for a row/column label pair.
- **axes**  Return index label(s) of the internal NDFrame
- **blocks**  (DEPRECATED) Internal property, property synonym for as_blocks()
- **dtypes**  Return the dtypes in the DataFrame.
- **empty**  Indicator whether DataFrame is empty.
- **ftypes**  Return the ftypes (indication of sparse/dense and dtype) in DataFrame.
- **iat**  Access a single value for a row/column pair by integer position.
- **iloc**  Purely integer-location based indexing for selection by position.
- **items**  A primarily label-location based indexer, with integer position fallback.
- **loc**  Access a group of rows and columns by label(s) or a boolean array.
- **major_axis**
- **minor_axis**

Continued on next page
Table 80 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>ndim</code></td>
<td>Return an int representing the number of axes / array dimensions.</td>
</tr>
<tr>
<td><code>shape</code></td>
<td>Return a tuple of axis dimensions.</td>
</tr>
<tr>
<td><code>size</code></td>
<td>Return an int representing the number of elements in this object.</td>
</tr>
<tr>
<td><code>values</code></td>
<td>Return a Numpy representation of the DataFrame.</td>
</tr>
</tbody>
</table>

**pandas.Panel.at**

`Panel.at`

Access a single value for a row/column label pair.

Similar to `loc`, in that both provide label-based lookups. Use `at` if you only need to get or set a single value in a DataFrame or Series.

*Raises* `KeyError`

When label does not exist in DataFrame

*See also:*

- `DataFrame.iat` Access a single value for a row/column pair by integer position
- `DataFrame.loc` Access a group of rows and columns by label(s)
- `Series.at` Access a single value using a label

**Examples**

```python
def = pd.DataFrame([[0, 2, 3], [0, 4, 1], [10, 20, 30]],
                    index=[4, 5, 6], columns=['A', 'B', 'C'])
def
A  B  C
4  0  2  3
5  0  4  1
6 10 20 30

Get value at specified row/column pair

`df.at[4, 'B']`

2

Set value at specified row/column pair

`df.at[4, 'B'] = 10`

`df.at[4, 'B']`

10

Get value within a Series

`df.loc[5].at['B']`

4
```
pandas.Panel.axes

Panel.axes
Return index label(s) of the internal NDFrame

pandas.Panel.blocks

Panel.blocks
Internal property, property synonym for as_blocks()
Deprecated since version 0.21.0.

pandas.Panel.dtypes

Panel.dtypes
Return the dtypes in the DataFrame.
This returns a Series with the data type of each column. The result’s index is the original DataFrame’s columns. Columns with mixed types are stored with the object dtype. See the User Guide for more.

    Returns  pandas.Series
    The data type of each column.

    See also:
    pandas.DataFrame.ftypes  dtype and sparsity information.

Examples

```python
>>> df = pd.DataFrame({'float': [1.0],
...                     'int': [1],
...                     'datetime': [pd.Timestamp('20180310')],
...                     'string': ['foo']})
>>> df.dtypes
float  float64
int    int64
datetime  datetime64[ns]
string  object
dtype: object
```

pandas.Panel.empty

Panel.empty
Indicator whether DataFrame is empty.
True if DataFrame is entirely empty (no items), meaning any of the axes are of length 0.

    Returns  bool
    If DataFrame is empty, return True, if not return False.

    See also:
    pandas.Series.dropna, pandas.DataFrame.dropna
Notes

If DataFrame contains only NaNs, it is still not considered empty. See the example below.

Examples

An example of an actual empty DataFrame. Notice the index is empty:

```python
>>> df_empty = pd.DataFrame({'A': []})
>>> df_empty
Empty DataFrame
Columns: [A]
Index: []
>>> df_empty.empty
True
```

If we only have NaNs in our DataFrame, it is not considered empty! We will need to drop the NaNs to make the DataFrame empty:

```python
>>> df = pd.DataFrame({'A': [np.nan]})
>>> df
A
0 NaN
>>> df.empty
False
>>> df.dropna().empty
True
```

pandas.Panel.ftypes

Panel.ftypes
Return the ftypes (indication of sparse/dense and dtype) in DataFrame.

This returns a Series with the data type of each column. The result’s index is the original DataFrame’s columns. Columns with mixed types are stored with the object dtype. See the User Guide for more.

Returns pandas.Series

The data type and indication of sparse/dense of each column.

See also:

pandas.DataFrame.dtypes Series with just dtype information.
pandas.SparseDataFrame Container for sparse tabular data.

Notes

Sparse data should have the same dtypes as its dense representation.
Examples

```python
>>> import numpy as np
>>> arr = np.random.RandomState(0).randn(100, 4)
>>> arr[arr < .8] = np.nan
>>> pd.DataFrame(arr).ftypes
0  float64:dense
1  float64:dense
2  float64:dense
3  float64:dense
dtype: object
```

```python
>>> pd.SparseDataFrame(arr).ftypes
0  float64:sparse
1  float64:sparse
2  float64:sparse
3  float64:sparse
dtype: object
```

**pandas.Panel.iat**

Panel.iat
Access a single value for a row/column pair by integer position.

Similar to iloc, in that both provide integer-based lookups. Use iat if you only need to get or set a single value in a DataFrame or Series.

**Raises** IndexError
When integer position is out of bounds

**See also:**

* **DataFrame.at**  Access a single value for a row/column label pair
* **DataFrame.loc**  Access a group of rows and columns by label(s)
* **DataFrame.iloc**  Access a group of rows and columns by integer position(s)

**Examples**

```python
>>> df = pd.DataFrame([[0, 2, 3], [0, 4, 1], [10, 20, 30]],
                   columns=['A', 'B', 'C'])
>>> df
     A  B  C
0   0  2  3
1   0  4  1
2  10 20 30
```

Get value at specified row/column pair

```python
>>> df.iat[1, 2]
1
```

Set value at specified row/column pair
>>> df.iat[1, 2] = 10
>>> df.iat[1, 2]
10

Get value within a series

>>> df.loc[0].iat[1]
2

**pandas.Panel.iloc**

Panel.iloc

Purely integer-location based indexing for selection by position.

.iloc[] is primarily integer position based (from 0 to length-1 of the axis), but may also be used with a boolean array.

Allowed inputs are:

- An integer, e.g. 5.
- A list or array of integers, e.g. [4, 3, 0].
- A slice object with ints, e.g. 1:7.
- A boolean array.
- A callable function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above)

.iloc will raise IndexError if a requested indexer is out-of-bounds, except slice indexers which allow out-of-bounds indexing (this conforms with python/numpy slice semantics).

See more at Selection by Position

**pandas.Panel.items**

Panel.items

**pandas.Panel.ix**

Panel.ix

A primarily label-location based indexer, with integer position fallback.

Warning: Starting in 0.20.0, the .ix indexer is deprecated, in favor of the more strict .iloc and .loc indexers.

.ix[] supports mixed integer and label based access. It is primarily label based, but will fall back to integer positional access unless the corresponding axis is of integer type.

.ix is the most general indexer and will support any of the inputs in .loc and .iloc. .ix also supports floating point label schemes. .ix is exceptionally useful when dealing with mixed positional and label based hierarchical indexes.

However, when an axis is integer based, ONLY label based access and not positional access is supported. Thus, in such cases, it’s usually better to be explicit and use .iloc or .loc.

See more at Advanced Indexing.
Panel.loc

Access a group of rows and columns by label(s) or a boolean array.
.loc[] is primarily label based, but may also be used with a boolean array.

Allowed inputs are:

- A single label, e.g. 5 or 'a', (note that 5 is interpreted as a label of the index, and never as an integer position along the index).
- A list or array of labels, e.g. ['a', 'b', 'c'].
- A slice object with labels, e.g. 'a': 'f'.

**Warning:** Note that contrary to usual python slices, both the start and the stop are included

- A boolean array of the same length as the axis being sliced, e.g. [True, False, True].
- A callable function with one argument (the calling Series, DataFrame or Panel) and that returns valid output for indexing (one of the above)

See more at *Selection by Label*

**Raises** `KeyError`:
when any items are not found

**See also:**

`DataFrame.at` Access a single value for a row/column label pair

`DataFrame.iloc` Access group of rows and columns by integer position(s)

`DataFrame.xs` Returns a cross-section (row(s) or column(s)) from the Series/DataFrame.

`Series.loc` Access group of values using labels

**Examples**

**Getting values**

```python
>>> df = pd.DataFrame([[1, 2], [4, 5], [7, 8]],
...                   index=['cobra', 'viper', 'sidewinder'],
...                   columns=['max_speed', 'shield'])
>>> df
     max_speed  shield
  cobra       1       2
  viper       4       5
  sidewinder  7       8
```

Single label. Note this returns the row as a Series.

```python
>>> df.loc['viper']
  max_speed  4
  shield     5
Name: viper, dtype: int64
```
List of labels. Note using `[]` returns a DataFrame.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>df.loc[['viper', 'sidewinder']]</td>
<td></td>
</tr>
<tr>
<td>max_speed shield</td>
<td></td>
</tr>
<tr>
<td>viper</td>
<td>4 5</td>
</tr>
<tr>
<td>sidewinder</td>
<td>7 8</td>
</tr>
</tbody>
</table>

Single label for row and column

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>df.loc['cobra', 'shield']</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

Slice with labels for row and single label for column. As mentioned above, note that both the start and stop of the slice are included.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>df.loc['cobra':'viper', 'max_speed']</td>
<td></td>
</tr>
<tr>
<td>max_speed</td>
<td></td>
</tr>
<tr>
<td>cobra</td>
<td>1</td>
</tr>
<tr>
<td>viper</td>
<td>4</td>
</tr>
<tr>
<td>Name: max_speed, dtype: int64</td>
<td></td>
</tr>
</tbody>
</table>

Boolean list with the same length as the row axis

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>df.loc[[False, False, True]]</td>
<td></td>
</tr>
<tr>
<td>max_speed shield</td>
<td></td>
</tr>
<tr>
<td>sidewinder</td>
<td>7 8</td>
</tr>
</tbody>
</table>

Conditional that returns a boolean Series

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>df.loc[df['shield'] &gt; 6]</td>
<td></td>
</tr>
<tr>
<td>max_speed shield</td>
<td></td>
</tr>
<tr>
<td>sidewinder</td>
<td>7 8</td>
</tr>
</tbody>
</table>

Conditional that returns a boolean Series with column labels specified

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>df.loc[df['shield'] &gt; 6, ['max_speed']]</td>
<td></td>
</tr>
<tr>
<td>max_speed</td>
<td></td>
</tr>
<tr>
<td>sidewinder</td>
<td>7</td>
</tr>
</tbody>
</table>

Callable that returns a boolean Series

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>df.loc[lambda df: df['shield'] == 8]</td>
<td></td>
</tr>
<tr>
<td>max_speed shield</td>
<td></td>
</tr>
<tr>
<td>sidewinder</td>
<td>7 8</td>
</tr>
</tbody>
</table>

Setting values

Set value for all items matching the list of labels

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>df.loc[['viper', 'sidewinder'], ['shield']] = 50</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td></td>
</tr>
<tr>
<td>max_speed shield</td>
<td></td>
</tr>
<tr>
<td>cobra</td>
<td>1 2</td>
</tr>
<tr>
<td>viper</td>
<td>4 50</td>
</tr>
<tr>
<td>sidewinder</td>
<td>7 50</td>
</tr>
</tbody>
</table>

Set value for an entire row
```python
>> df.loc['cobra'] = 10
>> df
    max_speed  shield
cobra     10      10
viper      4       50
sidewinder 7       50

Set value for an entire column

>> df.loc[:, 'max_speed'] = 30
>> df
    max_speed  shield
   cobra     30      10
   viper     30      50
   sidewinder 30      50

Set value for rows matching callable condition

>> df.loc[df['shield'] > 35] = 0
>> df
    max_speed  shield
   cobra     30      10
   viper      0      0
   sidewinder 0       0

Getting values on a DataFrame with an index that has integer labels

Another example using integers for the index

>>> df = pd.DataFrame([[1, 2], [4, 5], [7, 8]],
... index=[7, 8, 9], columns=['max_speed', 'shield'])
>>> df
   max_speed  shield
7          1      2
8          4      5
9          7      8

Slice with integer labels for rows. As mentioned above, note that both the start and stop of the slice are included.

>>> df.loc[7:9]
   max_speed  shield
7          1      2
8          4      5
9          7      8

Getting values with a MultiIndex

A number of examples using a DataFrame with a MultiIndex

>>> tuples = [
...   ('cobra', 'mark i'), ('cobra', 'mark ii'),
...   ('sidewinder', 'mark i'), ('sidewinder', 'mark ii'),
...   ('viper', 'mark ii'), ('viper', 'mark iii')
... ]
>>> index = pd.MultiIndex.from_tuples(tuples)
>>> values = [[12, 2], [0, 4], [10, 20],
...            [1, 4], [7, 1], [16, 36]]
```

(continues on next page)
>> df = pd.DataFrame(values, columns=['max_speed', 'shield'], index=index)
>> df

<table>
<thead>
<tr>
<th></th>
<th>max_speed</th>
<th>shield</th>
</tr>
</thead>
<tbody>
<tr>
<td>cobra</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mark i</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>mark ii</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>sidewinder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mark i</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>mark ii</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>viper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mark ii</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>mark iii</td>
<td>16</td>
<td>36</td>
</tr>
</tbody>
</table>

Single label. Note this returns a DataFrame with a single index.

```ipython
>>> df.loc['cobra']
max_speed  shield
mark i    12      2
mark ii   0       4
```

Single index tuple. Note this returns a Series.

```ipython
>>> df.loc[('cobra', 'mark ii')]
max_speed  shield
mark ii   0       4
```

Single label for row and column. Similar to passing in a tuple, this returns a Series.

```ipython
>>> df.loc['cobra', 'mark i']
max_speed  shield
mark i    12      2
mark ii   0       4
```

Single tuple. Note using [[]] returns a DataFrame.

```ipython
>>> df.loc[['cobra', 'mark ii']]
max_speed  shield
mark ii   0       4
```

Single tuple for the index with a single label for the column

```ipython
>>> df.loc[['cobra', 'mark i'], 'shield']
2
```

Slice from index tuple to single label

```ipython
>>> df.loc[['cobra', 'mark i':'viper']
max_speed  shield
mark i    12      2
mark ii   0       4
sidewinder mark i | 10     20
mark ii   1       4
viper     mark i   7       1
mark iii  16      36
```

Slice from index tuple to index tuple
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
>>> df.loc[('cobra', 'mark i'):('viper', 'mark ii')]
                     max_speed  shield
    cobra mark i      12       2
        mark ii      0       4
  sidewinder mark i   10      20
        mark ii       1       4
    viper mark ii      7       1
```

**pandas.Panel.major_axis**

`Panel.major_axis`

**pandas.Panel.minor_axis**

`Panel.minor_axis`

**pandas.Panel.ndim**

`Panel.ndim`

Return an int representing the number of axes / array dimensions.

Return 1 if Series. Otherwise return 2 if DataFrame.

**Examples**

```python
>>> s = pd.Series({'a': 1, 'b': 2, 'c': 3})
>>> s.ndim
1

>>> df = pd.DataFrame({'col1': [1, 2], 'col2': [3, 4]})
>>> df.ndim
2
```

**pandas.Panel.shape**

`Panel.shape`

Return a tuple of axis dimensions

**pandas.Panel.size**

`Panel.size`

Return an int representing the number of elements in this object.

Return the number of rows if Series. Otherwise return the number of rows times number of columns if DataFrame.
See also:

ndarray.size

Examples

```python
>>> s = pd.Series({'a': 1, 'b': 2, 'c': 3})
>>> s.size
3

```  
```
>>> df = pd.DataFrame({'col1': [1, 2], 'col2': [3, 4]})
>>> df.size
4
```  

**pandas.Panel.values**

*Panel.values*

Return a Numpy representation of the DataFrame.

Only the values in the DataFrame will be returned, the axes labels will be removed.

**Returns** numpy.ndarray

The values of the DataFrame.

See also:

**pandas.DataFrame.index** Retrievie the index labels

**pandas.DataFrame.columns** Retrieving the column names

Notes

The dtype will be a lower-common-denominator dtype (implicit upcasting); that is to say if the dtypes (even of numeric types) are mixed, the one that accommodates all will be chosen. Use this with care if you are not dealing with the blocks.

e.g. If the dtypes are float16 and float32, dtype will be upcast to float32. If dtypes are int32 and uint8, dtype will be upcast to int32. By `numpy.find_common_type()` convention, mixing int64 and uint64 will result in a float64 dtype.

Examples

A DataFrame where all columns are the same type (e.g., int64) results in an array of the same type.

```python
>>> df = pd.DataFrame({
        'age': [3, 29],
        'height': [94, 170],
        'weight': [31, 115]
    })
```

```python
>>> df
   age  height  weight
0   3     94       31
1  29    170      115
```
A DataFrame with mixed type columns (e.g., str/object, int64, float32) results in an ndarray of the broadest type that accommodates these mixed types (e.g., object).

```python
>>> df2 = pd.DataFrame([('parrot', 24.0, 'second'),
                      ('lion', 80.5, 1),
                      ('monkey', np.nan, None)],
                          columns=['name', 'max_speed', 'rank'])
>>> df2.dtypes
name          object
max_speed      float64
rank           object
dtype: object
```

```python
>>> df2.values
array([['parrot', 24.0, 'second'],
       ['lion', 80.5, 1],
       ['monkey', nan, None]], dtype=object)
```

## Methods

- `abs()`
  - Return a Series/DataFrame with absolute numeric value of each element.

- `add(other[, axis])`
  - Addition of series and other, element-wise (binary operator `add`).

- `add_prefix(prefix)`
  - Prefix labels with string `prefix`.

- `add_suffix(suffix)`
  - Suffix labels with string `suffix`.

- `align(other, **kwargs)`
  - Align two objects on their axes with the specified join method for each axis Index.

- `all([axis, bool_only, skipna, level])`
  - Return whether all elements are True, potentially over an axis.

- `any([axis, bool_only, skipna, level])`
  - Return whether any element is True over requested axis.

- `apply(func[, axis])`
  - Applies function along axis (or axes) of the Panel.

- `as_blocks([copy])`
  - (DEPRECATED) Convert the frame to a dict of dtype -> Constructor Types that each has a homogeneous dtype.

- `as_matrix([copy])`
  - Convert the frame to its Numpy-array representation.

- `asfreq(freq[, method, how, normalize, ...])`
  - Convert TimeSeries to specified frequency.

- `asof(where[, subset])`
  - The last row without any NaN is taken (or the last row without NaN considering only the subset of columns in the case of a DataFrame).
<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>astype(dtype[, copy, errors])</code></td>
<td>Cast a pandas object to a specified dtype <code>dtype</code>.</td>
</tr>
<tr>
<td><code>at_time(time[, asof])</code></td>
<td>Select values at particular time of day (e.g. 9:00-9:30 AM).</td>
</tr>
<tr>
<td><code>between_time(start_time, end_time[, ...])</code></td>
<td>Select values between particular times of the day (e.g., 9:00-9:30 AM).</td>
</tr>
<tr>
<td><code>bfill([axis, inplace, limit, downcast])</code></td>
<td>Synonym for <code>DataFrame.fillna(method='bfill')</code>.</td>
</tr>
<tr>
<td><code>bool()</code></td>
<td>Return the bool of a single element PandasObject.</td>
</tr>
<tr>
<td><code>clip([lower, upper, axis, inplace])</code></td>
<td>Trim values at input threshold(s).</td>
</tr>
<tr>
<td><code>clip_lower(threshold[, axis, inplace])</code></td>
<td>Return copy of the input with values below a threshold truncated.</td>
</tr>
<tr>
<td><code>clip_upper(threshold[, axis, inplace])</code></td>
<td>Return copy of input with values above given value(s) truncated.</td>
</tr>
<tr>
<td><code>compound([axis, skipna, level])</code></td>
<td>Return the compound percentage of the values for the requested axis.</td>
</tr>
<tr>
<td><code>conform(frame[, axis])</code></td>
<td>Conform input DataFrame to align with chosen axis pair.</td>
</tr>
<tr>
<td><code>consolidate([inplace])</code></td>
<td>(DEPRECATED) Compute NDFrame with “consolidated” internals (data of each dtype grouped together in a single ndarray).</td>
</tr>
<tr>
<td><code>convert_objects([convert_dates, ...])</code></td>
<td>(DEPRECATED) Attempt to infer better dtype for object columns.</td>
</tr>
<tr>
<td><code>copy([deep])</code></td>
<td>Make a copy of this object’s indices and data.</td>
</tr>
<tr>
<td><code>count([axis])</code></td>
<td>Return number of observations over requested axis.</td>
</tr>
<tr>
<td><code>cummax([axis, skipna])</code></td>
<td>Return cumulative maximum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>cummin([axis, skipna])</code></td>
<td>Return cumulative minimum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>cumprod([axis, skipna])</code></td>
<td>Return cumulative product over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>cumsum([axis, skipna])</code></td>
<td>Return cumulative sum over a DataFrame or Series axis.</td>
</tr>
<tr>
<td><code>describe([percentiles, include, exclude])</code></td>
<td>Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset’s distribution, excluding NaN values.</td>
</tr>
<tr>
<td><code>div(other[, axis])</code></td>
<td>Floating division of series and other, element-wise (binary operator <code>truediv</code>).</td>
</tr>
<tr>
<td><code>divide(other[, axis])</code></td>
<td>Floating division of series and other, element-wise (binary operator <code>truediv</code>).</td>
</tr>
<tr>
<td><code>dropna([axis, how, inplace])</code></td>
<td>Drop 2D from panel, holding passed axis constant</td>
</tr>
<tr>
<td><code>eq(other[, axis])</code></td>
<td>Wrapper for comparison method <code>eq</code>.</td>
</tr>
<tr>
<td><code>equals(other)</code></td>
<td>Determines if two NDFrame objects contain the same elements.</td>
</tr>
<tr>
<td><code>ffill([axis, inplace, limit, downcast])</code></td>
<td>Synonym for <code>DataFrame.fillna(method='ffill')</code>.</td>
</tr>
<tr>
<td><code>fillna([value, method, axis, inplace, ...])</code></td>
<td>Fill NA.NaN values using the specified method</td>
</tr>
<tr>
<td><code>filter([items, like, regex, axis])</code></td>
<td>Subset rows or columns of dataframe according to labels in the specified index.</td>
</tr>
<tr>
<td><code>first(offset)</code></td>
<td>Convenience method for subsetting initial periods of time series data based on a date offset.</td>
</tr>
<tr>
<td><code>first_valid_index()</code></td>
<td>Return index for first non-NA/null value.</td>
</tr>
</tbody>
</table>
**Table 81 – continued from previous page**

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>floordiv(other[, axis])</code></td>
<td>Integer division of series and other, element-wise (binary operator <code>floordiv</code>).</td>
</tr>
<tr>
<td><code>fromDict(data[, intersect, orient, dtype])</code></td>
<td>Construct Panel from dict of DataFrame objects</td>
</tr>
<tr>
<td><code>from_dict(data[, intersect, orient, dtype])</code></td>
<td>Construct Panel from dict of DataFrame objects</td>
</tr>
<tr>
<td><code>ge(other[, axis])</code></td>
<td>Wrapper for comparison method <code>ge</code></td>
</tr>
<tr>
<td><code>get(key[, default])</code></td>
<td>Get item from object for given key (DataFrame column, Panel slice, etc.).</td>
</tr>
<tr>
<td><code>get_dtype_counts()</code></td>
<td>Return counts of unique dtypes in this object.</td>
</tr>
<tr>
<td><code>get_ftype_counts()</code></td>
<td>(DEPRECATED) Return counts of unique ftypes in this object.</td>
</tr>
<tr>
<td><code>get_value(*args, **kwargs)</code></td>
<td>(DEPRECATED) Quickly retrieve single value at (item, major, minor) location</td>
</tr>
<tr>
<td><code>get_values()</code></td>
<td>Return an ndarray after converting sparse values to dense.</td>
</tr>
<tr>
<td><code>groupby(function[, axis])</code></td>
<td>Group data on given axis, returning GroupBy object</td>
</tr>
<tr>
<td><code>gt(other[, axis])</code></td>
<td>Wrapper for comparison method <code>gt</code></td>
</tr>
<tr>
<td><code>head([n])</code></td>
<td>Return the first n rows.</td>
</tr>
<tr>
<td><code>inter_objects()</code></td>
<td>Attempt to infer better dtypes for object columns.</td>
</tr>
<tr>
<td><code>interpolate([method, axis, limit, inplace, ...])</code></td>
<td>Interpolate values according to different methods.</td>
</tr>
<tr>
<td><code>isna()</code></td>
<td>Detect missing values.</td>
</tr>
<tr>
<td><code>isnull()</code></td>
<td>Detect missing values.</td>
</tr>
<tr>
<td><code>iteritems()</code></td>
<td>Iterate over (label, values) on info axis</td>
</tr>
<tr>
<td><code>join(other[, how, lsuffix, rsuffix])</code></td>
<td>Join items with other Panel either on major and minor axes column</td>
</tr>
<tr>
<td><code>keys()</code></td>
<td>Get the ‘info axis’ (see Indexing for more)</td>
</tr>
<tr>
<td><code>kurt([axis, skipna, level, numeric_only])</code></td>
<td>Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0).</td>
</tr>
<tr>
<td><code>kurtosis([axis, skipna, level, numeric_only])</code></td>
<td>Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0).</td>
</tr>
<tr>
<td><code>last(offset)</code></td>
<td>Convenience method for subsetting final periods of time series data based on a date offset.</td>
</tr>
<tr>
<td><code>last_valid_index()</code></td>
<td>Return index for last non-NA/null value.</td>
</tr>
<tr>
<td><code>le(other[, axis])</code></td>
<td>Wrapper for comparison method <code>le</code></td>
</tr>
<tr>
<td><code>lt(other[, axis])</code></td>
<td>Wrapper for comparison method <code>lt</code></td>
</tr>
<tr>
<td><code>mad([axis, skipna, level])</code></td>
<td>Return the mean absolute deviation of the values for the requested axis</td>
</tr>
<tr>
<td><code>major_xs(key)</code></td>
<td>Return slice of panel along major axis</td>
</tr>
<tr>
<td><code>mask(cond[, other, inplace, axis, level, ...])</code></td>
<td>Return an object of same shape as self and whose corresponding entries are from self where cond is False and otherwise are from other.</td>
</tr>
<tr>
<td><code>max([axis, skipna, level, numeric_only])</code></td>
<td>This method returns the maximum of the values in the object.</td>
</tr>
<tr>
<td><code>mean([axis, skipna, level, numeric_only])</code></td>
<td>Return the mean of the values for the requested axis</td>
</tr>
<tr>
<td><code>median([axis, skipna, level, numeric_only])</code></td>
<td>Return the median of the values for the requested axis</td>
</tr>
<tr>
<td><code>min([axis, skipna, level, numeric_only])</code></td>
<td>This method returns the minimum of the values in the object.</td>
</tr>
<tr>
<td><code>minor_xs(key)</code></td>
<td>Return slice of panel along minor axis</td>
</tr>
</tbody>
</table>

Continued on next page
Table 81 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>mod</code></td>
<td>Modulo of series and other, element-wise (binary operator <code>mod</code>).</td>
</tr>
<tr>
<td><code>mul</code></td>
<td>Multiplication of series and other, element-wise (binary operator <code>mul</code>).</td>
</tr>
<tr>
<td><code>multiply</code></td>
<td>Multiplication of series and other, element-wise (binary operator <code>mul</code>).</td>
</tr>
<tr>
<td><code>ne</code></td>
<td>Wrapper for comparison method <code>ne</code></td>
</tr>
<tr>
<td><code>notna()</code></td>
<td>Detect existing (non-missing) values.</td>
</tr>
<tr>
<td><code>notnull()</code></td>
<td>Detect existing (non-missing) values.</td>
</tr>
<tr>
<td><code>pct_change</code></td>
<td>Percentage change between the current and a prior element.</td>
</tr>
<tr>
<td><code>pipe</code></td>
<td>Apply <code>func(self, *args, **kwargs)</code></td>
</tr>
<tr>
<td><code>pop()</code></td>
<td>Return item and drop from frame.</td>
</tr>
<tr>
<td><code>pow</code></td>
<td>Exponential power of series and other, element-wise (binary operator <code>pow</code>).</td>
</tr>
<tr>
<td><code>prod</code></td>
<td>Return the product of the values for the requested axis.</td>
</tr>
<tr>
<td><code>radd</code></td>
<td>Addition of series and other, element-wise (binary operator <code>radd</code>).</td>
</tr>
<tr>
<td><code>rank</code></td>
<td>Compute numerical data ranks (1 through n) along axis.</td>
</tr>
<tr>
<td><code>rdiv</code></td>
<td>Floating division of series and other, element-wise (binary operator <code>rtruediv</code>).</td>
</tr>
<tr>
<td><code>reindex</code></td>
<td>Conform Panel to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.</td>
</tr>
<tr>
<td><code>reindex_axis</code></td>
<td>Conform input object to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.</td>
</tr>
<tr>
<td><code>rename</code></td>
<td>Alter axes input function or functions.</td>
</tr>
<tr>
<td><code>rename_axis</code></td>
<td>Alter the name of the index or columns.</td>
</tr>
<tr>
<td><code>replace</code></td>
<td>Replace values given in <code>to_replace</code> with <code>value</code>.</td>
</tr>
<tr>
<td><code>resample</code></td>
<td>Convenience method for frequency conversion and resampling of time series.</td>
</tr>
<tr>
<td><code>rfloordiv</code></td>
<td>Integer division of series and other, element-wise (binary operator <code>rfloordiv</code>).</td>
</tr>
<tr>
<td><code>rmod</code></td>
<td>Modulo of series and other, element-wise (binary operator <code>rmod</code>).</td>
</tr>
<tr>
<td><code>rmul</code></td>
<td>Multiplication of series and other, element-wise (binary operator <code>rmul</code>).</td>
</tr>
<tr>
<td><code>round</code></td>
<td>Round each value in Panel to a specified number of decimal places.</td>
</tr>
<tr>
<td><code>rpow</code></td>
<td>Exponential power of series and other, element-wise (binary operator <code>rpow</code>).</td>
</tr>
<tr>
<td><code>rsub</code></td>
<td>Subtraction of series and other, element-wise (binary operator <code>rsub</code>).</td>
</tr>
<tr>
<td><code>rtruediv</code></td>
<td>Floating division of series and other, element-wise (binary operator <code>rtruediv</code>).</td>
</tr>
</tbody>
</table>

Continued on next page
### Table 81 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>sample</code></td>
<td>Return a random sample of items from an axis of object.</td>
</tr>
<tr>
<td><code>select</code></td>
<td>(DEPRECATED) Return data corresponding to axis labels matching criteria.</td>
</tr>
<tr>
<td><code>sem</code></td>
<td>Return unbiased standard error of the mean over requested axis.</td>
</tr>
<tr>
<td><code>set_axis</code></td>
<td>Assign desired index to given axis.</td>
</tr>
<tr>
<td><code>set_value</code></td>
<td>(DEPRECATED) Quickly set single value at (item, major, minor) location.</td>
</tr>
<tr>
<td><code>shift</code></td>
<td>Shift index by desired number of periods with an optional time freq.</td>
</tr>
<tr>
<td><code>skew</code></td>
<td>Return unbiased skew over requested axis Normalized by N-1</td>
</tr>
<tr>
<td><code>slice_shift</code></td>
<td>Equivalent to <code>shift</code> without copying data.</td>
</tr>
<tr>
<td><code>sort_index</code></td>
<td>Sort object by labels (along an axis)</td>
</tr>
<tr>
<td><code>sort_values</code></td>
<td>NOT IMPLEMENTED: do not call this method, as sorting values is not supported for Panel objects and will raise an error.</td>
</tr>
<tr>
<td><code>squeeze</code></td>
<td>Squeeze length 1 dimensions.</td>
</tr>
<tr>
<td><code>std</code></td>
<td>Return sample standard deviation over requested axis.</td>
</tr>
<tr>
<td><code>sub</code></td>
<td>Subtraction of series and other, element-wise (binary operator <code>sub</code>).</td>
</tr>
<tr>
<td><code>subtract</code></td>
<td>Subtraction of series and other, element-wise (binary operator <code>sub</code>).</td>
</tr>
<tr>
<td><code>sum</code></td>
<td>Return the sum of the values for the requested axis.</td>
</tr>
<tr>
<td><code>swapaxes</code></td>
<td>Interchange axes and swap values axes appropriately</td>
</tr>
<tr>
<td><code>swaplevel</code></td>
<td>Swap levels i and j in a MultiIndex on a particular axis</td>
</tr>
<tr>
<td><code>tail</code></td>
<td>Return the last n rows.</td>
</tr>
<tr>
<td><code>take</code></td>
<td>Return the elements in the given positional indices along an axis.</td>
</tr>
<tr>
<td><code>to_clipboard</code></td>
<td>Copy object to the system clipboard.</td>
</tr>
<tr>
<td><code>to_dense</code></td>
<td>Return dense representation of NDFrame (as opposed to sparse)</td>
</tr>
<tr>
<td><code>to_excel</code></td>
<td>Write each DataFrame in Panel to a separate excel sheet</td>
</tr>
<tr>
<td><code>to_frame</code></td>
<td>Transform wide format into long (stacked) format as DataFrame whose columns are the Panel’s items and whose index is a MultiIndex formed of the Panel’s major and minor axes.</td>
</tr>
<tr>
<td><code>to_hdf</code></td>
<td>Write the contained data to an HDF5 file using HDFStore.</td>
</tr>
<tr>
<td><code>to_json</code></td>
<td>Convert the object to a JSON string.</td>
</tr>
<tr>
<td><code>to_latex</code></td>
<td>Render an object to a tabular environment table.</td>
</tr>
<tr>
<td><code>to_msgpack</code></td>
<td>msgpack (serialize) object to input file path</td>
</tr>
<tr>
<td><code>to_pickle</code></td>
<td>Pickle (serialize) object to file.</td>
</tr>
<tr>
<td><code>to_sparse</code></td>
<td>NOT IMPLEMENTED: do not call this method, as sparsifying is not supported for Panel objects and will raise an error.</td>
</tr>
</tbody>
</table>

Continued on next page
Table 81 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>to_sql(name, con[, schema, if_exists, ...])</code></td>
<td>Write records stored in a DataFrame to a SQL database.</td>
</tr>
<tr>
<td><code>to_xarray()</code></td>
<td>Return an xarray object from the pandas object.</td>
</tr>
<tr>
<td><code>transpose(*args, **kwargs)</code></td>
<td>Permute the dimensions of the Panel</td>
</tr>
<tr>
<td><code>truediv(other[, axis])</code></td>
<td>Floating division of series and other, element-wise (binary operator <code>truediv</code>).</td>
</tr>
<tr>
<td><code>truncate([before, after, axis, copy])</code></td>
<td>Truncate a Series or DataFrame before and after some index value.</td>
</tr>
<tr>
<td><code>tshift([periods, freq, axis])</code></td>
<td>Shift the time index, using the index’s frequency if available.</td>
</tr>
<tr>
<td><code>tz_convert(tz[, axis, level, copy])</code></td>
<td>Convert tz-aware axis to target time zone.</td>
</tr>
<tr>
<td><code>tz_localize(tz[, axis, level, copy, ambiguous])</code></td>
<td>Localize tz-naive TimeSeries to target time zone.</td>
</tr>
<tr>
<td><code>update(other[, join, overwrite, ...])</code></td>
<td>Modify Panel in place using non-NA values from passed Panel, or object coercible to Panel.</td>
</tr>
<tr>
<td><code>var([axis, skipna, level, ddof, numeric_only])</code></td>
<td>Return unbiased variance over requested axis.</td>
</tr>
<tr>
<td><code>where(cond[, other, inplace, axis, level, ...])</code></td>
<td>Return an object of same shape as self and whose corresponding entries are from self where <code>cond</code> is True and otherwise are from <code>other</code>.</td>
</tr>
<tr>
<td><code>xs(key[, axis])</code></td>
<td>Return slice of panel along selected axis</td>
</tr>
</tbody>
</table>

**pandas.Panel.abs**

Panel.abs()

Return a Series/DataFrame with absolute numeric value of each element.

This function only applies to elements that are all numeric.

**Returns abs**

Series/DataFrame containing the absolute value of each element.

**See also:**

`numpy.abs` calculate the absolute value element-wise.

**Notes**

For complex inputs, $1.2 + 1j$, the absolute value is $\sqrt{a^2 + b^2}$.

**Examples**

Absolute numeric values in a Series.

```python
>>> s = pd.Series([-1.10, 2, -3.33, 4])
>>> s.abs()
0   1.10
1   2.00
2   3.33
3   4.00
dtype: float64
```

Absolute numeric values in a Series with complex numbers.
>>> s = pd.Series([1.2 + 1j])
>>> s.abs()
0    1.56205
dtype: float64

Absolute numeric values in a Series with a Timedelta element.

>>> s = pd.Series([pd.Timedelta('1 days')])
>>> s.abs()
0      1 days
dtype: timedelta64[ns]

Select rows with data closest to certain value using argsort (from Stack Overflow).

>>> df = pd.DataFrame({
...     'a': [4, 5, 6, 7],
...     'b': [10, 20, 30, 40],
...     'c': [100, 50, -30, -50]
... })
>>> df
   a  b  c
0  4  10  100
1  5  20   50
2  6  30  -30
3  7  40  -50

>>> df.loc[(df.c - 43).abs().argsort()]
   a  b  c
0  4  10  100
1  5  20   50
2  6  30  -30
3  7  40  -50

**pandas.Panel.add**

Panel.add(other, axis=0)

Addition of series and other, element-wise (binary operator add). Equivalent to panel + other.

Parameters

other [DataFrame or Panel]

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns

Panel

See also:

Panel.radd

**pandas.Panel.add_prefix**

Panel.add_prefix(prefix)

Prefix labels with string prefix.
For Series, the row labels are prefixed. For DataFrame, the column labels are prefixed.

**Parameters**
- **prefix**: str
  The string to add before each label.

**Returns**
- Series or DataFrame
  New Series or DataFrame with updated labels.

**See also:**
- `Series.add_suffix` Suffix row labels with string `suffix`.
- `DataFrame.add_suffix` Suffix column labels with string `suffix`.

**Examples**

```python
g > s = pd.Series([1, 2, 3, 4])
g > s
0 1
1 2
2 3
3 4
dtype: int64
g > s.add_prefix('item_')
item_0 1
item_1 2
item_2 3
item_3 4
dtype: int64
g > df = pd.DataFrame({'A': [1, 2, 3, 4], 'B': [3, 4, 5, 6]})
g > df
   A  B
0 1  3
1 2  4
2 3  5
3 4  6
g > df.add_prefix('col_')
   col_A  col_B
0   1     3
1   2     4
2   3     5
3   4     6
```

**pandas.Panel.add_suffix**

Panel.add_suffix(**suffix**)  
Suffix labels with string `suffix`.

For Series, the row labels are suffixed. For DataFrame, the column labels are suffixed.

**Parameters**
- **suffix**: str
The string to add after each label.

**Returns**  **Series or DataFrame**

New Series or DataFrame with updated labels.

**See also:**

*Series.add_prefix* Prefix row labels with string *prefix*.

*DataFrame.add_prefix* Prefix column labels with string *prefix*.

**Examples**

```python
generate_code()```

**pandas.Panel.align**

Panel.*align*(other, **kwargs)

Align two objects on their axes with the specified join method for each axis Index

**Parameters**

other  [DataFrame or Series]

join  [{'outer', 'inner', 'left', 'right'}, default 'outer']

axis  : allowed axis of the other object, default None
Align on index (0), columns (1), or both (None)

**level**: int or level name, default None

Broadcast across a level, matching Index values on the passed MultiIndex level

**copy**: boolean, default True

Always returns new objects. If copy=False and no reindexing is required then original objects are returned.

**fill_value**: scalar, default np.NaN

Value to use for missing values. Defaults to NaN, but can be any “compatible” value

**method**: [str, default None]

**limit**: [int, default None]

**fill_axis**: int or labels for object, default 0

Filling axis, method and limit

**broadcast_axis**: int or labels for object, default None

Broadcast values along this axis, if aligning two objects of different dimensions

Returns (left, right) : (NDFrame, type of other)

Aligned objects

**pandas.Panel.all**

Panel.all (axis=0, bool_only= None, skipna=True, level=None, **kwargs)

Return whether all elements are True, potentially over an axis.

Returns True if all elements within a series or along a Dataframe axis are non-zero, not-empty or not-False.

**Parameters**

**axis**: {0 or ‘index’, 1 or ‘columns’, None}, default 0

Indicate which axis or axes should be reduced.

• 0 / ‘index’ : reduce the index, return a Series whose index is the original column labels.

• 1 / ‘columns’ : reduce the columns, return a Series whose index is the original index.

• None : reduce all axes, return a scalar.

**skipna**: boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA.

**level**: int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame.

**bool_only**: boolean, default None

Include only boolean columns. If None, will attempt to use everything, then use only boolean data. Not implemented for Series.
**kwargs** : any, default None

Additional keywords have no effect but might be accepted for compatibility with NumPy.

**Returns**

- all  [DataFrame or Panel (if level specified)]

**See also:**

- **pandas.Series.all**  Return True if all elements are True
- **pandas.DataFrame.any**  Return True if one (or more) elements are True

**Examples**

**Series**

```python
>>> pd.Series([True, True]).all()
True
>>> pd.Series([True, False]).all()
False
```

**DataFrames**

Create a dataframe from a dictionary.

```python
>>> df = pd.DataFrame({'col1': [True, True], 'col2': [True, False]})
>>> df
     col1  col2
0   True  True
1   True  False
```

Default behaviour checks if column-wise values all return True.

```python
>>> df.all()
     col1     col2
0   True   True
1   True  False
dtype: bool
```

Specify `axis='columns'` to check if row-wise values all return True.

```python
>>> df.all(axis='columns')
0   True
1   False
dtype: bool
```

Or `axis=None` for whether every value is True.

```python
>>> df.all(axis=None)
False
```

**pandas.Panel.any**

Panel.any  

(parameters: axis=0, bool_only=None, skipna=True, level=None, **kwargs)

Return whether any element is True over requested axis.
Unlike `DataFrame.all()`, this performs an or operation. If any of the values along the specified axis is True, this will return True.

**Parameters**

- **axis**: {0 or ‘index’, 1 or ‘columns’, None}, default 0  
  Indicate which axis or axes should be reduced.  
  - 0 / ‘index’ : reduce the index, return a Series whose index is the original column labels.  
  - 1 / ‘columns’ : reduce the columns, return a Series whose index is the original index.  
  - None : reduce all axes, return a scalar.

- **skipna**: boolean, default True  
  Exclude NA/null values. If an entire row/column is NA, the result will be NA.

- **level**: int or level name, default None  
  If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame.

- **bool_only**: boolean, default None  
  Include only boolean columns. If None, will attempt to use everything, then use only boolean data. Not implemented for Series.

- **kwargs**: any, default None  
  Additional keywords have no effect but might be accepted for compatibility with NumPy.

**Returns**

- **any**: [DataFrame or Panel (if level specified)]

**See also:**

- `pandas.DataFrame.all` Return whether all elements are True.

**Examples**

**Series**

For Series input, the output is a scalar indicating whether any element is True.

```python
>>> pd.Series([True, False]).any()
True
```

**DataFrame**

Whether each column contains at least one True element (the default).

```python
>>> df = pd.DataFrame({"A": [1, 2], "B": [0, 2], "C": [0, 0]})
>>> df
   A  B  C
0  1  0  0
1  2  2  0
```
```python
>>> df.any()
A   True
B   True
C   False
dtype: bool

Aggregating over the columns.

```}

```python
>>> df = pd.DataFrame({'A': [True, False], 'B': [1, 2]})
>>> df
   A  B
0  True  1
1  False  2
```

```python
>>> df.any(axis='columns')
0   True
1   True
dtype: bool
```

```python
>>> df = pd.DataFrame({'A': [True, False], 'B': [1, 0]})
>>> df
   A  B
0  True  1
1  False  0
```

```python
>>> df.any(axis='columns')
0   True
1   False
dtype: bool
```

Aggregating over the entire DataFrame with `axis=None`.

```python
>>> df = pd.DataFrame({'A': [True, False], 'B': [1, 0]})
>>> df
   A  B
0  True  1
1  False  0
```

```python
>>> df.any(axis='columns')
0   True
1   False
dtype: bool
```

```python
>>> df.any(axis=None)
True
```

`any` for an empty DataFrame is an empty Series.

```python
>>> pd.DataFrame([]).any()
Series([], dtype: bool)
```

**pandas.Panel.apply**

Panel.apply (func, axis='major', **kwargs)
Applies function along axis (or axes) of the Panel

Parameters

- **func**: function
  
  Function to apply to each combination of ‘other’ axes e.g. if axis = ‘items’, the combination of major_axis/minor_axis will each be passed as a Series; if axis = (‘items’, ‘major’), DataFrames of items & major axis will be passed

- **axis**: {‘items’, ‘minor’, ‘major’}, or {0, 1, 2}, or a tuple with two
  
  axes

Additional keyword arguments will be passed as keywords to the function
**Returns**

result [Panel, DataFrame, or Series]

**Examples**

Returns a Panel with the square root of each element

```python
>>> p = pd.Panel(np.random.rand(4,3,2))
>>> p.apply(np.sqrt)
```

Equivalent to p.sum(1), returning a DataFrame

```python
>>> p.apply(lambda x: x.sum(), axis=1)
```

Equivalent to previous:

```python
>>> p.apply(lambda x: x.sum(), axis='major')
```

Return the shapes of each DataFrame over axis 2 (i.e the shapes of items x major), as a Series

```python
>>> p.apply(lambda x: x.shape, axis=(0,1))
```

**pandas.Panel.as_blocks**

Panel.as_blocks (copy=True)
Convert the frame to a dict of dtype -> Constructor Types that each has a homogeneous dtype.

Deprecated since version 0.21.0.

NOTE: the dtypes of the blocks WILL BE PRESERVED HERE (unlike in as_matrix)

**Parameters**

copy [boolean, default True]

**Returns**

values [a dict of dtype -> Constructor Types]

**pandas.Panel.as_matrix**

Panel.as_matrix()
Convert the frame to its Numpy-array representation.

Deprecated since version 0.23.0: Use DataFrame.values() instead.

**Parameters**

columns: list, optional, default:None
If None, return all columns, otherwise, returns specified columns.

**Returns**

values : ndarray
If the caller is heterogeneous and contains booleans or objects, the result will be of dtype=object. See Notes.

**See also:**

pandas.DataFrame.values
Notes

Return is NOT a Numpy-matrix, rather, a Numpy-array.

The dtype will be a lower-common-denominator dtype (implicit upcasting); that is to say if the dtypes (even of numeric types) are mixed, the one that accommodates all will be chosen. Use this with care if you are not dealing with the blocks.

e.g. If the dtypes are float16 and float32, dtype will be upcast to float32. If dtypes are int32 and uint8, dtype will be upcase to int32. By numpy.find_common_type convention, mixing int64 and uint64 will result in a float64 dtype.

This method is provided for backwards compatibility. Generally, it is recommended to use `.values`.

pandas.Panel.asfreq

Panel.asfreq(freq=None, method=None, how=None, normalize=False, fill_value=None)

Convert TimeSeries to specified frequency.

Optionally provide filling method to pad/backfill missing values.

Returns the original data conformed to a new index with the specified frequency. resample is more appropriate if an operation, such as summarization, is necessary to represent the data at the new frequency.

Parameters

- **freq** [DateOffset object, or string]
  - Method to use for filling holes in reindexed Series (note this does not fill NaNs that already were present):
    - ‘pad’ / ‘ffill’: propagate last valid observation forward to next valid
    - ‘backfill’ / ‘bfill’: use NEXT valid observation to fill

- **method** : {'backfill'/'bfill', 'pad'/'ffill'}, default None
  - For PeriodIndex only, see PeriodIndex.asfreq

- **how** : {'start', 'end'}, default end
  - Whether to reset output index to midnight

- **normalize** : bool, default False
  - Whether to reset output index to midnight

- **fill_value** : scalar, optional
  - Value to use for missing values, applied during upsampling (note this does not fill NaNs that already were present).

New in version 0.20.0.

Returns

converted [type of caller]

See also:

reindex

Notes

To learn more about the frequency strings, please see this link.
Examples

Start by creating a series with 4 one minute timestamps.

```python
>>> index = pd.date_range('1/1/2000', periods=4, freq='T')
>>> series = pd.Series([0.0, None, 2.0, 3.0], index=index)
>>> df = pd.DataFrame({'s':series})
>>> df
          s
2000-01-01 00:00:00  0.0
2000-01-01 00:01:00  NaN
2000-01-01 00:02:00  2.0
2000-01-01 00:03:00  3.0
```

Upsample the series into 30 second bins.

```python
>>> df.asfreq(freq='30S')
          s
2000-01-01 00:00:00  0.0
2000-01-01 00:00:30  NaN
2000-01-01 00:01:00  NaN
2000-01-01 00:01:30  NaN
2000-01-01 00:02:00  2.0
2000-01-01 00:02:30  NaN
2000-01-01 00:03:00  3.0
```

Upsample again, providing a fill value.

```python
>>> df.asfreq(freq='30S', fill_value=9.0)
          s
2000-01-01 00:00:00  0.0
2000-01-01 00:00:30  9.0
2000-01-01 00:01:00  NaN
2000-01-01 00:01:30  9.0
2000-01-01 00:02:00  2.0
2000-01-01 00:02:30  9.0
2000-01-01 00:03:00  3.0
```

Upsample again, providing a method.

```python
>>> df.asfreq(freq='30S', method='bfill')
          s
2000-01-01 00:00:00  0.0
2000-01-01 00:00:30  NaN
2000-01-01 00:01:00  NaN
2000-01-01 00:01:30  2.0
2000-01-01 00:02:00  2.0
2000-01-01 00:02:30  3.0
2000-01-01 00:03:00  3.0
```

**pandas.Panel.asof**

Panel.asof(where, subset=None)

The last row without any NaN is taken (or the last row without NaN considering only the subset of columns in the case of a DataFrame)

New in version 0.19.0: For DataFrame
If there is no good value, NaN is returned for a Series a Series of NaN values for a DataFrame

Parameters

- **where** [date or array of dates]
- **subset** : string or list of strings, default None
  
  if not None use these columns for NaN propagation

Returns

- **where** is scalar
  
  • value or NaN if input is Series
  
  • Series if input is DataFrame

- **where** is Index: same shape object as input

See also:

- `merge_asof`

Notes

Dates are assumed to be sorted Raises if this is not the case

**pandas.Panel.astype**

`Panel.astype(dtype, copy=True, errors='raise', **kwargs)`

Cast a pandas object to a specified dtype `dtype`.

Parameters

- **dtype** : data type, or dict of column name -> data type
  
  Use a numpy.dtype or Python type to cast entire pandas object to the same type.
  
  Alternatively, use `{col: dtype, ...}`, where col is a column label and dtype is a numpy.dtype or Python type to cast one or more of the DataFrame’s columns to column-specific types.

- **copy** : bool, default True.
  
  Return a copy when `copy=True` (be very careful setting `copy=False` as changes to values then may propagate to other pandas objects).

- **errors** : {'raise', 'ignore'}, default 'raise'.
  
  Control raising of exceptions on invalid data for provided dtype.
  
  - **raise**: allow exceptions to be raised
  
  - **ignore**: suppress exceptions. On error return original object
  
  New in version 0.20.0.

- **raise_on_error** : raise on invalid input
  
  Deprecated since version 0.20.0: Use `errors` instead

- **kwargs** [keyword arguments to pass on to the constructor]

Returns

- **casted** [type of caller]
See also:

**pandas.to_datetime** Convert argument to datetime.
**pandas.to_timedelta** Convert argument to timedelta.
**pandas.to_numeric** Convert argument to a numeric type.
**numpy.ndarray.astype** Cast a numpy array to a specified type.

**Examples**

```python
>>> ser = pd.Series([1, 2], dtype='int32')
>>> ser
0   1
1   2
dtype: int32
>>> ser.astype('int64')
0   1
1   2
dtype: int64

Convert to categorical type:

```python
>>> ser.astype('category')
0   1
1   2
dtype: category
Categories (2, int64): [1, 2]
```  

Convert to ordered categorical type with custom ordering:

```python
>>> ser.astype('category', ordered=True, categories=[2, 1])
0   1
1   2
dtype: category
Categories (2, int64): [2 < 1]
```  

Note that using `copy=False` and changing data on a new pandas object may propagate changes:

```python
>>> s1 = pd.Series([1,2])
>>> s2 = s1.astype('int64', copy=False)
>>> s2[0] = 10
>>> s1
# note that s1[0] has changed too
0   10
1   2
dtype: int64
```  

**pandas.Panel.at_time**

Panel.at_time(time, asof=False)

Select values at particular time of day (e.g. 9:30AM).

**Parameters**

- **time** [datetime.time or string]
Returns

values_at_time [type of caller]

Raises TypeError

If the index is not a DatetimeIndex

See also:

between_time Select values between particular times of the day
first Select initial periods of time series based on a date offset
last Select final periods of time series based on a date offset

DatetimeIndex.indexer_at_time Get just the index locations for values at particular time of the day

Examples

```python
ts.at_time('12:00')
```

pandas.Panel.between_time

Panel.between_time(start_time, end_time, include_start=True, include_end=True)
Select values between particular times of the day (e.g., 9:00-9:30 AM).

By setting start_time to be later than end_time, you can get the times that are not between the two times.

Parameters

start_time [datetime.time or string]
end_time [datetime.time or string]
include_start [boolean, default True]
include_end [boolean, default True]

Returns

values_between_time [type of caller]

Raises TypeError

If the index is not a DatetimeIndex
See also:

**at_time** Select values at a particular time of the day

**first** Select initial periods of time series based on a date offset

**last** Select final periods of time series based on a date offset

**DatetimeIndex.indexer_between_time** Get just the index locations for values between particular times of the day

### Examples

```python
code
>>> i = pd.date_range('2018-04-09', periods=4, freq='1D20min')
>>> ts = pd.DataFrame({'A': [1, 2, 3, 4]}, index=i)
>>> ts
     A
2018-04-09 00:00:00  1
2018-04-10 00:20:00  2
2018-04-11 00:40:00  3
2018-04-12 01:00:00  4

>>> ts.between_time('0:15', '0:45')
     A
2018-04-10 00:20:00  2
2018-04-11 00:40:00  3

You get the times that are *not* between two times by setting `start_time` later than `end_time`:

```python
code
>>> ts.between_time('0:45', '0:15')
     A
2018-04-09 00:00:00  1
2018-04-12 01:00:00  4
```
Assigns values outside boundary to boundary values. Thresholds can be singular values or array like, and in the latter case the clipping is performed element-wise in the specified axis.

**Parameters**
- `lower`: float or array_like, default None
  - Minimum threshold value. All values below this threshold will be set to it.
- `upper`: float or array_like, default None
  - Maximum threshold value. All values above this threshold will be set to it.
- `axis`: int or string axis name, optional
  - Align object with lower and upper along the given axis.
- `inplace`: boolean, default False
  - Whether to perform the operation in place on the data.
  - New in version 0.21.0.
- `*args, **kwargs`
  - Additional keywords have no effect but might be accepted for compatibility with numpy.

**Returns**
- Series or DataFrame
  - Same type as calling object with the values outside the clip boundaries replaced

**See also:**
- `clip_lower` Clip values below specified threshold(s).
- `clip_upper` Clip values above specified threshold(s).

**Examples**

```python
>>> data = {'col_0': [9, -3, 0, -1, 5], 'col_1': [-2, -7, 6, 8, -5]}
>>> df = pd.DataFrame(data)
>>> df
    col_0  col_1
0      9   -2
1     -3   -7
2      0    6
3     -1    8
4      5   -5

Clips per column using lower and upper thresholds:

```python
>>> df.clip(-4, 6)
    col_0  col_1
0      6   -2
1     -3   -4
2      0    6
3     -1    6
4      5   -4
```
```python
>>> t = pd.Series([2, -4, -1, 6, 3])
>>> t
0   2
1  -4
2  -1
3   6
4   3
dtype: int64

>>> df.clip(t, t + 4, axis=0)
   col_0  col_1
0     4      2
1    -3     -4
2     0      3
3     6      8
4     5      3
```

### pandas.Panel.clip_lower

Panel.clip_lower(threshold, axis=None, inplace=False)

Return copy of the input with values below a threshold truncated.

**Parameters**

- **threshold**: numeric or array-like
  
  Minimum value allowed. All values below threshold will be set to this value.

  - float: every value is compared to `threshold`.
  - array-like: The shape of `threshold` should match the object it’s compared to. When `self` is a Series, `threshold` should be the length. When `self` is a DataFrame, `threshold` should be 2-D and the same shape as `self` for `axis=None`, or 1-D and the same length as the axis being compared.

- **axis**: {0 or ‘index’, 1 or ‘columns’}, default 0
  
  Align `self` with `threshold` along the given axis.

- **inplace**: boolean, default False
  
  Whether to perform the operation in place on the data.
  
  New in version 0.21.0.

**Returns**

- **clipped** [same type as input]

**See also:**

- **Series.clip** Return copy of input with values below and above thresholds truncated.
- **Series.clip_upper** Return copy of input with values above threshold truncated.

### Examples

Series single threshold clipping:
Series clipping element-wise using an array of thresholds. *threshold* should be the same length as the Series.

>>> elemwise_thresholds = [4, 8, 7, 2, 5]
>>> s.clip_lower(elemwise_thresholds)
0  5
1  8
2  7
3  8
4  9
dtype: int64

DataFrames can be compared to a scalar.

>>> df = pd.DataFrame({"A": [1, 3, 5], "B": [2, 4, 6]})
>>> df
   A  B
0  1  2
1  3  4
2  5  6

>>> df.clip_lower(3)
   A  B
0  3  3
1  3  4
2  5  6

Or to an array of values. By default, *threshold* should be the same shape as the DataFrame.

>>> df.clip_lower(np.array([[3, 4], [2, 2], [6, 2]]))
   A  B
0  3  4
1  3  4
2  6  6

Control how *threshold* is broadcast with *axis*. In this case *threshold* should be the same length as the axis specified by *axis*.

>>> df.clip_lower(np.array([3, 3, 5]), axis='index')
   A  B
0  3  3
1  3  4
2  5  6

>>> df.clip_lower(np.array([4, 5]), axis='columns')
   A  B
0  4  5

(continues on next page)
pandas.Panel.clip_upper

Panel.clip_upper(threshold, axis=None, inplace=False)
Return copy of input with values above given value(s) truncated.

Parameters

threshold [float or array_like]
axis: int or string axis name, optional
   Align object with threshold along the given axis.
inplace: boolean, default False
   Whether to perform the operation in place on the data
New in version 0.21.0.

Returns

clipped [same type as input]

See also:
clip

pandas.Panel.compound

Panel.compound(axis=None, skipna=None, level=None)
Return the compound percentage of the values for the requested axis

Parameters

axis [[items (0), major_axis (1), minor_axis (2)]]
skipna: boolean, default True
   Exclude NA/null values when computing the result.
level: int or level name, default None
   If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing
   into a DataFrame
numeric_only : boolean, default None
   Include only float, int, boolean columns. If None, will attempt to use everything,
   then use only numeric data. Not implemented for Series.

Returns

compounded [DataFrame or Panel (if level specified)]
pandas.Panel.conform

Panel.conform(frame, axis=`items`)  
Conform input DataFrame to align with chosen axis pair.

Parameters

  frame [DataFrame]
  axis : {`items`, `'major`, `'minor`}

          Axis the input corresponds to. Eg., if axis=`major`, then the frame’s columns
          would be items, and the index would be values of the minor axis

Returns

  DataFrame

pandas.Panel.consolidate

Panel.consolidate(inplace=False)  
Compute NDFrame with “consolidated” internals (data of each dtype grouped together in a single ndar-
ray).

Deprecated since version 0.20.0: Consolidate will be an internal implementation only.

pandas.Panel.convert_objects

Panel.convert_objects(convert_dates=True, convert_numeric=False, convert_timedeltas=True, copy=True)  
Attempt to infer better dtype for object columns.

Deprecated since version 0.21.0.

Parameters

  convert_dates : boolean, default True

          If True, convert to date where possible. If ‘coerce’, force conversion, with unconvertible values becoming NaT.

  convert_numeric : boolean, default False

          If True, attempt to coerce to numbers (including strings), with unconvertible values becoming NaN.

  convert_timedeltas : boolean, default True

          If True, convert to timedelta where possible. If ‘coerce’, force conversion, with unconvertible values becoming NaT.

  copy : boolean, default True

          If True, return a copy even if no copy is necessary (e.g. no conversion was done). 
          Note: This is meant for internal use, and should not be confused with inplace.

Returns

  converted [same as input object]

See also:

pandas.to_datetime Convert argument to datetime.
**pandas.to_timedelta** Convert argument to timedelta.

**pandas.to_numeric** Return a fixed frequency timedelta index, with day as the default.

**pandas.Panel.copy**

Panel.

```
copy(deep=True)
```

Make a copy of this object’s indices and data.

When `deep=True` (default), a new object will be created with a copy of the calling object’s data and indices. Modifications to the data or indices of the copy will not be reflected in the original object (see notes below).

When `deep=False`, a new object will be created without copying the calling object’s data or index (only references to the data and index are copied). Any changes to the data of the original will be reflected in the shallow copy (and vice versa).

**Parameters**

- **deep**: bool, default True
  
  Make a deep copy, including a copy of the data and the indices. With `deep=False` neither the indices nor the data are copied.

**Returns**

- **copy**: Series, DataFrame or Panel
  
  Object type matches caller.

**Notes**

When `deep=True`, data is copied but actual Python objects will not be copied recursively, only the reference to the object. This is in contrast to `copy.deepcopy` in the Standard Library, which recursively copies object data (see examples below).

While Index objects are copied when `deep=True`, the underlying numpy array is not copied for performance reasons. Since Index is immutable, the underlying data can be safely shared and a copy is not needed.

**Examples**

```python
>>> s = pd.Series([1, 2], index=["a", "b"])
>>> s
a    1
b    2
dtype: int64

>>> s_copy = s.copy()
>>> s_copy
a    1
b    2
dtype: int64
```

Shallow copy versus default (deep) copy:

```python
>>> s = pd.Series([1, 2], index=["a", "b"])
>>> deep = s.copy()
>>> shallow = s.copy(deep=False)
```
Shallow copy shares data and index with original.

```python
>>> s is shallow
False
>>> s.values is shallow.values and s.index is shallow.index
True
```

Deep copy has own copy of data and index.

```python
>>> s is deep
False
>>> s.values is deep.values or s.index is deep.index
False
```

Updates to the data shared by shallow copy and original is reflected in both; deep copy remains unchanged.

```python
>>> s[0] = 3
>>> shallow[1] = 4
>>> s
a 3
b 4
dtype: int64
>>> shallow
a 3
b 4
dtype: int64
>>> deep
a 1
b 2
dtype: int64
```

Note that when copying an object containing Python objects, a deep copy will copy the data, but will not do so recursively. Updating a nested data object will be reflected in the deep copy.

```python
>>> s = pd.Series([[1, 2], [3, 4]])
>>> deep = s.copy()
>>> s[0][0] = 10
>>> s
0 [10, 2]
1 [3, 4]
dtype: object
>>> deep
0 [10, 2]
1 [3, 4]
dtype: object
```

**pandas.Panel.count**

```
Panel.count (axis='major')
Return number of observations over requested axis.
```

**Parameters**

- `axis` [{‘items’, ‘major’, ‘minor’} or {0, 1, 2}]

**Returns**

- `count` [DataFrame]
pandas.Panel.cummax

Panel.cummax (axis=None, skipna=True, *args, **kwargs)
Return cumulative maximum over a DataFrame or Series axis.

Returns a DataFrame or Series of the same size containing the cumulative maximum.

Parameters

axis : {0 or ‘index’, 1 or ‘columns’}, default 0
The index or the name of the axis. 0 is equivalent to None or ‘index’.

skipna : boolean, default True
Exclude NA/null values. If an entire row/column is NA, the result will be NA.

*args, **kwargs :
Additional keywords have no effect but might be accepted for compatibility with NumPy.

Returns

cummax [DataFrame or Panel]

See also:

pandas.core.window.Expanding.max Similar functionality but ignores NaN values.
Panel.max Return the maximum over Panel axis.
Panel.cummax Return cumulative maximum over Panel axis.
Panel.cummin Return cumulative minimum over Panel axis.
Panel.cumsum Return cumulative sum over Panel axis.
Panel.cumprod Return cumulative product over Panel axis.

Examples

Series

```python
>>> s = pd.Series([2, np.nan, 5, -1, 0])
>>> s
0    2.0
1    NaN
2    5.0
3   -1.0
4     0.0
dtype: float64
```

By default, NA values are ignored.

```python
>>> s.cummax()
0    2.0
1    NaN
2    5.0
3    5.0
4    5.0
dtype: float64
```

To include NA values in the operation, use skipna=False
>>> s.cummax(skipna=False)
0    2.0
1   NaN
2   NaN
3   NaN
4   NaN
dtype: float64

DataFrame

>>> df = pd.DataFrame([[2.0, 1.0],
...                     [3.0, np.nan],
...                     [1.0, 0.0]],
...                    columns=list('AB'))

>>> df
    A   B
0  2.0  1.0
1  3.0  NaN
2  1.0  0.0

By default, iterates over rows and finds the maximum in each column. This is equivalent to axis=None or axis='index'.

>>> df.cummax()
    A   B
0   2.0  2.0
1   3.0  NaN
2   1.0  1.0

To iterate over columns and find the maximum in each row, use axis=1

>>> df.cummax(axis=1)
    A   B
0  2.0  2.0
1  3.0  NaN
2  1.0  1.0

pandas.Panel.cummin

Panel.cummin (axis=None, skipna=True, *args, **kwargs)

Return cumulative minimum over a DataFrame or Series axis.

Returns a DataFrame or Series of the same size containing the cumulative minimum.

Parameters axis: {0 or ‘index’, 1 or ‘columns’}, default 0

The index or the name of the axis. 0 is equivalent to None or ‘index’.

skipna: boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA.

*args, **kwargs:

Additional keywords have no effect but might be accepted for compatibility with NumPy.
cummin  [DataFrame or Panel]

See also:

pandas.core.window.Expanding.min  Similar functionality but ignores NaN values.
Panel.min  Return the minimum over Panel axis.
Panel.cummax  Return cumulative maximum over Panel axis.
Panel.cummin  Return cumulative minimum over Panel axis.
Panel.cumsum  Return cumulative sum over Panel axis.
Panel.cumprod  Return cumulative product over Panel axis.

Examples

Series

```python
>>> s = pd.Series([2, np.nan, 5, -1, 0])
>>> s
0    2.0
1    NaN
2    5.0
3   -1.0
4     0.0
Name: s, dtype: float64
```

By default, NA values are ignored.

```python
>>> s.cummin()  # default
0    2.0
1    NaN
2    2.0
3   -1.0
4   -1.0
Name: s, dtype: float64
```

To include NA values in the operation, use skipna=False

```python
>>> s.cummin(skipna=False)
0    2.0
1    NaN
2    NaN
3   NaN
4   NaN
Name: s, dtype: float64
```

DataFrame

```python
>>> df = pd.DataFrame([[2.0, 1.0],
...                     [3.0, np.nan],
...                     [1.0, 0.0]],
...                     columns=list('AB'))
>>> df
       A   B
0  2.0  1.0
```

(continues on next page)
By default, iterates over rows and finds the minimum in each column. This is equivalent to `axis=None` or `axis='index'`.

```
>>> df.cummin()
   A  B
0  2.0  1.0
1  2.0  NaN
2  1.0  0.0
```

To iterate over columns and find the minimum in each row, use `axis=1`

```
>>> df.cummin(axis=1)
   A  B
0  2.0  1.0
1  3.0 NaN
2  1.0  0.0
```

### pandas.Panel.cumprod

`Panel.cumprod(axis=None, skipna=True, *args, **kwargs)`

Return cumulative product over a DataFrame or Series axis.

Returns a DataFrame or Series of the same size containing the cumulative product.

- **Parameters**
  - `axis` : {0 or ‘index’, 1 or ‘columns’}, default 0
    
    The index or the name of the axis. 0 is equivalent to None or ‘index’.
  - `skipna` : boolean, default True
    
    Exclude NA/null values. If an entire row/column is NA, the result will be NA.
  - `*args`, `**kwargs` :
    
    Additional keywords have no effect but might be accepted for compatibility with NumPy.

- **Returns**
  - `cumprod` [DataFrame or Panel]

See also:

- `pandas.core.window.Expanding.prod`  Similar functionality but ignores NaN values.
- `Panel.prod`  Return the product over Panel axis.
- `Panel.cummax`  Return cumulative maximum over Panel axis.
- `Panel.cummin`  Return cumulative minimum over Panel axis.
- `Panel.cumsum`  Return cumulative sum over Panel axis.
- `Panel.cumprod`  Return cumulative product over Panel axis.
Examples

Series

```python
>>> s = pd.Series([2, np.nan, 5, -1, 0])
>>> s
0   2.0
1   NaN
2    5.0
3   -1.0
4    0.0
dtype: float64
```

By default, NA values are ignored.

```python
>>> s.cumprod()
0   2.0
1   NaN
2  10.0
3 -10.0
4   -0.0
dtype: float64
```

To include NA values in the operation, use `skipna=False`

```python
>>> s.cumprod(skipna=False)
0   2.0
1   NaN
2   NaN
3   NaN
4   NaN
dtype: float64
```

DataFrame

```python
>>> df = pd.DataFrame(
... [[2.0, 1.0],
...   [3.0, np.nan],
...   [1.0, 0.0]],
... columns=list('AB'))
```

By default, iterates over rows and finds the product in each column. This is equivalent to `axis=None` or `axis='index'`.

```python
>>> df.cumprod()
   A    B
0  2.0  1.0
1  3.0  NaN
2  1.0  0.0
```

To iterate over columns and find the product in each row, use `axis=1`
>>> df.cumprod(axis=1)
    A  B
0  2.0 2.0
1  3.0 NaN
2  1.0 0.0

pandas.Panel.cumsum

Panel.cumsum(axis=None, skipna=True, *args, **kwargs)
Return cumulative sum over a DataFrame or Series axis.

Returns a DataFrame or Series of the same size containing the cumulative sum.

Parameters
axis : {0 or ‘index’, 1 or ‘columns’}, default 0
The index or the name of the axis. 0 is equivalent to None or ‘index’.

skipna : boolean, default True
Exclude NA/null values. If an entire row/column is NA, the result will be NA.

*args, **kwargs :
Additional keywords have no effect but might be accepted for compatibility with NumPy.

Returns
cumsum [DataFrame or Panel]

See also:
pandas.core.window.Expanding.sum Similar functionality but ignores NaN values.
Panel.sum Return the sum over Panel axis.
Panel.cummax Return cumulative maximum over Panel axis.
Panel.cummin Return cumulative minimum over Panel axis.
Panel.cumsum Return cumulative sum over Panel axis.
Panel.cumprod Return cumulative product over Panel axis.

Examples

Series

>>> s = pd.Series([2, np.nan, 5, -1, 0])
>>> s
0  2.0
1  NaN
2  5.0
3  -1.0
4  0.0
dtype: float64

By default, NA values are ignored.
pandas: powerful Python data analysis toolkit, Release 0.23.2

```python
>>> s.cumsum()
0   2.0
1   NaN
2   7.0
3   6.0
4   6.0
dtype: float64
```

To include NA values in the operation, use `skipna=False`

```python
>>> s.cumsum(skipna=False)
0   2.0
1   NaN
2   NaN
3   NaN
4   NaN
dtype: float64
```

**DataFrame**

```python
>>> df = pd.DataFrame([[2.0, 1.0],
...                     [3.0, np.nan],
...                     [1.0, 0.0]],
...                    columns=list('AB'))
```

```python
>>> df
   A  B
0  2.0  1.0
1  3.0   NaN
2  1.0  0.0
```

By default, iterates over rows and finds the sum in each column. This is equivalent to `axis=None` or `axis='index'`.

```python
>>> df.cumsum()
   A  B
0  2.0  1.0
1  5.0  NaN
2  6.0  1.0
```

To iterate over columns and find the sum in each row, use `axis=1`

```python
>>> df.cumsum(axis=1)
   A  B
0  2.0  3.0
1  3.0   NaN
2  1.0  1.0
```

**pandas.Panel.describe**

`Panel.describe(percentiles=None, include=None, exclude=None)`

Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset’s distribution, excluding NaN values.

Analyzes both numeric and object series, as well as DataFrame column sets of mixed data types. The output will vary depending on what is provided. Refer to the notes below for more detail.

- **Parameters**
  - percentiles : list-like of numbers, optional
The percentiles to include in the output. All should fall between 0 and 1. The default is [.25, .5, .75], which returns the 25th, 50th, and 75th percentiles.

**include**: ‘all’, list-like of dtypes or None (default), optional

A white list of data types to include in the result. Ignored for Series. Here are the options:
- ‘all’: All columns of the input will be included in the output.
- A list-like of dtypes: Limits the results to the provided data types. To limit the result to numeric types submit `numpy.number`. To limit it instead to object columns submit the `numpy.object` data type. Strings can also be used in the style of `select_dtypes` (e.g. `df.describe(include=['O'])`). To select pandas categorical columns, use ‘category’
- None (default): The result will include all numeric columns.

**exclude**: list-like of dtypes or None (default), optional,

A black list of data types to omit from the result. Ignored for Series. Here are the options:
- A list-like of dtypes: Excludes the provided data types from the result. To exclude numeric types submit `numpy.number`. To exclude object columns submit the data type `numpy.object`. Strings can also be used in the style of `select_dtypes` (e.g. `df.describe(include=['O'])`). To exclude pandas categorical columns, use 'category'
- None (default): The result will exclude nothing.

**Returns**

**summary**: Series/DataFrame of summary statistics

**See also:**

`DataFrame.count`, `DataFrame.max`, `DataFrame.min`, `DataFrame.mean`, `DataFrame.std`, `DataFrame.select_dtypes`

**Notes**

For numeric data, the result’s index will include `count`, `mean`, `std`, `min`, `max` as well as lower, 50 and upper percentiles. By default the lower percentile is 25 and the upper percentile is 75. The 50 percentile is the same as the median.

For object data (e.g. strings or timestamps), the result’s index will include `count`, `unique`, `top`, and `freq`. The `top` is the most common value. The `freq` is the most common value’s frequency. Timestamps also include the `first` and `last` items.

If multiple object values have the highest count, then the `count` and `top` results will be arbitrarily chosen from among those with the highest count.

For mixed data types provided via a `DataFrame`, the default is to return only an analysis of numeric columns. If the dataframe consists only of object and categorical data without any numeric columns, the default is to return an analysis of both the object and categorical columns. If `include='all'` is provided as an option, the result will include a union of attributes of each type.

The `include` and `exclude` parameters can be used to limit which columns in a `DataFrame` are analyzed for the output. The parameters are ignored when analyzing a `Series`. 

---

2008 Chapter 34. API Reference
Examples

Describing a numeric Series.

```python
>>> s = pd.Series([1, 2, 3])
>>> s.describe()
count 3.0
mean 2.0
std 1.0
min 1.0
25% 1.5
50% 2.0
75% 2.5
max 3.0
```

Describing a categorical Series.

```python
>>> s = pd.Series(['a', 'a', 'b', 'c'])
>>> s.describe()
count 4
unique 3
top a
freq 2
dtype: object
```

Describing a timestamp Series.

```python
>>> s = pd.Series([np.datetime64("2000-01-01"),
... np.datetime64("2010-01-01"),
... np.datetime64("2010-01-01")
... ])  
>>> s.describe()
count 3
unique 2
top 2010-01-01 00:00:00
freq 2
first 2000-01-01 00:00:00
last 2010-01-01 00:00:00
dtype: object
```

Describing a DataFrame. By default only numeric fields are returned.

```python
>>> df = pd.DataFrame({ 'object': ['a', 'b', 'c'],
... 'numeric': [1, 2, 3],
... 'categorical': pd.Categorical(['d', 'e', 'f'])
... })
>>> df.describe()
numeric
count 3.0
mean 2.0
std 1.0
min 1.0
25% 1.5
50% 2.0
75% 2.5
max 3.0
```
Describing all columns of a DataFrame regardless of data type.

```python
>>> df.describe(include='all')
categorical  numeric  object
count     3   3.0       3
unique    3   NaN       3
top       f   NaN       c
text      1   NaN       1
mean      NaN  2.0       NaN
std       NaN  1.0       NaN
min       NaN  1.0       NaN
25%       NaN  1.5       NaN
50%       NaN  2.0       NaN
75%       NaN  2.5       NaN
max       NaN  3.0       NaN
```

Describing a column from a DataFrame by accessing it as an attribute.

```python
>>> df.numeric.describe()
count   3.0
mean    2.0
std     1.0
min     1.0
25%     1.5
50%     2.0
75%     2.5
max     3.0
Name: numeric, dtype: float64
```

Including only numeric columns in a DataFrame description.

```python
>>> df.describe(include=[np.number])
numeric
count  3.0
mean  2.0
std  1.0
min  1.0
25%  1.5
50%  2.0
75%  2.5
max  3.0
```

Including only string columns in a DataFrame description.

```python
>>> df.describe(include=[np.object])
object
count  3
unique 3
top  c
text  1
```

Including only categorical columns from a DataFrame description.

```python
>>> df.describe(include=['category'])
categorical
count  3
unique 3
```
Excluding numeric columns from a DataFrame description.

```python
>>> df.describe(exclude=[np.number])
categorical object
   count   3    3
   unique  3    3
top  f  c
  freq  1    1
```

Excluding object columns from a DataFrame description.

```python
>>> df.describe(exclude=[np.object])
categorical  numeric
   count   3    3.0
   unique  3    NaN
top  f  NaN
  freq  1    NaN
  mean    NaN   2.0
   std    NaN   1.0
  min    NaN   1.0
  25%    NaN   1.5
  50%    NaN   2.0
  75%    NaN   2.5
  max    NaN   3.0
```

**pandas.Panel.div**

Panel.div(other, axis=0)

Floating division of series and other, element-wise (binary operator truediv). Equivalent to panel / other.

**Parameters**

- **other** [DataFrame or Panel]
- **axis** : {items, major_axis, minor_axis}

  Axis to broadcast over

**Returns**

Panel

**See also:**

Panel.rtruediv

**pandas.Panel.divide**

Panel.divide(other, axis=0)

Floating division of series and other, element-wise (binary operator truediv). Equivalent to panel / other.

**Parameters**

- **other** [DataFrame or Panel]
- **axis** : {items, major_axis, minor_axis}
other [DataFrame or Panel]
axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns
Panel

See also:
Panel.rtruediv

pandas.Panel.dropna

Panel.dropna (axis=0, how='any', inplace=False)
Drop 2D from panel, holding passed axis constant

Parameters axis: int, default 0

Axis to hold constant. E.g. axis=1 will drop major_axis entries having a certain amount of NA data

how: {'all', 'any'}, default 'any'

'any': one or more values are NA in the DataFrame along the axis. For 'all' they all must be.

inplace: bool, default False

If True, do operation inplace and return None.

Returns

dropped [Panel]

pandas.Panel.eq

Panel.eq (other, axis=None)

Wrapper for comparison method eq

pandas.Panel.equals

Panel.equals (other)

Determines if two NDFrame objects contain the same elements. NaNs in the same location are considered equal.

pandas.Panel.ffill

Panel.ffill (axis=None, inplace=False, limit=None, downcast=None)

Synonym for DataFrame.fillna (method='ffill')
pandas.Panel.fillna

Panel.fillna(value=None, method=None, axis=None, inplace=False, limit=None, downcast=None, **kwargs)

Fill NA/NaN values using the specified method

Parameters

value : scalar, dict, Series, or DataFrame
    Value to use to fill holes (e.g. 0), alternately a dict/Series/DataFrame of values specifying which value to use for each index (for a Series) or column (for a DataFrame). (values not in the dict/Series/DataFrame will not be filled). This value cannot be a list.

method : {'backfill', 'bfill', 'pad', 'ffill'}, default None
    Method to use for filling holes in reindexed Series pad / ffill: propagate last valid observation forward to next valid backfill / bfill: use NEXT valid observation to fill gap

axis : intuitively
    [0, 1, 2, 'items', 'major_axis', 'minor_axis']

inplace : boolean, default False
    If True, fill in place. Note: this will modify any other views on this object, (e.g. a no-copy slice for a column in a DataFrame).

limit : int, default None
    If method is specified, this is the maximum number of consecutive NaN values to forward/backward fill. In other words, if there is a gap with more than this number of consecutive NaNs, it will only be partially filled. If method is not specified, this is the maximum number of entries along the entire axis where NaNs will be filled. Must be greater than 0 if not None.

downcast : dict, default is None
    a dict of item->dtype of what to downcast if possible, or the string ‘infer’ which will try to downcast to an appropriate equal type (e.g. float64 to int64 if possible)

Returns

filled [Panel]

See also:

interpolate Fill NaN values using interpolation.

reindex, asfreq

Examples

```python
>>> df = pd.DataFrame([[np.nan, 2, np.nan, 0],
...                     [3, 4, np.nan, 1],
...                     [np.nan, np.nan, np.nan, 5],
...                     [np.nan, 3, np.nan, 4]],
...                    columns=list('ABCD'))
>>> df
          A     B     C     D
0       NaN  2.0  NaN  0.0
1       3.0  4.0  NaN  1.0
2  NaN  NaN  NaN  5.0
3  NaN  3.0  NaN  4.0
```
Replace all NaN elements with 0s.

```python
>>> df.fillna(0)
   A  B  C  D
0  0  2  0  0
1  3  4  0  1
2  0  0  0  5
3  0  3  0  4
```

We can also propagate non-null values forward or backward.

```python
>>> df.fillna(method='ffill')
   A  B  C  D
0  NaN 2.0 0.0 0
1  3.0 4.0 0.0 1
2  3.0 4.0 NaN 5
3  3.0 3.0 NaN 4
```

Replace all NaN elements in column ‘A’, ‘B’, ‘C’, and ‘D’, with 0, 1, 2, and 3 respectively.

```python
>>> values = {'A': 0, 'B': 1, 'C': 2, 'D': 3}
>>> df.fillna(value=values)
   A  B  C  D
0  0.0 2.0 2.0 0
1  3.0 4.0 2.0 1
2  0.0 1.0 2.0 5
3  0.0 3.0 2.0 4
```

Only replace the first NaN element.

```python
>>> df.fillna(value=values, limit=1)
   A  B  C  D
0  0.0 2.0 2.0 0
1  3.0 4.0 NaN 1
2  NaN 1.0 NaN 5
3  NaN 3.0 NaN 4
```

**pandas.Panel.filter**

Panel.filter(items=None, like=None, regex=None, axis=None)

Subset rows or columns of dataframe according to labels in the specified index.

Note that this routine does not filter a dataframe on its contents. The filter is applied to the labels of the index.

**Parameters**

- **items** : list-like
  - List of info axis to restrict to (must not all be present)
- **like** : string
  - Keep info axis where “arg in col == True”
regex : string (regular expression)
Keep info axis with re.search(regex, col) == True

axis : int or string axis name
The axis to filter on. By default this is the info axis, ‘index’ for Series, ‘columns’ for DataFrame

Returns
same type as input object

See also:
pandas.DataFrame.loc

Notes
The items, like, and regex parameters are enforced to be mutually exclusive.
axis defaults to the info axis that is used when indexing with [].

Examples

```python
>>> df
  one  two  three
mouse 1  2  3
rabbit 4  5  6

>>> # select columns by name
>>> df.filter(items=['one', 'three'])
  one  three
mouse  1  3
rabbit  4  6

>>> # select columns by regular expression
>>> df.filter(regex='e$', axis=1)
  one  three
mouse  1  3
rabbit  4  6

>>> # select rows containing 'bbi'
>>> df.filter(like='bbi', axis=0)
  one  two  three
rabbit  4  5  6
```

pandas.Panel.first

Panel.first(offset)
Convenience method for subsetting initial periods of time series data based on a date offset.

Parameters
offset [string, DateOffset, dateutil.relativedelta]
Returns

subset [type of caller]

Raises TypeError

If the index is not a `DatetimeIndex`

See also:

*last* Select final periods of time series based on a date offset

*at_time* Select values at a particular time of the day

*between_time* Select values between particular times of the day

Examples

```python
>>> i = pd.date_range('2018-04-09', periods=4, freq='2D')
>>> ts = pd.DataFrame({'A': [1,2,3,4]}, index=i)
>>> ts
   A
2018-04-09  1
2018-04-11  2
2018-04-13  3
2018-04-15  4
```

Get the rows for the first 3 days:

```python
>>> ts.first('3D')
   A
2018-04-09  1
2018-04-11  2
```

Notice the data for 3 first calendar days were returned, not the first 3 days observed in the dataset, and therefore data for 2018-04-13 was not returned.

**pandas.Panel.first_valid_index**

Panel.`first_valid_index()`

Return index for first non-NA/null value.

Returns

scalar [type of index]

Notes

If all elements are non-NA/null, returns None. Also returns None for empty NDFrame.

**pandas.Panel.floordiv**

Panel.`floordiv(other, axis=0)`

Integer division of series and other, element-wise (binary operator `floordiv`). Equivalent to `panel // other`. 

2016 Chapter 34. API Reference
Parameters

other [DataFrame or Panel]
axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns

Panel

See also:

Panel.rfloordiv

pandas.Panel.fromDict

classmethod Panel.fromDict (data, intersect=False, orient='items', dtype=None)

Construct Panel from dict of DataFrame objects

Parameters data : dict

{ field : DataFrame }

intersect : boolean

Intersect indexes of input DataFrames

orient : {'items', 'minor'}, default 'items'

The “orientation” of the data. If the keys of the passed dict should be the items of the result panel, pass ‘items’ (default). Otherwise if the columns of the values of the passed DataFrame objects should be the items (which in the case of mixed-dtype data you should do), instead pass ‘minor’

dtype : dtype, default None

Data type to force, otherwise infer

Returns

Panel

pandas.Panel.from_dict

classmethod Panel.from_dict (data, intersect=False, orient='items', dtype=None)

Construct Panel from dict of DataFrame objects

Parameters data : dict

{ field : DataFrame }

intersect : boolean

Intersect indexes of input DataFrames

orient : {'items', 'minor'}, default 'items'

The “orientation” of the data. If the keys of the passed dict should be the items of the result panel, pass ‘items’ (default). Otherwise if the columns of the values of the passed DataFrame objects should be the items (which in the case of mixed-dtype data you should do), instead pass ‘minor’
**dtype**: dtype, default None

Data type to force, otherwise infer

**Returns**

Panel

**pandas.Panel.ge**

Panel.ge (other, axis=None)

Wrapper for comparison method ge

**pandas.Panel.get**

Panel.get (key, default=None)

Get item from object for given key (DataFrame column, Panel slice, etc.). Returns default value if not found.

**Parameters**

- **key** [object]

**Returns**

- **value** [type of items contained in object]

**pandas.Panel.get_dtype_counts**

Panel.get_dtype_counts ()

Return counts of unique dtypes in this object.

**Returns**

- **dtype** : Series

  Series with the count of columns with each dtype.

**See also:**

- **dtypes** Return the dtypes in this object.

**Examples**

```python
>>> a = [['a', 1, 1.0], ['b', 2, 2.0], ['c', 3, 3.0]]
>>> df = pd.DataFrame(a, columns=['str', 'int', 'float'])
>>> df
     str  int  float
0     a    1   1.0
1     b    2   2.0
2     c    3   3.0

>>> df.get_dtype_counts()
float64    1
int64      1
object     1
dtype: int64
```
pandas.Panel.get_ftype_counts

Panel.get_ftype_counts()
Return counts of unique ftypes in this object.
Deprecated since version 0.23.0.
This is useful for SparseDataFrame or for DataFrames containing sparse arrays.

Returns dtype : Series
Series with the count of columns with each type and sparsity (dense/sparse)

See also:
ftypes Return ftypes (indication of sparse/dense and dtype) in this object.

Examples

```python
>>> a = [['a', 1, 1.0], ['b', 2, 2.0], ['c', 3, 3.0]]
>>> df = pd.DataFrame(a, columns=['str', 'int', 'float'])
>>> df
     str  int  float
0     a   1   1.0
1     b   2   2.0
2     c   3   3.0
```

```python
>>> df.get_ftype_counts()
float64:dense 1
int64:dense 1
object:dense 1
dtype: int64
```

pandas.Panel.get_value

Panel.get_value(*args, **kwargs)
Quickly retrieve single value at (item, major, minor) location
Deprecated since version 0.21.0.
Please use .at[] or .iat[] accessors.

Parameters

- item [item label (panel item)]
- major [major axis label (panel item row)]
- minor [minor axis label (panel item column)]
- takeable [interpret the passed labels as indexers, default False]

Returns

value [scalar value]
pandas.Panel.get_values

Panel.get_values()
Return an ndarray after converting sparse values to dense.
This is the same as .values for non-sparse data. For sparse data contained in a pandas.SparseArray, the data are first converted to a dense representation.

Returns numpy.ndarray
Numpy representation of DataFrame

See also:
values Numpy representation of DataFrame.
pandas.SparseArray Container for sparse data.

Examples

```python
def = pd.DataFrame({'a': [1, 2], 'b': [True, False], 'c': [1.0, 2.0]})
def
  a   b     c
0  1 True  1.0
1  2 False 2.0
def.get_values()
array([[1, True, 1.0], [2, False, 2.0]], dtype=object)
def = pd.DataFrame({'a': pd.SparseArray([1, None, None]), 'c': [1.0, 2.0, 3.0]})
def
  a  c
0 1.0 1.0
1  NaN 2.0
2  NaN 3.0
def.get_values()
array([[ 1., 1.], [nan, 2.], [nan, 3.]])
```
pandas: powerful Python data analysis toolkit, Release 0.23.2

```markdown
**grouped** [PanelGroupBy]

**pandas.Panel.gt**

**Panel.gt** *(other, axis=None)*

Wrapper for comparison method gt

**pandas.Panel.head**

**Panel.head**(n=5)

Return the first \(n\) rows.

This function returns the first \(n\) rows for the object based on position. It is useful for quickly testing if your object has the right type of data in it.

**Parameters**

\(n\) : int, default 5

Number of rows to select.

**Returns**

\(\text{obj.head}\) : type of caller

The first \(n\) rows of the caller object.

**See also:**

**pandas.DataFrame.tail** Returns the last \(n\) rows.

**Examples**

```python
>>> df = pd.DataFrame({'animal':['alligator', 'bee', 'falcon', 'lion', ...
   ...      'monkey', 'parrot', 'shark', 'whale', 'zebra']})

>>> df
animal
0  alligator
1    bee
2  falcon
3    lion
4  monkey
5  parrot
6   shark
7  whale
8   zebra

Viewing the first 5 lines

```python
>>> df.head()
animal
0  alligator
1    bee
2  falcon
3    lion
4  monkey

Viewing the first \(n\) lines (three in this case)
pandas: powerful Python data analysis toolkit, Release 0.23.2

```
>>> df.head(3)
   animal
0  alligator
1     bee
2   falcon
```

### pandas.Panel.infer_objects

Panel.infer_objects()

Attempt to infer better dtypes for object columns.

Attempts soft conversion of object-dtyped columns, leaving non-object and unconvertible columns unchanged. The inference rules are the same as during normal Series/DataFrame construction.

New in version 0.21.0.

**Returns**

converted [same type as input object]

**See also:**
- pandas.to_datetime: Convert argument to datetime.
- pandas.to_timedelta: Convert argument to timedelta.
- pandas.to_numeric: Convert argument to numeric type

**Examples**

```
>>> df = pd.DataFrame({'A': ['a', 1, 2, 3]})
>>> df = df.iloc[1:]
>>> df
    A
   1  1
   2  2
   3  3
```

```
>>> df.dtypes
A   object
dtype: object
```

```
>>> df.infer_objects().dtypes
A   int64
dtype: object
```

### pandas.Panel.interpolate

Panel.interpolate(method='linear', axis=0, limit=None, inplace=False, limit_direction='forward', limit_area=None, downcast=None, **kwargs)

Interpolate values according to different methods.

Please note that only **method='linear'** is supported for DataFrames/Series with a MultiIndex.

**Parameters**

- method : {'linear', 'time', 'index', 'values', 'nearest', 'zero',...}
`'linear'`, `'quadratic'`, `'cubic'`, `'barycentric'`, `'krogh'`, `'polynomial'`, `'spline'`,
`'piecewise_polynomial'`, `'from_derivatives'`, `'pchip'`, `'akima'`)

- `'linear'`: ignore the index and treat the values as equally spaced. This is the only method supported on MultiIndexes. default
- `'time'`: interpolation works on daily and higher resolution data to interpolate given length of interval
- `'index'`, `'values'`: use the actual numerical values of the index
- `'nearest'`, `'zero'`, `'linear'`, `'quadratic'`, `'cubic'`, `'barycentric'`, `'polynomial'` is passed to scipy.interpolate.interp1d. Both `polynomial` and `spline` require that you also specify an `order` (int), e.g. 
  `df.interpolate(method='polynomial', order=4)`. These use the actual numerical values of the index.
- `'krogh'`, `'piecewise_polynomial'`, `'spline'`, `'pchip'` and `akima` are all wrappers around the scipy interpolation methods of similar names. These use the actual numerical values of the index. For more information on their behavior, see the scipy documentation and tutorial documentation
- `'from_derivatives'` refers to BPoly.from_derivatives which replaces `piecewise_polynomial` interpolation method in scipy 0.18

New in version 0.18.1: Added support for the `akima` method Added interpolate method `from_derivatives` which replaces `piecewise_polynomial` in scipy 0.18; backwards-compatible with scipy < 0.18

**axis**: {0, 1}, default 0
- 0: fill column-by-column
- 1: fill row-by-row

**limit**: int, default None.
Maximum number of consecutive NaNs to fill. Must be greater than 0.

**limit_direction** [{`'forward'`, `'backward'`, `'both'`}, default `forward`]

**limit_area** : `{`'inside'`, `'outside'`}, default None
- None: (default) no fill restriction
- `'inside'` Only fill NaNs surrounded by valid values (interpolate).
- `'outside'` Only fill NaNs outside valid values (extrapolate).

If limit is specified, consecutive NaNs will be filled in this direction.
New in version 0.21.0.

**inplace** : bool, default False
Update the NDFrame in place if possible.

**downcast** : optional, `infer` or None, defaults to None
Downcast dtypes if possible.

**kwargs** [keyword arguments to pass on to the interpolating function.]
Returns

Series or DataFrame of same shape interpolated at the NaNs

See also:

reindex, replace,fillna

Examples

Filling in NaNs

```python
>>> s = pd.Series([0, 1, np.nan, 3])
>>> s.interpolate()
0    0
1    1
2    2
3    3
dtype: float64
```

**pandas.Panel.isna**

Panel.isna()

Detect missing values.

Return a boolean same-sized object indicating if the values are NA. NA values, such as None or numpy. NaN, gets mapped to True values. Everything else gets mapped to False values. Characters such as empty strings '' or numpy.inf are not considered NA values (unless you set pandas.options.mode.use_inf_as_na = True).

Returns NDFrame

Mask of bool values for each element in NDFrame that indicates whether an element is not an NA value.

See also:

NDFrame.isnull alias of isna
NDFrame.notna boolean inverse of isna
NDFrame.dropna omit axes labels with missing values

isna top-level isna

Examples

Show which entries in a DataFrame are NA.

```python
>>> df = pd.DataFrame({'age': [5, 6, np.NaN],
... 'born': [pd.NaT, pd.Timestamp('1939-05-27'),
... pd.Timestamp('1940-04-25')],
... 'name': ['Alfred', 'Batman', ''],
... 'toy': [None, 'Batmobile', 'Joker']})
>>> df
age    born    name      toy
0    5  NaT       Alfred  None
1    6 1939-05-27  Batman  Batmobile
2    NaN 1940-04-25     ''     Joker
```
(continued from previous page)

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.0</td>
<td>NaT</td>
<td>Alfred</td>
</tr>
<tr>
<td>1</td>
<td>6.0</td>
<td>1939-05-27</td>
<td>Batman</td>
</tr>
<tr>
<td>2</td>
<td>NaN</td>
<td>1940-04-25</td>
<td>Joker</td>
</tr>
</tbody>
</table>

```python
>>> df.isna()
    age  born   name  toy
   0 False  True  False  True
   1  False  False  False  False
   2  True  False  False  False
```

Show which entries in a Series are NA.

```python
>>> ser = pd.Series([5, 6, np.NaN])

>>> ser
0  5.0
1  6.0
2  NaN
dtype: float64

>>> ser.isna()
0  False
1  False
2  True
dtype: bool
```

### pandas.Panel.isnull

**Panel.isnull()**

Detect missing values.

Return a boolean same-sized object indicating if the values are NA. NA values, such as None or `numpy.Nan`, gets mapped to True values. Everything else gets mapped to False values. Characters such as empty strings '' or `numpy.inf` are not considered NA values (unless you set `pandas.options.mode.use_inf_as_na = True`).

**Returns** NDFrame

Mask of bool values for each element in NDFrame that indicates whether an element is not an NA value.

**See also:**

- `NDFrame.isnull` alias of isna
- `NDFrame.notna` boolean inverse of isna
- `NDFrame.dropna` omit axes labels with missing values
- `isna` top-level isna

### Examples

Show which entries in a DataFrame are NA.
```python
>>> df = pd.DataFrame({'age': [5, 6, np.NaN],
...                    'born': [pd.NaT, pd.Timestamp('1939-05-27'),
...                             pd.Timestamp('1940-04-25')],
...                    'name': ['Alfred', 'Batman', ''],
...                    'toy': [None, 'Batmobile', 'Joker']})

>>> df
age  born        name      toy
0    5.0  NaT  Alfred     None
1    6.0 1939-05-27 Batman  Batmobile
2  NaN    1940-04-25  Joker

>>> df.isna()
    age   born    name   toy
0  False  True  False  True
1  False  False  False   False
2   True  False  False   False

Show which entries in a Series are NA.

```python
>>> ser = pd.Series([5, 6, np.NaN])

```python
>>> ser
0    5.0
1    6.0
2    NaN
dtype: float64

>>> ser.isna()
0   False
1   False
2    True
dtype: bool
```

### pandas.Panel.

#### pandas.Panel.iteritems

**Panel.iteritems()**

Iterate over (label, values) on info axis

This is index for Series, columns for DataFrame, major_axis for Panel, and so on.

#### pandas.Panel.join

**Panel.join(other, how='left', lsuffix='', rsuffix='')**

Join items with other Panel either on major and minor axes column

- **Parameters**
  - other : Panel or list of Panels
  - how : {'left', 'right', 'outer', 'inner'}
  - lsuffix : string
  - rsuffix : string

  Index should be similar to one of the columns in this one

  How to handle indexes of the two objects. Default: ‘left’ for joining on index,
  None otherwise * left: use calling frame’s index * right: use input frame’s index
  * outer: form union of indexes * inner: use intersection of indexes
```
Suffix to use from left frame’s overlapping columns

rsuffix : string

Suffix to use from right frame’s overlapping columns

Returns

joined [Panel]

pandas.Panel.keys

Panel.keys()

Get the ‘info axis’ (see Indexing for more)

This is index for Series, columns for DataFrame and major_axis for Panel.

pandas.Panel.kurt

Panel.kurt(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)

Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0). Normalized by N-1

Parameters

axis [{items (0), major_axis (1), minor_axis (2)}]

skipna : boolean, default True

Exclude NA/null values when computing the result.

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns

kurt [DataFrame or Panel (if level specified)]

pandas.Panel.kurtosis

Panel.kurtosis(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)

Return unbiased kurtosis over requested axis using Fisher’s definition of kurtosis (kurtosis of normal == 0.0). Normalized by N-1

Parameters

axis [{items (0), major_axis (1), minor_axis (2)}]

skipna : boolean, default True

Exclude NA/null values when computing the result.

level : int or level name, default None
If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

**numeric_only**  : boolean, default None
Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

kurt  [DataFrame or Panel (if level specified)]

**pandas.Panel.last**

**Panel.last(offset)**
Convenience method for subsetting final periods of time series data based on a date offset.

**Parameters**

- offset  [string, DateOffset, dateutil.relativedelta]

**Returns**

subset  [type of caller]

**Raises**  TypeError

If the index is not a *DateTimeIndex*

**See also:**

- first  Select initial periods of time series based on a date offset
- at_time  Select values at a particular time of the day
- between_time  Select values between particular times of the day

**Examples**

```python
>>> i = pd.date_range('2018-04-09', periods=4, freq='2D')
>>> ts = pd.DataFrame({'A': [1,2,3,4]}, index=i)
>>> ts
          A
2018-04-09  1
2018-04-11  2
2018-04-13  3
2018-04-15  4

Get the rows for the last 3 days:

```python
>>> ts.last('3D')
          A
2018-04-13  3
2018-04-15  4
```

Notice the data for 3 last calendar days were returned, not the last 3 observed days in the dataset, and therefore data for 2018-04-11 was not returned.
pandas.Panel.last_valid_index

Panel\texttt{.last\_valid\_index}()
Return index for last non-NA/null value.

Returns

\texttt{scalar} [type of index]

Notes

If all elements are non-NA/null, returns None. Also returns None for empty NDFrame.

pandas.Panel.le

Panel\texttt{.le}\texttt{(other, axis=None)}
Wrapper for comparison method \texttt{le}

pandas.Panel.lt

Panel\texttt{.lt}\texttt{(other, axis=None)}
Wrapper for comparison method \texttt{lt}

pandas.Panel.mad

Panel\texttt{.mad}\texttt{(axis=None, skipna=None, level=None)}
Return the mean absolute deviation of the values for the requested axis

Parameters

axis \texttt{[\{items (0), major\_axis (1), minor\_axis (2)\}]}

skipna : boolean, default True
Exclude NA/null values when computing the result.

level : int or level name, default None
If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric\_only : boolean, default None
Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns

mad \texttt{[DataFrame or Panel (if level specified)]}

pandas.Panel.major_xs

Panel\texttt{.major\_xs}\texttt{(key)}
Return slice of panel along major axis
**Parameters**  
**key**: object  
Major axis label

**Returns**  
**y**: DataFrame  
index -> minor axis, columns -> items

**Notes**

major_xs is only for getting, not setting values.

MultiIndex Slicers is a generic way to get/set values on any level or levels and is a superset of major_xs functionality, see *MultiIndex Slicers*

**pandas.Panel.mask**

```python
Panel.mask(cond, other=nan, inplace=False, axis=None, level=None, errors='raise', try_cast=False, raise_on_error=None)
```

Return an object of same shape as self and whose corresponding entries are from self where *cond* is False and otherwise are from *other*.

**Parameters**

**cond**: boolean NDFrame, array-like, or callable  
Where *cond* is False, keep the original value. Where True, replace with corresponding value from *other*. If *cond* is callable, it is computed on the NDFrame and should return boolean NDFrame or array. The callable must not change input NDFrame (though pandas doesn’t check it).

New in version 0.18.1: A callable can be used as *cond*.

**other**: scalar, NDFrame, or callable  
Entries where *cond* is True are replaced with corresponding value from *other*. If other is callable, it is computed on the NDFrame and should return scalar or NDFrame. The callable must not change input NDFrame (though pandas doesn’t check it).

New in version 0.18.1: A callable can be used as *other*.

**inplace**: boolean, default False  
Whether to perform the operation in place on the data

**axis** [alignment axis if needed, default None]  
**level** [alignment level if needed, default None]

**errors**: str, {‘raise’, ‘ignore’}, default ‘raise’  
- **raise**: allow exceptions to be raised  
- **ignore**: suppress exceptions. On error return original object  

Note that currently this parameter won’t affect the results and will always coerce to a suitable dtype.

**try_cast**: boolean, default False  
try to cast the result back to the input type (if possible),

**raise_on_error**: boolean, default True
Whether to raise on invalid data types (e.g. trying to where on strings)

Deprecated since version 0.21.0.

Returns

wh [same type as caller]

See also:

DataFrame.where()

Notes

The mask method is an application of the if-then idiom. For each element in the calling DataFrame, if
cond is False the element is used; otherwise the corresponding element from the DataFrame other
is used.

The signature for DataFrame.where() differs from numpy.where(). Roughly df1.where(m, df2) is equivalent to np.where(m, df1, df2).

For further details and examples see the mask documentation in indexing.

Examples

```python
>>> s = pd.Series(range(5))
>>> s.where(s > 0)
   0   NaN
   1     1
   2     2
   3     3
   4     4

>>> s.mask(s > 0)
   0    0
   1   NaN
   2   NaN
   3   NaN
   4   NaN

>>> s.where(s > 1, 10)
   0    10
   1    10
   2     2
   3     3
   4     4

>>> df = pd.DataFrame(np.arange(10).reshape(-1, 2), columns=['A', 'B'])
>>> m = df % 3 == 0
>>> df.where(m, -df)
     A     B
   0    0   -1
   1   -2    3
   2   -4   -5
   3    6   -7
   4   -8    9
```
```python
>>> df.where(m, -df) == np.where(m, df, -df)
   A  B
0  True True
1  True True
2  True True
3  True True
4  True True
```
If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

**numeric_only** : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

**mean** [DataFrame or Panel (if level specified)]

**pandas.Panel.median**

**Panel.median**(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)

Return the median of the values for the requested axis

**Parameters**

**axis** [[items (0), major_axis (1), minor_axis (2)]]

**skipna** : boolean, default True

Exclude NA/null values when computing the result.

**level** : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

**numeric_only** : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

**median** [DataFrame or Panel (if level specified)]

**pandas.Panel.min**

**Panel.min**(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)

This method returns the minimum of the values in the object. If you want the index of the minimum, use idxmin. This is the equivalent of the numpy.ndarray method argmin.

**Parameters**

**axis** [[items (0), major_axis (1), minor_axis (2)]]

**skipna** : boolean, default True

Exclude NA/null values when computing the result.

**level** : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

**numeric_only** : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.
Returns

min [DataFrame or Panel (if level specified)]

pandas.Panel.minor_xs

Panel.minor_xs(key)
Return slice of panel along minor axis

Parameters
key : object
Minor axis label

Returns
y : DataFrame
index -> major axis, columns -> items

Notes

minor_xs is only for getting, not setting values.
MultiIndex Slicers is a generic way to get/set values on any level or levels and is a superset of minor_xs functionality, see MultiIndex Slicers

pandas.Panel.mod

Panel.mod(other, axis=0)
Modulo of series and other, element-wise (binary operator mod). Equivalent to panel % other.

Parameters
other [DataFrame or Panel]
axis : {items, major_axis, minor_axis}
Axis to broadcast over

Returns
Panel

See also:
Panel.rmod

pandas.Panel.mul

Panel.mul(other, axis=0)
Multiplication of series and other, element-wise (binary operator mul). Equivalent to panel * other.

Parameters
other [DataFrame or Panel]
axis : {items, major_axis, minor_axis}
Axis to broadcast over

Returns
Panel

See also:

Panel.rmul

pandas.Panel.multiply

Panel.multiply(other, axis=0)
Multiplication of series and other, element-wise (binary operator \texttt{mul}). Equivalent to \texttt{panel * other}.

Parameters

- \texttt{other} [DataFrame or Panel]
- \texttt{axis} : \{items, major_axis, minor_axis\}
  Axis to broadcast over

Returns

Panel

See also:

Panel.rmul

pandas.Panel.ne

Panel.ne(other, axis=None)
Wrapper for comparison method \texttt{ne}

pandas.Panel.notna

Panel.notna()
Detect existing (non-missing) values.

Return a boolean same-sized object indicating if the values are not NA. Non-missing values get mapped to True. Characters such as empty strings '' or \texttt{numpy.inf} are not considered NA values (unless you set \texttt{pandas.options.mode.use_inf_as_na = True}). NA values, such as \texttt{None} or \texttt{numpy.NaN}, get mapped to False values.

Returns NDFrame

Mask of bool values for each element in NDFrame that indicates whether an element is not an NA value.

See also:

NDFrame.notnull alias of notna
NDFrame.isna boolean inverse of notna
NDFrame.dropna omit axes labels with missing values
notna top-level notna
Examples

Show which entries in a DataFrame are not NA.

```python
def = pd.DataFrame({'age': [5, 6, np.NaN],
                            pd.Timestamp('1940-04-25')],
                   'name': ['Alfred', 'Batman', ''],
                   'toy': [None, 'Batmobile', 'Joker']})
```

```python
>>> df
   age    born     name    toy
0  5.0  NaT  Alfred  None
1  6.0 1939-05-27  Batman  Batmobile
2 NaN 1940-04-25   Joker  
```

```python
>>> df.notna()
   age    born     name    toy
0  True  False  True  False
1  True   True  True  True
2 False  True  True  True
```

Show which entries in a Series are not NA.

```python
ser = pd.Series([5, 6, np.NaN])
```

```python
>>> ser
0  5.0
1  6.0
2 NaN
dtype: float64
```

```python
>>> ser.notna()
0  True
1  True
2 False
dtype: bool
```

**pandas.Panel.notnull**

Panel.notnull()  
Detect existing (non-missing) values.  

Return a boolean same-sized object indicating if the values are not NA. Non-missing values get mapped to True. Characters such as empty strings '' or numpy.inf are not considered NA values (unless you set pandas.options.mode.use_inf_as_na = True). NA values, such as None or numpy.NaN, get mapped to False values.

Returns NDFrame  
Mask of bool values for each element in NDFrame that indicates whether an element is not an NA value.

See also:

- NDFrame.notnull  alias of notna
- NDFrame.isna  boolean inverse of notna
**NDFrame.dropna**  omit axes labels with missing values

**notna**  top-level notna

### Examples

**Show which entries in a DataFrame are not NA.**

```python
>>> df = pd.DataFrame({'age': [5, 6, np.NaN],
...                     'born': [pd.NaT, pd.Timestamp('1939-05-27'),
...                             pd.Timestamp('1940-04-25')],
...                     'name': ['Alfred', 'Batman', ''],
...                     'toy': [None, 'Batmobile', 'Joker']})
```

```bash
>>> df
   age  born           name  toy
0   5.0  NaT        Alfred  None
1   6.0 1939-05-27  Batman  Batmobile
2  NaN  1940-04-25  Joker
```

```python
>>> df.notna()
   age  born  name  toy
0   True False  True False
1   True  True  True  True
2  False  True  True  True
```

**Show which entries in a Series are not NA.**

```python
>>> ser = pd.Series([5, 6, np.NaN])
```

```bash
>>> ser
0    5.0
1    6.0
2   NaN
dtype: float64
```

```python
>>> ser.notna()
0   True
1   True
2  False
dtype: bool
```

**pandas.Panel.pct_change**

Panel.pct_change(periods=1, fill_method='pad', limit=None, freq=None, **kwargs)

Percentage change between the current and a prior element.

Computes the percentage change from the immediately previous row by default. This is useful in comparing the percentage of change in a time series of elements.

- **Parameters**
  - **periods**: int, default 1
    
    Periods to shift for forming percent change.
  - **fill_method**: str, default ‘pad’
    
    How to handle NAs before computing percent changes.
  - **limit**: int, default None
The number of consecutive NAs to fill before stopping.

`freq` : DateOffset, timedelta, or offset alias string, optional
Increment to use from time series API (e.g. ‘M’ or BDay()).

**kwargs
Additional keyword arguments are passed into `DataFrame.shift` or `Series.shift`.

Returns `chg` : Series or DataFrame
The same type as the calling object.

See also:

`Series.diff` Compute the difference of two elements in a Series.
`DataFrame.diff` Compute the difference of two elements in a DataFrame.
`Series.shift` Shift the index by some number of periods.
`DataFrame.shift` Shift the index by some number of periods.

Examples

Series

```python
>>> s = pd.Series([90, 91, None, 85])
>>> s
   0    90
   1    91
   2   NaN
   3    85
 dtype: int64
```

```python
>>> s.pct_change()
   0   NaN
   1  0.011111
   2 -0.065934
 dtype: float64
```

```python
>>> s.pct_change(periods=2)
   0   NaN
   1   NaN
   2 -0.055556
 dtype: float64
```

See the percentage change in a Series where filling NAs with last valid observation forward to next valid.

```python
>>> s = pd.Series([90, 91, None, 85])
>>> s
   0    90
   1    91
   2   NaN
   3    85
 dtype: float64
```
DataFrame

Percentage change in French franc, Deutsche Mark, and Italian lira from 1980-01-01 to 1980-03-01.

```python
>>> df = pd.DataFrame({
... 'FR': [4.0405, 4.0963, 4.3149],
... 'GR': [1.7246, 1.7482, 1.8519],
... 'IT': [804.74, 810.01, 860.13]},
... index=['1980-01-01', '1980-02-01', '1980-03-01'])

>>> df
   FR     GR    IT
1980-01-01 4.0405 1.7246 804.74
1980-02-01 4.0963 1.7482 810.01
1980-03-01 4.3149 1.8519 860.13
```

Percentage change in GOOG and APPL stock volume. Shows computing the percentage change between columns.

```python
>>> df = pd.DataFrame({
... '2016': [1769950, 30586265],
... '2015': [1500923, 40912316],
... '2014': [1371819, 41403351]},
... index=['GOOG', 'APPL'])

>>> df
   2016  2015  2014
GOOG 1769950 1500923 1371819
APPL 30586265 40912316 41403351
```

```python
>>> df.pct_change(axis='columns')
     2016   2015    2014
GOOG -0.151997 -0.086016
APPL  0.337604  0.012002
```

pandas.Panel.pipe

Panel.pipe(func, *args, **kwargs)

Apply func(self, *args, **kwargs)

Parameters

func : function

function to apply to the NDFrame. args, and kwargs are passed into func. Alternatively a (callable, data_keyword) tuple where
data_keyword is a string indicating the keyword of callable that expects the NDFrame.

args : iterable, optional
    positional arguments passed into func.

kwargs : mapping, optional
    a dictionary of keyword arguments passed into func.

Returns

object [the return type of func.]

See also:
pandas.DataFrame.apply, pandas.DataFrame.applymap, pandas.Series.map

Notes

Use .pipe when chaining together functions that expect Series, DataFrames or GroupBy objects. Instead of writing

```python
>>> f(g(h(df), arg1=a), arg2=b, arg3=c)
```

You can write

```python
>>> (df.pipe(h)
...     .pipe(g, arg1=a)
...     .pipe(f, arg2=b, arg3=c)
... )
```

If you have a function that takes the data as (say) the second argument, pass a tuple indicating which keyword expects the data. For example, suppose f takes its data as arg2:

```python
>>> (df.pipe(h)
...     .pipe(g, arg1=a)
...     .pipe((f, 'arg2'), arg1=a, arg3=c)
... )
```

pandas.Panel.pop

Panel.pop(item)
Return item and drop from frame. Raise KeyError if not found.

Parameters item : str
    Column label to be popped

Returns

popped [Series]

Examples
```python
>>> df = pd.DataFrame(
    [['falcon', 'bird', 389.0],
     ['parrot', 'bird', 24.0],
     ['lion', 'mammal', 80.5],
     ['monkey', 'mammal', np.nan]],
    columns=('name', 'class', 'max_speed'))
>>> df
  name class  max_speed
0  falcon   bird       389.0
1   parrot   bird        24.0
2     lion  mammal       80.5
3   monkey  mammal        NaN
```
```python
>>> df.pop('class')
0   bird
1   bird
2  mammal
3  mammal
Name: class, dtype: object
```
```python
>>> df
  name  max_speed
0  falcon       389.0
1   parrot       24.0
2     lion       80.5
3   monkey        NaN
```

**pandas.Panel.pow**

Panel.pow(other, axis=0)

Exponential power of series and other, element-wise (binary operator pow). Equivalent to panel ** other.

**Parameters**

- **other** [DataFrame or Panel]
- **axis** : {items, major_axis, minor_axis}
  
  Axis to broadcast over

**Returns**

Panel

**See also:**

Panel.rpow

**pandas.Panel.prod**

Panel.prod(axis=None, skipna=None, level=None, numeric_only=None, min_count=0, **kwargs)

Return the product of the values for the requested axis

**Parameters**

- **axis** [{items (0), major_axis (1), minor_axis (2)}]
- **skipna** : boolean, default True
Exclude NA/null values when computing the result.

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

min_count : int, default 0

The required number of valid values to perform the operation. If fewer than min_count non-NA values are present the result will be NA.

New in version 0.22.0: Added with the default being 0. This means the sum of an all-NA or empty Series is 0, and the product of an all-NA or empty Series is 1.

Returns

prod [DataFrame or Panel (if level specified)]

Examples

By default, the product of an empty or all-NA Series is 1

```python
gpd.Series([]).prod()
1.0
```

This can be controlled with the min_count parameter

```python
gpd.Series([]).prod(min_count=1)
nan
```

Thanks to the skipna parameter, min_count handles all-NA and empty series identically.

```python
gpd.Series([np.nan]).prod()
1.0
```

```python
gpd.Series([np.nan]).prod(min_count=1)
nan
```

Panel.product

Panel.product (axis=None, skipna=None, level=None, numeric_only=None, min_count=0, **kwargs)
Return the product of the values for the requested axis

Parameters

axis {items (0), major_axis (1), minor_axis (2)}

skipna : boolean, default True

Exclude NA/null values when computing the result.

level : int or level name, default None
If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

**numeric_only**: boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**min_count**: int, default 0

The required number of valid values to perform the operation. If fewer than `min_count` non-NA values are present the result will be NA.

New in version 0.22.0: Added with the default being 0. This means the sum of an all-NA or empty Series is 0, and the product of an all-NA or empty Series is 1.

**Returns**

**prod** [DataFrame or Panel (if level specified)]

**Examples**

By default, the product of an empty or all-NA Series is 1

```python
>>> pd.Series([]).prod()
1.0
```

This can be controlled with the `min_count` parameter

```python
>>> pd.Series([]).prod(min_count=1)
nan
```

Thanks to the `skipna` parameter, `min_count` handles all-NA and empty series identically.

```python
>>> pd.Series([np.nan]).prod()
1.0
```

```python
>>> pd.Series([np.nan]).prod(min_count=1)
nan
```

**pandas.Panel.radd**

`Panel.radd(other, axis=0)`

Addition of series and other, element-wise (binary operator `radd`). Equivalent to `other + panel`.

**Parameters**

- **other** [DataFrame or Panel]
- **axis** : [items, major_axis, minor_axis]

  Axis to broadcast over

**Returns**

- **Panel**

**See also:**

`Panel.add`
pandas.Panel.rank

`Panel.rank(axis=0, method='average', numeric_only=None, na_option='keep', ascending=True, pct=False)`

Compute numerical data ranks (1 through n) along axis. Equal values are assigned a rank that is the average of the ranks of those values.

**Parameters**
- **axis**: {0 or ‘index’, 1 or ‘columns’}, default 0
  - Index to direct ranking
- **method**: {'average', 'min', 'max', 'first', 'dense'}
  - average: average rank of group
  - min: lowest rank in group
  - max: highest rank in group
  - first: ranks assigned in order they appear in the array
  - dense: like ‘min’, but rank always increases by 1 between groups
- **numeric_only**: boolean, default None
  - Include only float, int, boolean data. Valid only for DataFrame or Panel objects
- **na_option**: {'keep', ‘top’, ‘bottom’}
  - keep: leave NA values where they are
  - top: smallest rank if ascending
  - bottom: smallest rank if descending
- **ascending**: boolean, default True
  - False for ranks by high (1) to low (N)
- **pct**: boolean, default False
  - Computes percentage rank of data

**Returns**
- **ranks** [same type as caller]

pandas.Panel.rdiv

`Panel.rdiv(other, axis=0)`

Floating division of series and other, element-wise (binary operator `rtruediv`). Equivalent to `other / panel`.

**Parameters**
- **other** [DataFrame or Panel]
- **axis**: {items, major_axis, minor_axis}
  - Axis to broadcast over

**Returns**
- **Panel**
See also:

Panel.truediv

**pandas.Panel.reindex**

Panel\[\texttt{reindex} (\ast args, \ast kwargs)\]

Conform Panel to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index. A new object is produced unless the new index is equivalent to the current one and copy=False

**Parameters**

\texttt{items, major_axis, minor_axis : array-like, optional (should be specified using keywords)}

- New labels / index to conform to. Preferably an Index object to avoid duplicating data

\texttt{method : \{None, ‘backfill’/’bfill’, ‘pad’/’ffill’, ‘nearest’\}, optional}

- method to use for filling holes in reindexed DataFrame. Please note: this is only applicable to DataFrames/Series with a monotonically increasing/decreasing index.
  - default: don’t fill gaps
  - pad / ffill: propagate last valid observation forward to next valid
  - backfill / bfill: use next valid observation to fill gap
  - nearest: use nearest valid observations to fill gap

\texttt{copy : boolean, default True}

- Return a new object, even if the passed indexes are the same

\texttt{level : int or name}

- Broadcast across a level, matching Index values on the passed MultiIndex level

\texttt{fill_value : scalar, default \texttt{np.NaN}}

- Value to use for missing values. Defaults to NaN, but can be any “compatible” value

\texttt{limit : int, default None}

- Maximum number of consecutive elements to forward or backward fill

\texttt{tolerance : optional}

- Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations must satisfy the equation \texttt{abs(index[indexer] - target) \leq tolerance}.

  Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index’s type.

- New in version 0.21.0: (list-like tolerance)

**Returns**

\texttt{reindexed [Panel]}
Examples

DataFrame.reindex supports two calling conventions

• (index=index_labels, columns=column_labels, ...)

• (labels, axis={'index', 'columns'}, ...)

We highly recommend using keyword arguments to clarify your intent.

Create a dataframe with some fictional data.

```python
>>> index = ['Firefox', 'Chrome', 'Safari', 'IE10', 'Konqueror']
>>> df = pd.DataFrame({
...     'http_status': [200, 200, 404, 404, 301],
...     'response_time': [0.04, 0.02, 0.07, 0.08, 1.0],
...     'index': index}
>>> df
http_status  response_time
Firefox       200  0.04
Chrome        200  0.02
Safari        404  0.07
IE10          404  0.08
Konqueror     301  1.00
```

Create a new index and reindex the dataframe. By default values in the new index that do not have corresponding records in the dataframe are assigned NaN.

```python
>>> new_index= ['Safari', 'Iceweasel', 'Comodo Dragon', 'IE10', 'Chrome']
>>> df.reindex(new_index)
http_status  response_time
Safari       404  0.07
Iceweasel    NaN  NaN
Comodo Dragon NaN  NaN
IE10         404  0.08
Chrome       200  0.02
```

We can fill in the missing values by passing a value to the keyword fill_value. Because the index is not monotonically increasing or decreasing, we cannot use arguments to the keyword method to fill the NaN values.

```python
>>> df.reindex(new_index, fill_value=0)
http_status  response_time
Safari       404  0.07
Iceweasel    0   0.00
Comodo Dragon NaN  NaN
IE10         404  0.08
Chrome       200  0.02
```

```python
>>> df.reindex(new_index, fill_value='missing')
http_status  response_time
Safari       404  0.07
Iceweasel    missing  missing
Comodo Dragon missing  missing
IE10         404  0.08
Chrome       200  0.02
```

We can also reindex the columns.
Or we can use “axis-style” keyword arguments

To further illustrate the filling functionality in reindex, we will create a dataframe with a monotonically increasing index (for example, a sequence of dates).

Suppose we decide to expand the dataframe to cover a wider date range.

The index entries that did not have a value in the original data frame (for example, ‘2009-12-29’) are by default filled with NaN. If desired, we can fill in the missing values using one of several options.

For example, to backpropagate the last valid value to fill the NaN values, pass bfill as an argument to the method keyword.
Please note that the NaN value present in the original dataframe (at index value 2010-01-03) will not be filled by any of the value propagation schemes. This is because filling while reindexing does not look at dataframe values, but only compares the original and desired indexes. If you do want to fill in the NaN values present in the original dataframe, use the fillna() method.

See the user guide for more.

**pandas.Panel.reindex_axis**

Panel.reindex_axis(
    labels, axis=0, method=None, level=None, copy=True, limit=None,
    fill_value=nan
)

Conform input object to new index with optional filling logic, placing NA/Nan in locations having no value in the previous index. A new object is produced unless the new index is equivalent to the current one and copy=False

**Parameters**

labels : array-like

New labels / index to conform to. Preferably an Index object to avoid duplicating data

axis [{0, 1, 2, ‘items’, ‘major_axis’, ‘minor_axis’}]


Method to use for filling holes in reindexed DataFrame:

• default: don’t fill gaps
• pad / ffill: propagate last valid observation forward to next valid
• backfill / bfill: use next valid observation to fill gap
• nearest: use nearest valid observations to fill gap

copy : boolean, default True

Return a new object, even if the passed indexes are the same

level : int or name

Broadcast across a level, matching Index values on the passed MultiIndex level

limit : int, default None

Maximum number of consecutive elements to forward or backward fill

tolerance : optional

<table>
<thead>
<tr>
<th>Date</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-12-29</td>
<td>100</td>
</tr>
<tr>
<td>2009-12-30</td>
<td>100</td>
</tr>
<tr>
<td>2009-12-31</td>
<td>100</td>
</tr>
<tr>
<td>2010-01-01</td>
<td>100</td>
</tr>
<tr>
<td>2010-01-02</td>
<td>101</td>
</tr>
<tr>
<td>2010-01-03</td>
<td>NaN</td>
</tr>
<tr>
<td>2010-01-04</td>
<td>100</td>
</tr>
<tr>
<td>2010-01-05</td>
<td>89</td>
</tr>
<tr>
<td>2010-01-06</td>
<td>88</td>
</tr>
<tr>
<td>2010-01-07</td>
<td>NaN</td>
</tr>
</tbody>
</table>
Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations most satisfy the equation
\[ |\text{index}[\text{indexer}] - \text{target} | \leq \text{tolerance} \].

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index’s type.

New in version 0.21.0: (list-like tolerance)

Returns

reindexed [Panel]

See also:

reindex, reindex_like

Examples

```python
>>> df.reindex_axis(['A', 'B', 'C'], axis=1)
```

pandas.Panel.reindex_like

Panel.reindex_like(other=None, method=None, copy=True, limit=None, tolerance=None)
Return an object with matching indices to myself.

Parameters

other [Object]
method [string or None]
copy [boolean, default True]
limit : int, default None
    Maximum number of consecutive labels to fill for inexact matches.

tolerance : optional
    Maximum distance between labels of the other object and this object for inexact matches. Can be list-like.

New in version 0.21.0: (list-like tolerance)

Returns

reindexed [same as input]

Notes

Like calling s.reindex(index=other.index, columns=other.columns, method=...)
pandas.Panel.rename

Panel.rename(items=None, major_axis=None, minor_axis=None, **kwargs)
Alter axes input function or functions. Function / dict values must be unique (1-to-1). Labels not contained in a dict / Series will be left as-is. Extra labels listed don’t throw an error. Alternatively, change Series. name with a scalar value (Series only).

Parameters  items, major_axis, minor_axis : scalar, list-like, dict-like or function, optional
Scalar or list-like will alter the Series.name attribute, and raise on DataFrame or Panel. dict-like or functions are transformations to apply to that axis’ values

copy : boolean, default True
Also copy underlying data

inplace : boolean, default False
Whether to return a new Panel. If True then value of copy is ignored.

level : int or level name, default None
In case of a MultiIndex, only rename labels in the specified level.

Returns

renamed [Panel (new object)]

See also:
pandas.NDFrame.rename_axis

Examples

```python
>>> s = pd.Series([1, 2, 3])
>>> s
0 1
1 2
2 3
dtype: int64
>>> s.rename("my_name") # scalar, changes Series.name
0 1
1 2
2 3
Name: my_name, dtype: int64
>>> s.rename(lambda x: x ** 2) # function, changes labels
0 1
1 2
4 3
dtype: int64
>>> s.rename({1: 3, 2: 5}) # mapping, changes labels
0 1
3 2
5 3
dtype: int64
```

Since DataFrame doesn’t have a .name attribute, only mapping-type arguments are allowed.
```
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
>>> df.rename(2)
Traceback (most recent call last):
...
TypeError: 'int' object is not callable
```

DataFrame.rename supports two calling conventions

- (index=index_mapper, columns=columns_mapper, ...)
- (mapper, axis={'index', 'columns'}, ...)

We highly recommend using keyword arguments to clarify your intent.

```
>>> df.rename(index=str, columns={"A": "a", "B": "c"})
   a  c
0 1  4
1 2  5
2 3  6
```

```
>>> df.rename(index=str, columns={"A": "a", "C": "c"})
   a  B
0 1  4
1 2  5
2 3  6
```

Using axis-style parameters

```
>>> df.rename(str.lower, axis='columns')
   a  b
0 1  4
1 2  5
2 3  6
```

```
>>> df.rename({1: 2, 2: 4}, axis='index')
   A  B
0 1  4
2 2  5
4 3  6
```

See the user guide for more.

**pandas.Panel.rename_axis**

Panel.rename_axis (mapper, axis=0, copy=True, inplace=False)
Alter the name of the index or columns.

- **mapper** : scalar, list-like, optional
  Value to set as the axis name attribute.
- **axis** : {0 or ‘index’, 1 or ‘columns’}, default 0
  The index or the name of the axis.
- **copy** : boolean, default True
  Also copy underlying data.
**inplace**: boolean, default False

Modifies the object directly, instead of creating a new Series or DataFrame.

**Returns** renamed: Series, DataFrame, or None

The same type as the caller or None if inplace is True.

**See also:**

- `pandas.Series.rename` Alter Series index labels or name
- `pandas.DataFrame.rename` Alter DataFrame index labels or name
- `pandas.Index.rename` Set new names on index

**Notes**

Prior to version 0.21.0, `rename_axis` could also be used to change the axis labels by passing a mapping or scalar. This behavior is deprecated and will be removed in a future version. Use `rename` instead.

**Examples**

**Series**

```python
>>> s = pd.Series([1, 2, 3])
>>> s.rename_axis("foo")
foo
0 1
1 2
2 3
dtype: int64
```

**DataFrame**

```python
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
>>> df.rename_axis("foo")
   A  B
foo
0  1  4
1  2  5
2  3  6

>>> df.rename_axis("bar", axis="columns")
   bar  A  B
0  foo  1  4
1  1   2  5
2  2   3  6
```

**pandas.Panel.replace**

`Panel.replace(to_replace=None, value=None, inplace=False, limit=None, regex=False, method='pad')` Replace values given in to_replace with value.
Values of the NDFrame are replaced with other values dynamically. This differs from updating with `.loc` or `.iloc`, which require you to specify a location to update with some value.

**Parameters**

- **to_replace**: str, regex, list, dict, Series, int, float, or None
  
  How to find the values that will be replaced.
  
  - numeric, str or regex:
    
    - numeric: numeric values equal to `to_replace` will be replaced with `value`
    
    - str: string exactly matching `to_replace` will be replaced with `value`
    
    - regex: regexs matching `to_replace` will be replaced with `value`
  
  - list of str, regex, or numeric:
    
    - First, if `to_replace` and `value` are both lists, they **must** be the same length.
    
    - Second, if `regex=True` then all of the strings in both lists will be interpreted as regexs otherwise they will match directly. This doesn’t matter much for `value` since there are only a few possible substitution regexes you can use.
    
    - str, regex and numeric rules apply as above.
  
  - dict:
    
    - Dicts can be used to specify different replacement values for different existing values. For example, `{'a': 'b', 'y': 'z'}` replaces the value ‘a’ with ‘b’ and ‘y’ with ‘z’. To use a dict in this way the `value` parameter should be `None`.
    
    - For a DataFrame a dict can specify that different values should be replaced in different columns. For example, `{'a': 1, 'b': 'z'}` looks for the value 1 in column ‘a’ and the value ‘z’ in column ‘b’ and replaces these values with whatever is specified in `value`. The `value` parameter should not be `None` in this case. You can treat this as a special case of passing two lists except that you are specifying the column to search in.
    
    - For a DataFrame nested dictionaries, e.g., `{'a': {'b': np.nan}}`, are read as follows: look in column ‘a’ for the value ‘b’ and replace it with NaN. The `value` parameter should be `None` to use a nested dict in this way. You can nest regular expressions as well. Note that column names (the top-level dictionary keys in a nested dictionary) **cannot** be regular expressions.
    
  - None:
    
    - This means that the `regex` argument must be a string, compiled regular expression, or list, dict, ndarray or Series of such elements. If `value` is also `None` then this **must** be a nested dictionary or Series.

See the examples section for examples of each of these.

**value**: scalar, dict, list, str, regex, default None

Value to replace any values matching `to_replace` with. For a DataFrame a dict of values can be used to specify which value to use for each column (columns not in the dict will not be filled). Regular expressions, strings and lists or dicts of such objects are also allowed.

**inplace**: boolean, default False
If True, in place. Note: this will modify any other views on this object (e.g. a column from a DataFrame). Returns the caller if this is True.

**limit**: int, default None

Maximum size gap to forward or backward fill.

**regex**: bool or same types as `to_replace`, default False

Whether to interpret `to_replace` and/or `value` as regular expressions. If this is True then `to_replace must be` a string. Alternatively, this could be a regular expression or a list, dict, or array of regular expressions in which case `to_replace` must be None.

**method**: {'pad', 'ffill', 'bfill', None}

The method to use when for replacement, when `to_replace` is a scalar, list or tuple and `value` is None.

Changed in version 0.23.0: Added to DataFrame.

**Returns**: NDFrame

Object after replacement.

**Raises**: `AssertionError`

- If `regex` is not a bool and `to_replace` is not None.

**TypeError**

- If `to_replace` is a dict and `value` is not a list, dict, ndarray, or Series
- If `to_replace` is None and `regex` is not compilable into a regular expression or is a list, dict, ndarray, or Series.
- When replacing multiple bool or datetime64 objects and the arguments to `to_replace` does not match the type of the value being replaced

**ValueError**

- If a list or an ndarray is passed to `to_replace` and `value` but they are not the same length.

**See also:**

NDFrame.fillna Fill NA values

NDFrame.where Replace values based on boolean condition

Series.str.replace Simple string replacement.

**Notes**

- Regex substitution is performed under the hood with re.sub. The rules for substitution for re.sub are the same.
- Regular expressions will only substitute on strings, meaning you cannot provide, for example, a regular expression matching floating point numbers and expect the columns in your frame that have a numeric dtype to be matched. However, if those floating point numbers are strings, then you can do this.
- This method has a lot of options. You are encouraged to experiment and play with this method to gain intuition about how it works.
• When dict is used as the \texttt{to_replace} value, it is like key(s) in the dict are the to_replace part and value(s) in the dict are the value parameter.

\textbf{Examples}

\textbf{Scalar `to_replace` and `value`}

\begin{verbatim}
>>> s = pd.Series([0, 1, 2, 3, 4])
>>> s.replace(0, 5)
0  5
1  1
2  2
3  3
4  4
dtype: int64

>>> df = pd.DataFrame({'A': [0, 1, 2, 3, 4],
... 'B': [5, 6, 7, 8, 9],
... 'C': ['a', 'b', 'c', 'd', 'e']})

>>> df.replace(0, 5)
   A  B  C
0  5  5  a
1  1  6  b
2  2  7  c
3  3  8  d
4  4  9  e

>>> df.replace([0, 1, 2, 3], 4)
   A  B  C
0  4  5  a
1  4  6  b
2  4  7  c
3  4  8  d
4  4  9  e

>>> df.replace([0, 1, 2, 3], [4, 3, 2, 1])
   A  B  C
0  4  5  a
1  3  6  b
2  2  7  c
3  1  8  d
4  4  9  e

>>> s.replace([1, 2], method='bfill')
0  0
1  3
2  3
3  3
4  4
dtype: int64
\end{verbatim}

\textbf{dict-like `to_replace`}

\begin{verbatim}
34.5. Panel
\end{verbatim}
>>> df.replace({0: 10, 1: 100})
   A  B  C
0  10  5  a
1 100  6  b
2  2  7  c
3  3  8  d
4  4  9  e

>>> df.replace({'A': 0, 'B': 5}, 100)
   A  B  C
0 100 100  a
1   1  6  b
2   2  7  c
3   3  8  d
4   4  9  e

>>> df.replace({'A': {0: 100, 4: 400}})
   A  B  C
0 100  5  a
1   1  6  b
2   2  7  c
3   3  8  d
4  400  9  e

Regular expression 'to_replace'

>>> df = pd.DataFrame({'A': ['bat', 'foo', 'bait'], ...
                     'B': ['abc', 'bar', 'xyz']})

>>> df.replace(to_replace=r'^ba.$', value='new', regex=True)
   A  B
0 new abc
1   foo new
2   bait xyz

>>> df.replace({'A': r'^ba.$'}, {'A': 'new'}, regex=True)
   A  B
0 new abc
1   foo bar
2   bait xyz

>>> df.replace(regex=r'^ba.$', value='new')
   A  B
0 new abc
1   foo new
2   bait xyz

>>> df.replace(regex={r'^ba.$':'new', 'foo': 'xyz'})
   A  B
0 new abc
1   xyz new
2   bait xyz

>>> df.replace(regex=[r'^ba.$', 'foo'], value='new')
   A  B
0 new abc

(continues on next page)
Note that when replacing multiple bool or datetime64 objects, the data types in the to_replace parameter must match the data type of the value being replaced:

```python
>>> df = pd.DataFrame({'A': [True, False, True],
                    'B': [False, True, False]})
>>> df.replace({'a string': 'new value', True: False})  # raises
Traceback (most recent call last):
  ...
TypeError: Cannot compare types 'ndarray(dtype=bool)' and 'str'
```

This raises a TypeError because one of the dict keys is not of the correct type for replacement.

Compare the behavior of `s.replace({'a': None})` and `s.replace('a', None)` to understand the peculiarities of the to_replace parameter:

```python
>>> s = pd.Series([10, 'a', 'a', 'b', 'a'])

When one uses a dict as the to_replace value, it is like the value(s) in the dict are equal to the value parameter. `s.replace({'a': None})` is equivalent to `s.replace(to_replace={'a': None}, value=None, method=None):

```python
>>> s.replace({'a': None})
0 10
1 None
2 None
3 b
4 None
dtype: object
```

When value=None and to_replace is a scalar, list or tuple, replace uses the method parameter (default ‘pad’) to do the replacement. So this is why the ‘a’ values are being replaced by 10 in rows 1 and 2 and ‘b’ in row 4 in this case. The command `s.replace('a', None)` is actually equivalent to `s.replace(to_replace='a', value=None, method='pad'):

```python
>>> s.replace('a', None)
0 10
1 10
2 10
3 b
4 b
dtype: object
```

### pandas.Panel.resample

`pandas.Panel.resample`  

Panel.resample(rule, how=None, axis=0, fill_method=None, closed=None, label=None, convention='start', kind=None, offset=None, limit=None, base=0, on=None, level=None)  

Convenience method for frequency conversion and resampling of time series. Object must have a datetime-like index (DatetimeIndex, PeriodIndex, or TimedeltaIndex), or pass datetime-like values to the on or level keyword.

**Parameters**  

- **rule**: string
the offset string or object representing target conversion

**axis**  [int, optional, default 0]

**closed**  :  {'right’, ‘left’}

Which side of bin interval is closed. The default is ‘left’ for all frequency offsets except for ‘M’, ‘A’, ‘Q’, ‘BM’, ‘BA’, ‘BQ’, and ‘W’ which all have a default of ‘right’.

**label**  :  {'right’, ‘left’}

Which bin edge label to label bucket with. The default is ‘left’ for all frequency offsets except for ‘M’, ‘A’, ‘Q’, ‘BM’, ‘BA’, ‘BQ’, and ‘W’ which all have a default of ‘right’.

**convention**  :  {'start’, ‘end’, ‘s’, ‘e’}

For PeriodIndex only, controls whether to use the start or end of rule

**kind**  :  {'timestamp’, ‘period’}, optional

Pass ‘timestamp’ to convert the resulting index to a DateTimeIndex or ‘period’ to convert it to a PeriodIndex. By default the input representation is retained.

**loffset**  :  timedelta

Adjust the resampled time labels

**base**  :  int, default 0

For frequencies that evenly subdivide 1 day, the “origin” of the aggregated intervals. For example, for ‘5min’ frequency, base could range from 0 through 4. Defaults to 0

**on**  :  string, optional

For a DataFrame, column to use instead of index for resampling. Column must be datetime-like.

New in version 0.19.0.

**level**  :  string or int, optional

For a MultiIndex, level (name or number) to use for resampling. Level must be datetime-like.

New in version 0.19.0.

**Returns**

Resampler object

**See also:**

*groupby*  Group by mapping, function, label, or list of labels.

**Notes**

See the user guide for more.

To learn more about the offset strings, please see this link.
Examples

Start by creating a series with 9 one minute timestamps.

```python
>>> index = pd.date_range('1/1/2000', periods=9, freq='T')
>>> series = pd.Series(range(9), index=index)
>>> series
2000-01-01 00:00:00    0
2000-01-01 00:01:00    1
2000-01-01 00:02:00    2
2000-01-01 00:03:00    3
2000-01-01 00:04:00    4
2000-01-01 00:05:00    5
2000-01-01 00:06:00    6
2000-01-01 00:07:00    7
2000-01-01 00:08:00    8
Freq: T, dtype: int64
```

Downsample the series into 3 minute bins and sum the values of the timestamps falling into a bin.

```python
>>> series.resample('3T').sum()
2000-01-01 00:00:00    3
2000-01-01 00:03:00   12
2000-01-01 00:06:00   21
Freq: 3T, dtype: int64
```

Downsample the series into 3 minute bins as above, but label each bin using the right edge instead of the left. Please note that the value in the bucket used as the label is not included in the bucket, which it labels. For example, in the original series the bucket 2000-01-01 00:03:00 contains the value 3, but the summed value in the resampled bucket with the label 2000-01-01 00:03:00 does not include 3 (if it did, the summed value would be 6, not 3). To include this value close the right side of the bin interval as illustrated in the example below this one.

```python
>>> series.resample('3T', label='right').sum()
2000-01-01 00:03:00    3
2000-01-01 00:06:00   12
2000-01-01 00:09:00   21
Freq: 3T, dtype: int64
```

Downsample the series into 3 minute bins as above, but close the right side of the bin interval.

```python
>>> series.resample('3T', label='right', closed='right').sum()
2000-01-01 00:00:00    0
2000-01-01 00:03:00    6
2000-01-01 00:06:00   15
2000-01-01 00:09:00   15
Freq: 3T, dtype: int64
```

Upsample the series into 30 second bins.

```python
>>> series.resample('30S').asfreq()[0:5] #select first 5 rows
2000-01-01 00:00:00    0.0
2000-01-01 00:00:30   NaN
2000-01-01 00:01:00    1.0
2000-01-01 00:01:30   NaN
2000-01-01 00:02:00    2.0
Freq: 30S, dtype: float64
```
Upsample the series into 30 second bins and fill the NaN values using the pad method.

```python
>>> series.resample('30S').pad()[0:5]
2000-01-01 00:00:00 0
2000-01-01 00:00:30 0
2000-01-01 00:01:00 1
2000-01-01 00:01:30 1
2000-01-01 00:02:00 2
Freq: 30S, dtype: int64
```

Upsample the series into 30 second bins and fill the NaN values using the bfill method.

```python
>>> series.resample('30S').bfill()[0:5]
2000-01-01 00:00:00 0
2000-01-01 00:00:30 1
2000-01-01 00:01:00 1
2000-01-01 00:01:30 2
2000-01-01 00:02:00 2
Freq: 30S, dtype: int64
```

Pass a custom function via apply

```python
>>> def custom_resampler(array_like):
...     return np.sum(array_like)+5

>>> series.resample('3T').apply(custom_resampler)
2000-01-01 00:00:00 8
2000-01-01 00:03:00 17
2000-01-01 00:06:00 26
Freq: 3T, dtype: int64
```

For a Series with a PeriodIndex, the keyword `convention` can be used to control whether to use the start or end of `rule`.

```python
>>> s = pd.Series([1, 2], index=pd.period_range('2012-01-01',
                freq='A',
                periods=2))

>>> s
2012    1
2013    2
Freq: A-DEC, dtype: int64
```

Resample by month using `start` convention. Values are assigned to the first month of the period.

```python
>>> s.resample('M', convention='start').asfreq().head()
2012-01  1.0
2012-02  NaN
2012-03  NaN
2012-04  NaN
2012-05  NaN
Freq: M, dtype: float64
```

Resample by month using `end` convention. Values are assigned to the last month of the period.

```python
>>> s.resample('M', convention='end').asfreq()
2012-12  1.0
2013-01  NaN
(continues on next page)
For DataFrame objects, the keyword `on` can be used to specify the column instead of the index for resampling.

```python
>>> df = pd.DataFrame(data=9*[range(4)], columns=['a', 'b', 'c', 'd'])
>>> df['time'] = pd.date_range('1/1/2000', periods=9, freq='T')
>>> df.resample('3T', on='time').sum()
     a  b  c  d
time
2000-01-01 00:00:00 0  3  6  9
2000-01-01 00:03:00 0  3  6  9
2000-01-01 00:06:00 0  3  6  9
```

For a DataFrame with MultiIndex, the keyword `level` can be used to specify on level the resampling needs to take place.

```python
>>> time = pd.date_range('1/1/2000', periods=5, freq='T')
>>> df2 = pd.DataFrame(data=10*[range(4)],
                     columns=['a', 'b', 'c', 'd'],
                     index=pd.MultiIndex.from_product([time, [1, 2]]))
>>> df2.resample('3T', level=0).sum()
     a  b  c  d
2000-01-01 00:00:00 0  6 12 18
2000-01-01 00:03:00 0  4  8 12
```

### pandas.Panel.rfloordiv

Panel\[rfloordiv\](other, axis=0)

Integer division of series and other, element-wise (binary operator `rfloordiv`). Equivalent to `other // panel`.

**Parameters**

- **other** [DataFrame or Panel]

- **axis** : [items, major_axis, minor_axis]

  Axis to broadcast over

**Returns**

Panel

**See also:**
**Panel.floordiv**

**pandas.Panel.rmod**

Panel.rmod(other, axis=0)

Modulo of series and other, element-wise (binary operator rmod). Equivalent to other % panel.

Parameters

- other [DataFrame or Panel]
- axis : [items, major_axis, minor_axis]
  
  Axis to broadcast over

Returns

Panel

See also:

Panel.mod

**pandas.Panel.rmul**

Panel.rmul(other, axis=0)

Multiplication of series and other, element-wise (binary operator rmul). Equivalent to other * panel.

Parameters

- other [DataFrame or Panel]
- axis : [items, major_axis, minor_axis]
  
  Axis to broadcast over

Returns

Panel

See also:

Panel.mul

**pandas.Panel.round**

Panel.round(decimals=0, *args, **kwargs)

Round each value in Panel to a specified number of decimal places.

New in version 0.18.0.

Parameters decimals : int

Number of decimal places to round to (default: 0). If decimals is negative, it specifies the number of positions to the left of the decimal point.

Returns

Panel object
See also:

numpy.around

pandas.Panel.rpow

Panel.rpow(other, axis=0)

Exponential power of series and other, element-wise (binary operator rpow). Equivalent to other ** panel.

Parameters

other [DataFrame or Panel]

axis : [items, major_axis, minor_axis]

Axis to broadcast over

Returns

Panel

See also:

Panel.pow

pandas.Panel.rsub

Panel.rsub(other, axis=0)

Subtraction of series and other, element-wise (binary operator rsub). Equivalent to other - panel.

Parameters

other [DataFrame or Panel]

axis : [items, major_axis, minor_axis]

Axis to broadcast over

Returns

Panel

See also:

Panel.sub

pandas.Panel.rtruediv

Panel.rtruediv(other, axis=0)

Floating division of series and other, element-wise (binary operator rtruediv). Equivalent to other / panel.

Parameters

other [DataFrame or Panel]

axis : [items, major_axis, minor_axis]

Axis to broadcast over

Returns
Panel

See also:

Panel.truediv

pandas.Panel.sample

Panel.sample(n=None, frac=None, replace=False, weights=None, random_state=None, axis=None)

Return a random sample of items from an axis of object.

You can use random_state for reproducibility.

Parameters

n : int, optional
    Number of items from axis to return. Cannot be used with frac. Default = 1 if frac = None.

frac : float, optional
    Fraction of axis items to return. Cannot be used with n.

replace : boolean, optional
    Sample with or without replacement. Default = False.

weights : str or ndarray-like, optional
    Default ‘None’ results in equal probability weighting. If passed a Series, will align with target object on index. Index values in weights not found in sampled object will be ignored and index values in sampled object not in weights will be assigned weights of zero. If called on a DataFrame, will accept the name of a column when axis = 0. Unless weights are a Series, weights must be same length as axis being sampled. If weights do not sum to 1, they will be normalized to sum to 1. Missing values in the weights column will be treated as zero. inf and -inf values not allowed.

random_state : int or numpy.random.RandomState, optional
    Seed for the random number generator (if int), or numpy RandomState object.

axis : int or string, optional
    Axis to sample. Accepts axis number or name. Default is stat axis for given data type (0 for Series and DataFrames, 1 for Panels).

Returns

A new object of same type as caller.

Examples

Generate an example Series and DataFrame:

```python
>>> s = pd.Series(np.random.randn(50))
>>> s.head()
0   -0.038497
1    1.820773
2   -0.972766
3   -1.598270
```

(continues on next page)
Next extract a random sample from both of these objects...

3 random elements from the Series:

```python
>>> s.sample(n=3)
27 -0.994689
55 -1.049016
67 -0.224565
dtype: float64
```

And a random 10% of the DataFrame with replacement:

```python
>>> df.sample(frac=0.1, replace=True)
A  B   C   D
35 1.981780 0.142106 1.817165 -0.290805
49 -1.336199 -0.448634 -0.789640 0.217116
40 0.823173 -0.078816 1.009536 1.015108
15 1.421154 -0.055301 -1.922594 -0.019696
 6 -0.148339 0.832938 1.787600 -1.383767
```

You can use random state for reproducibility:

```python
>>> df.sample(random_state=1)
A  B   C   D
37 -2.027662 0.103611 0.237496 -0.165867
43 -0.259323 -0.583426 1.516140 -0.479118
12 -1.686325 -0.579510 0.985195 -0.460286
 8 1.167946 0.429082 1.215742 -1.636041
 9 1.197475 -0.864188 1.554031 -1.505264
```

**pandas.Panel.select**

Panel.select(crit, axis=0)

Return data corresponding to axis labels matching criteria

Deprecated since version 0.21.0: Use df.loc[df.index.map(crit)] to select via labels

Parameters

- **crit**: function
  To be called on each index (label). Should return True or False
  
- **axis**: int

Returns

- **selection**: type of caller
pandas.Panel.sem

Panel.sem(axis=None, skipna=None, level=None, ddof=1, numeric_only=None, **kwargs)

Return unbiased standard error of the mean over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument

Parameters

- **axis**
  - [items (0), major_axis (1), minor_axis (2)]
- **skipna**
  - boolean, default True
  - Exclude NA/null values. If an entire row/column is NA, the result will be NA
- **level**
  - int or level name, default None
  - If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame
- **ddof**
  - int, default 1
  - Delta Degrees of Freedom. The divisor used in calculations is N - ddof, where N represents the number of elements.
- **numeric_only**
  - boolean, default None
  - Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns

- sem [DataFrame or Panel (if level specified)]

pandas.Panel.set_axis

Panel.set_axis(labels, axis=0, inplace=None)

Assign desired index to given axis.

Indexes for column or row labels can be changed by assigning a list-like or Index.

Changed in version 0.21.0: The signature is now labels and axis, consistent with the rest of pandas API. Previously, the axis and labels arguments were respectively the first and second positional arguments.

Parameters

- **labels**
  - list-like, Index
  - The values for the new index.
- **axis**
  - [0 or ‘index’, 1 or ‘columns’], default 0
  - The axis to update. The value 0 identifies the rows, and 1 identifies the columns.
- **inplace**
  - boolean, default None
  - Whether to return a new %(klass)s instance.

Warning: inplace=None currently falls back to True, but in a future version, will default to False. Use inplace=True explicitly rather than relying on the default.

Returns

- renamed : %(klass)s or None
An object of same type as caller if inplace=False, None otherwise.

See also:

\textit{pandas.DataFrame.rename_axis} Alter the name of the index or columns.

\textbf{Examples}

\textbf{Series}

```python
>>> s = pd.Series([1, 2, 3])
>>> s
0    1
1    2
2    3
dtype: int64

>>> s.set_axis([‘a’, ‘b’, ‘c’], axis=0, inplace=False)
da 1
b 2
c 3
dtype: int64
```

The original object is not modified.

```python
>>> s
0    1
1    2
2    3
dtype: int64
```

\textbf{DataFrame}

```python
>>> df = pd.DataFrame({"A": [1, 2, 3], "B": [4, 5, 6]})
```

Change the row labels.

```python
>>> df.set_axis([‘a’, ‘b’, ‘c’], axis=’index’, inplace=False)
     A  B
 a  1  4
 b  2  5
 c  3  6
```

Change the column labels.

```python
>>> df.set_axis([‘I’, ‘II’], axis=’columns’, inplace=False)
     I  II
  0  1  4
  1  2  5
  2  3  6
```

Now, update the labels inplace.

```python
>>> df.set_axis([‘i’, ‘ii’], axis=’columns’, inplace=True)
>>> df
   i  ii
0  1  4
1  2  5
2  3  6
```
pandas.Panel.set_value

Panel.set_value(*args, **kwargs)

Quickly set single value at (item, major, minor) location

Deprecated since version 0.21.0.

Please use .at[] or .iat[] accessors.

Parameters

item [item label (panel item)]

major [major axis label (panel item row)]

minor [minor axis label (panel item column)]

value [scalar]

takeable [interpret the passed labels as indexers, default False]

Returns panel : Panel

If label combo is contained, will be reference to calling Panel, otherwise a new object

pandas.Panel.shift

Panel.shift(periods=1, freq=None, axis='major')

Shift index by desired number of periods with an optional time freq. The shifted data will not include the dropped periods and the shifted axis will be smaller than the original. This is different from the behavior of DataFrame.shift()

Parameters periods : int

Number of periods to move, can be positive or negative

freq [DateOffset, timedelta, or time rule string, optional]

axis [{‘items’, ‘major’, ‘minor’} or {0, 1, 2}]

Returns

shifted [Panel]

pandas.Panel.skew

Panel.skew(axis=None, skipna=None, level=None, numeric_only=None, **kwargs)

Return unbiased skew over requested axis Normalized by N-1

Parameters

axis [{items (0), major_axis (1), minor_axis (2)}]
skipna : boolean, default True
    Exclude NA/null values when computing the result.

level : int or level name, default None
    If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing
    into a DataFrame

numeric_only : boolean, default None
    Include only float, int, boolean columns. If None, will attempt to use everything,
    then use only numeric data. Not implemented for Series.

Returns

    skew [DataFrame or Panel (if level specified)]

pandas.Panel.slice_shift

Panel.slice_shift (periods=1, axis=0)
    Equivalent to shift without copying data. The shifted data will not include the dropped
    periods and the shifted axis will be smaller than the original.

Parameters periods : int
    Number of periods to move, can be positive or negative

Returns

    shifted [same type as caller]

Notes

While the slice_shift is faster than shift, you may pay for it later during alignment.

pandas.Panel.sort_index

Panel.sort_index (axis=0, level=None, ascending=True, inplace=False, kind='quicksort',
na_position='last', sort_remaining=True)
    Sort object by labels (along an axis)

Parameters

    axis [axes to direct sorting]
    level : int or level name or list of ints or list of level names
        if not None, sort on values in specified index level(s)
    ascending : boolean, default True
        Sort ascending vs. descending
    inplace : bool, default False
        if True, perform operation in-place
    kind : {'quicksort', 'mergesort', 'heapsort'}, default 'quicksort'
Choice of sorting algorithm. See also ndarray.sort for more information. 
mergesort is the only stable algorithm. For DataFrames, this option is only applied when sorting on a single column or label.

na_position : {'first', 'last'}, default 'last'

first puts NaNs at the beginning, last puts NaNs at the end. Not implemented for MultiIndex.

sort_remaining : bool, default True

if true and sorting by level and index is multilevel, sort by other levels too (in order) after sorting by specified level

Returns

sorted_obj [NDFrame]

pandas.Panel.sort_values

Panel.sort_values(by=None, axis=0, ascending=True, inplace=False, kind='quicksort', na_position='last')

NOT IMPLEMENTED: do not call this method, as sorting values is not supported for Panel objects and will raise an error.

pandas.Panel.squeeze

Panel.squeeze(axis=None)

Squeeze length 1 dimensions.

Parameters axis : None, integer or string axis name, optional

The axis to squeeze if 1-sized.

New in version 0.20.0.

Returns

scalar if 1-sized, else original object

pandas.Panel.std

Panel.std(axis=None, skipna=None, level=None, ddof=1, numeric_only=None, **kwargs)

Return sample standard deviation over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument

Parameters

axis [{items (0), major_axis (1), minor_axis (2)}]

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

ddof : int, default 1
Delta Degrees of Freedom. The divisor used in calculations is N - ddof, where N represents the number of elements.

**numeric_only**: boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

**std** [DataFrame or Panel (if level specified)]

### pandas.Panel.sub

**Panel.sub** *(other, axis=0)*

Subtraction of series and other, element-wise (binary operator sub). Equivalent to panel - other.

**Parameters**

- **other** [DataFrame or Panel]
- **axis** : [items, major_axis, minor_axis]
  
  Axis to broadcast over

**Returns**

Panel

**See also:**

*Panel.rsub*

### pandas.Panel.subtract

**Panel.subtract** *(other, axis=0)*

Subtraction of series and other, element-wise (binary operator sub). Equivalent to panel - other.

**Parameters**

- **other** [DataFrame or Panel]
- **axis** : [items, major_axis, minor_axis]
  
  Axis to broadcast over

**Returns**

Panel

**See also:**

*Panel.rsub*

### pandas.Panel.sum

**Panel.sum** *(axis=None, skipna=None, level=None, numeric_only=None, min_count=0, **kwargs)*

Return the sum of the values for the requested axis

**Parameters**

- **axis** [[items (0), major_axis (1), minor_axis (2)]]
skipna : boolean, default True

Exclude NA/null values when computing the result.

level : int or level name, default None

If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame

numeric_only : boolean, default None

Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

min_count : int, default 0

The required number of valid values to perform the operation. If fewer than min_count non-NA values are present the result will be NA.

New in version 0.22.0: Added with the default being 0. This means the sum of an all-NA or empty Series is 0, and the product of an all-NA or empty Series is 1.

Returns

sum [DataFrame or Panel (if level specified)]

Examples

By default, the sum of an empty or all-NA Series is 0.

```python
>>> pd.Series([]).sum()  # min_count=0 is the default
0.0
```

This can be controlled with the min_count parameter. For example, if you’d like the sum of an empty series to be NaN, pass min_count=1.

```python
>>> pd.Series([]).sum(min_count=1)
nan
```

Thanks to the skipna parameter, min_count handles all-NA and empty series identically.

```python
>>> pd.Series([np.nan]).sum()
0.0
```

```python
>>> pd.Series([np.nan]).sum(min_count=1)
nan
```

pandas.Panel.swapaxes

Panel.swapaxes (axis1, axis2, copy=True)

Interchange axes and swap values axes appropriately

Returns

y [same as input]
pandas.Panel.swaplevel

Panel.swaplevel(i=-2, j=-1, axis=0)
Swap levels i and j in a MultiIndex on a particular axis

Parameters i, j: int, string (can be mixed)
Level of index to be swapped. Can pass level name as string.

Returns

swapped [type of caller (new object)]
.. versionchanged:: 0.18.1
The indexes i and j are now optional, and default to the two innermost levels of the index.

pandas.Panel.tail

Panel.tail(n=5)
Return the last n rows.

This function returns last n rows from the object based on position. It is useful for quickly verifying data, for example, after sorting or appending rows.

Parameters n: int, default 5
Number of rows to select.

Returns type of caller
The last n rows of the caller object.

See also:
pandas.DataFrame.head The first n rows of the caller object.

Examples

```python
>>> df = pd.DataFrame({'animal': ['alligator', 'bee', 'falcon', 'lion',
... 'monkey', 'parrot', 'shark', 'whale', 'zebra']})
>>> df
   animal
0  alligator
1     bee
2   falcon
3     lion
4   monkey
5   parrot
6     shark
7    whale
8    zebra
```

Viewing the last 5 lines
>>> df.tail()
    animal
4    monkey
5    parrot
6    shark
7    whale
8    zebra

Viewing the last $n$ lines (three in this case)

>>> df.tail(3)
    animal
6    shark
7    whale
8    zebra

pandas.Panel.take

Panel.take(indices, axis=0, convert=None, is_copy=True, **kwargs)

Return the elements in the given positional indices along an axis.

This means that we are not indexing according to actual values in the index attribute of the object. We are indexing according to the actual position of the element in the object.

**Parameters**

 indices : array-like
    An array of ints indicating which positions to take.

 axis : {0 or 'index', 1 or 'columns', None}, default 0
    The axis on which to select elements. 0 means that we are selecting rows, 1 means that we are selecting columns.

 convert : bool, default True
    Whether to convert negative indices into positive ones. For example, −1 would map to the len(axis) − 1. The conversions are similar to the behavior of indexing a regular Python list.

    Deprecated since version 0.21.0: In the future, negative indices will always be converted.

 is_copy : bool, default True
    Whether to return a copy of the original object or not.

 **kwargs
    For compatibility with numpy.take(). Has no effect on the output.

**Returns**

taken : type of caller
    An array-like containing the elements taken from the object.

See also:

DataFrame.loc Select a subset of a DataFrame by labels.

DataFrame.iloc Select a subset of a DataFrame by positions.

numpy.take Take elements from an array along an axis.
Examples

```python
>>> df = pd.DataFrame([('falcon', 'bird', 389.0),
...                   ('parrot', 'bird', 24.0),
...                   ('lion', 'mammal', 80.5),
...                   ('monkey', 'mammal', np.nan)],
...                   columns=['name', 'class', 'max_speed'],
...                   index=[0, 2, 3, 1])
```

<table>
<thead>
<tr>
<th>name</th>
<th>class</th>
<th>max_speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>falcon</td>
<td>bird</td>
<td>389.0</td>
</tr>
<tr>
<td>parrot</td>
<td>bird</td>
<td>24.0</td>
</tr>
<tr>
<td>lion</td>
<td>mammal</td>
<td>80.5</td>
</tr>
<tr>
<td>monkey</td>
<td>mammal</td>
<td>NaN</td>
</tr>
</tbody>
</table>

Take elements at positions 0 and 3 along the axis 0 (default).

Note how the actual indices selected (0 and 1) do not correspond to our selected indices 0 and 3. That's because we are selecting the 0th and 3rd rows, not rows whose indices equal 0 and 3.

```python
>>> df.take([0, 3])
```

<table>
<thead>
<tr>
<th>name</th>
<th>class</th>
<th>max_speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>falcon</td>
<td>bird</td>
<td>389.0</td>
</tr>
<tr>
<td>monkey</td>
<td>mammal</td>
<td>NaN</td>
</tr>
</tbody>
</table>

Take elements at indices 1 and 2 along the axis 1 (column selection).

```python
>>> df.take([1, 2], axis=1)
```

<table>
<thead>
<tr>
<th>class</th>
<th>max_speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>bird</td>
<td>389.0</td>
</tr>
<tr>
<td>bird</td>
<td>24.0</td>
</tr>
<tr>
<td>mammal</td>
<td>80.5</td>
</tr>
<tr>
<td>mammal</td>
<td>NaN</td>
</tr>
</tbody>
</table>

We may take elements using negative integers for positive indices, starting from the end of the object, just like with Python lists.

```python
>>> df.take([-1, -2])
```

<table>
<thead>
<tr>
<th>name</th>
<th>class</th>
<th>max_speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>monkey</td>
<td>mammal</td>
<td>NaN</td>
</tr>
<tr>
<td>lion</td>
<td>mammal</td>
<td>80.5</td>
</tr>
</tbody>
</table>

---

pandas.Panel.to_clipboard

Panel.to_clipboard(excel=True, sep=None, **kwargs)
Copy object to the system clipboard.

Write a text representation of object to the system clipboard. This can be pasted into Excel, for example.

**Parameters**

- **excel** : bool, default True
  - True, use the provided separator, writing in a csv format for allowing easy pasting into excel.
  - False, write a string representation of the object to the clipboard.

- **sep** : str, default '\t'
Field delimiter.

**kwargs

These parameters will be passed to DataFrame.to_csv.

See also:

**DataFrame.to_csv** Write a DataFrame to a comma-separated values (csv) file.

**read_clipboard** Read text from clipboard and pass to read_table.

See also:

**DataFrame.to_csv** Write a DataFrame to a comma-separated values (csv) file.

**read_clipboard** Read text from clipboard and pass to read_table.

Notes

Requirements for your platform.

- **Linux**: xclip, or xsel (with gtk or PyQt4 modules)
- **Windows**: none
- **OS X**: none

Examples

Copy the contents of a DataFrame to the clipboard.

```python
>>> df = pd.DataFrame([[1, 2, 3], [4, 5, 6]], columns=['A', 'B', 'C'])
>>> df.to_clipboard(sep=',')
... # Wrote the following to the system clipboard:
... # ,A,B,C
... # 0,1,2,3
... # 1,4,5,6
```

We can omit the index by passing the keyword `index` and setting it to false.

```python
>>> df.to_clipboard(sep=',', index=False)
... # Wrote the following to the system clipboard:
... # A,B,C
... # 1,2,3
... # 4,5,6
```

pandas.Panel.to_dense

**Panel.to_dense**

Return dense representation of NDFrame (as opposed to sparse)

pandas.Panel.to_excel

**Panel.to_excel** *(path, na_rep='', engine=None, **kwargs)*

Write each DataFrame in Panel to a separate excel sheet

Parameters

- **path** : string or ExcelWriter object
  File path or existing ExcelWriter
- **na_rep** : string, default ‘’
Missing data representation

**engine** : string, default None

write engine to use - you can also set this via the options `io.excel.xlsx.writer`, `io.excel.xls.writer`, and `io.excel.xlsm.writer`.

**Other Parameters**

**float_format** : string, default None

Format string for floating point numbers

**cols** : sequence, optional

Columns to write

**header** : boolean or list of string, default True

Write out column names. If a list of string is given it is assumed to be aliases for the column names

**index** : boolean, default True

Write row names (index)

**index_label** : string or sequence, default None

Column label for index column(s) if desired. If None is given, and `header` and `index` are True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.

**startrow** [upper left cell row to dump data frame]

**startcol** [upper left cell column to dump data frame]

**Notes**

Keyword arguments (and `na_rep`) are passed to the `to_excel` method for each DataFrame written.

**pandas.Panel.to_frame**

Panel.to_frame(*filter_observations=True*)

Transform wide format into long (stacked) format as DataFrame whose columns are the Panel’s items and whose index is a MultiIndex formed of the Panel’s major and minor axes.

**Parameters**

**filter_observations** : boolean, default True

Drop (major, minor) pairs without a complete set of observations across all the items

**Returns**

y [DataFrame]

**pandas.Panel.to_hdf**

Panel.to_hdf(*path_or_buf, key, **kwargs*)

Write the contained data to an HDF5 file using HDFStore.
Hierarchical Data Format (HDF) is self-describing, allowing an application to interpret the structure and contents of a file with no outside information. One HDF file can hold a mix of related objects which can be accessed as a group or as individual objects.

In order to add another DataFrame or Series to an existing HDF file please use append mode and a different key.

For more information see the user guide.

**Parameters**

- **path_or_buf**: str or pandas.HDFStore
  - File path or HDFStore object.
- **key**: str
  - Identifier for the group in the store.
- **mode**: {'a', 'w', 'r+'}, default ‘a’
  - Mode to open file:
    - ‘w’: write, a new file is created (an existing file with the same name would be deleted).
    - ‘a’: append, an existing file is opened for reading and writing, and if the file does not exist it is created.
    - ‘r+’: similar to ‘a’, but the file must already exist.
- **format**: {'fixed', 'table'}, default ‘fixed’
  - Possible values:
    - ‘table’: Table format. Write as a PyTables Table structure which may perform worse but allow more flexible operations like searching / selecting subsets of the data.
- **append**: bool, default False
  - For Table formats, append the input data to the existing.
- **data_columns**: list of columns or True, optional
  - List of columns to create as indexed data columns for on-disk queries, or True to use all columns. By default only the axes of the object are indexed. See Query via Data Columns. Applicable only to format='table'.
- **complevel**: {0-9}, optional
  - Specifies a compression level for data. A value of 0 disables compression.
- **complib**: {'zlib', 'lz4', 'bzip2', 'blosc'}, default ‘zlib’
  - Specifies the compression library to be used. As of v0.20.2 these additional compressors for Blosc are supported (default if no compressor specified: ‘blosc:blosclz’): {'blosc:blosclz', 'blosc:lz4', 'blosc:lz4hc', 'blosc:snappy', 'blosc:zlib', 'blosc:zstd'}. Specifying a compression library which is not available issues a ValueError.
- **fletcher32**: bool, default False
  - If applying compression use the fletcher32 checksum.
- **dropna**: bool, default False
If true, ALL nan rows will not be written to store.

**errors**: str, default ‘strict’

Specifies how encoding and decoding errors are to be handled. See the errors argument for `open()` for a full list of options.

**See also:**

- `DataFrame.read_hdf` Read from HDF file.
- `DataFrame.to_parquet` Write a DataFrame to the binary parquet format.
- `DataFrame.to_sql` Write to a sql table.
- `DataFrame.to_feather` Write out feather-format for DataFrames.
- `DataFrame.to_csv` Write out to a csv file.

**Examples**

```python
>>> df = pd.DataFrame({'A': [1, 2, 3], 'B': [4, 5, 6]},
                    index=['a', 'b', 'c'])
>>> df.to_hdf('data.h5', key='df', mode='w')

We can add another object to the same file:

```python
>>> s = pd.Series([1, 2, 3, 4])
>>> s.to_hdf('data.h5', key='s')
```

Reading from HDF file:

```python
>>> pd.read_hdf('data.h5', 'df')
A    B
a  1  4
b  2  5
c  3  6

>>> pd.read_hdf('data.h5', 's')
0  1
1  2
2  3
3  4
dtype: int64
```

Deleting file with data:

```python
>>> import os
>>> os.remove('data.h5')
```

**pandas.Panel.to_json**

`Panel.to_json(path_or_buf=None, orient=None, date_format=None, double_precision=10, force_ascii=True, date_unit='ms', default_handler=None, lines=False, compression=None, index=True)`

Convert the object to a JSON string.

Note NaN’s and None will be converted to null and datetime objects will be converted to UNIX timestamps.
Parameters `path_or_buf` : string or file handle, optional

File path or object. If not specified, the result is returned as a string.

orient : string

Indication of expected JSON string format.

- Series
  - default is ‘index’
  - allowed values are: {‘split’,‘records’,‘index’}
- DataFrame
  - default is ‘columns’
  - allowed values are: {‘split’,‘records’,‘index’,‘columns’,‘values’}
- The format of the JSON string
  - ‘split’ : dict like {‘index’ -> [index], ‘columns’ -> [columns], ‘data’ -> [values]}
  - ‘records’ : list like [{column -> value}, . . . , {column -> value}]
  - ‘index’ : dict like {index -> {column -> value}}
  - ‘columns’ : dict like {column -> {index -> value}}
  - ‘values’ : just the values array
  - ‘table’ : dict like {‘schema’: {schema}, ‘data’: {data}} describing the data, and the data component is like orient=‘records’.

Changed in version 0.20.0.

date_format : {None, ‘epoch’, ‘iso’}

Type of date conversion. ‘epoch’ = epoch milliseconds, ‘iso’ = ISO8601. The default depends on the orient. For orient=’table’, the default is ‘iso’. For all other orients, the default is ‘epoch’.

double_precision : int, default 10

The number of decimal places to use when encoding floating point values.

force_ascii : boolean, default True

Force encoded string to be ASCII.

date_unit : string, default ‘ms’ (milliseconds)

The time unit to encode to, governs timestamp and ISO8601 precision. One of ‘s’, ‘ms’, ‘us’, ‘ns’ for second, millisecond, microsecond, and nanosecond respectively.

default_handler : callable, default None

Handler to call if object cannot otherwise be converted to a suitable format for JSON. Should receive a single argument which is the object to convert and return a serialisable object.

lines : boolean, default False
pandas: powerful Python data analysis toolkit, Release 0.23.2

If ‘orient’ is ‘records’ write out line delimited json format. Will throw ValueError
if incorrect ‘orient’ since others are not list like.
New in version 0.19.0.
A string representing the compression to use in the output file, only used when
the first argument is a filename.
New in version 0.21.0.
index : boolean, default True
Whether to include the index values in the JSON string. Not including the index
(index=False) is only supported when orient is ‘split’ or ‘table’.
New in version 0.23.0.
See also:
pandas.read_json
Examples
>>> df = pd.DataFrame([['a', 'b'], ['c', 'd']],
...
index=['row 1', 'row 2'],
...
columns=['col 1', 'col 2'])
>>> df.to_json(orient='split')
'{"columns":["col 1","col 2"],
"index":["row 1","row 2"],
"data":[["a","b"],["c","d"]]}'

Encoding/decoding a Dataframe using 'records' formatted JSON. Note that index labels are not preserved with this encoding.
>>> df.to_json(orient='records')
'[{"col 1":"a","col 2":"b"},{"col 1":"c","col 2":"d"}]'

Encoding/decoding a Dataframe using 'index' formatted JSON:
>>> df.to_json(orient='index')
'{"row 1":{"col 1":"a","col 2":"b"},"row 2":{"col 1":"c","col 2":"d"}}'

Encoding/decoding a Dataframe using 'columns' formatted JSON:
>>> df.to_json(orient='columns')
'{"col 1":{"row 1":"a","row 2":"c"},"col 2":{"row 1":"b","row 2":"d"}}'

Encoding/decoding a Dataframe using 'values' formatted JSON:
>>> df.to_json(orient='values')
'[["a","b"],["c","d"]]'

Encoding with Table Schema
>>> df.to_json(orient='table')
'{"schema": {"fields": [{"name": "index", "type": "string"},
{"name": "col 1", "type": "string"},
(continues on next page)

34.5. Panel

2081


pandas.Panel.to_latex

Panel.to_latex(buf=None, columns=None, col_space=None, header=True, index=True, na_rep='NaN', formatters=None, float_format=None, sparsify=None, index_names=True, bold_rows=False, column_format=None, longtable=None, escape=None, encoding=None, decimal='.', multicolumn=True, multicolumn_format='l', multirow=False)

Render an object to a tabular environment table. You can splice this into a LaTeX document. Requires \usepackage{booktabs}.

Changed in version 0.20.2: Added to Series
to_latex-specific options:

**bold_rows** [boolean, default False] Make the row labels bold in the output

**column_format** [str, default None] The columns format as specified in LaTeX table format e.g 'rcl' for 3 columns

**longtable** [boolean, default will be read from the pandas config module] Default: False. Use a longtable environment instead of tabular. Requires adding a \usepackage{longtable} to your LaTeX preamble.

**escape** [boolean, default will be read from the pandas config module] Default: True. When set to False prevents from escaping latex special characters in column names.

**encoding** [str, default None] A string representing the encoding to use in the output file, defaults to ‘ascii’ on Python 2 and ‘utf-8’ on Python 3.

**decimal** [string, default ‘.’] Character recognized as decimal separator, e.g. ‘,’ in Europe.

New in version 0.18.0.

**multicolumn** [boolean, default True] Use multicolumn to enhance MultiIndex columns. The default will be read from the config module.

New in version 0.20.0.

**multicolumn_format** [str, default ‘l’] The alignment for multicolumns, similar to column_format. The default will be read from the config module.

New in version 0.20.0.

**multirow** [boolean, default False] Use multirow to enhance MultiIndex rows. Requires adding a \usepackage{multirow} to your LaTeX preamble. Will print centered labels (instead of top-aligned) across the contained rows, separating groups via clines. The default will be read from the pandas config module.

New in version 0.20.0.
**pandas.Panel.to_msgpack**

```
pandas.Panel.to_msgpack(path_or_buf=None, encoding='utf-8', **kwargs)
```

msgpack (serialize) object to input file path

THIS IS AN EXPERIMENTAL LIBRARY and the storage format may not be stable until a future release.

**Parameters**

- `path` : string
  File path, buffer-like, or None
  if None, return generated string

- `append` : boolean
  whether to append to an existing msgpack
  (default is False)

- `compress` : type of compressor (zlib or blosc), default to None (no compression)

**pandas.Panel.to_pickle**

```
pandas.Panel.to_pickle(path, compression='infer', protocol=4)
```

Pickle (serialize) object to file.

**Parameters**

- `path` : str
  File path where the pickled object will be stored.

- `compression` : {'infer', 'gzip', 'bz2', 'zip', 'xz', None}, default 'infer'
  A string representing the compression to use in the output file. By default, infers from the file extension in specified path.
  New in version 0.20.0.

- `protocol` : int
  Int which indicates which protocol should be used by the pickler, default HIGHEST_PROTOCOL (see [R21] paragraph 12.1.2). The possible values for this parameter depend on the version of Python. For Python 2.x, possible values are 0, 1, 2. For Python>=3.0, 3 is a valid value. For Python >= 3.4, 4 is a valid value. A negative value for the protocol parameter is equivalent to setting its value to HIGHEST_PROTOCOL.
  New in version 0.21.0.

**See also:**

- `read_pickle` Load pickled pandas object (or any object) from file.
- `DataFrame.to_hdf` Write DataFrame to an HDF5 file.
- `DataFrame.to_sql` Write DataFrame to a SQL database.
- `DataFrame.to_parquet` Write a DataFrame to the binary parquet format.

**Examples**
>>> original_df = pd.DataFrame({"foo": range(5), "bar": range(5, 10)})
>>> original_df
  foo  bar
0 0  5
1 1  6
2 2  7
3 3  8
4 4  9
>>> original_df.to_pickle("./dummy.pkl")

>>> unpickled_df = pd.read_pickle("./dummy.pkl")
>>> unpickled_df
  foo  bar
0 0  5
1 1  6
2 2  7
3 3  8
4 4  9

>>> import os
>>> os.remove("./dummy.pkl")

pandas.Panel.to_sparse

Panel.to_sparse(*args, **kwargs)

  NOT IMPLEMENTED: do not call this method, as sparsifying is not supported for Panel objects and will raise an error.

  Convert to SparsePanel

pandas.Panel.to_sql

Panel.to_sql(name, con, schema=None, if_exists='fail', index=True, index_label=None, chunksize=None, dtype=None)

Write records stored in a DataFrame to a SQL database.

Databases supported by SQLAlchemy [R22] are supported. Tables can be newly created, appended to, or overwritten.

Parameters

  name : string
    Name of SQL table.

  con : sqlalchemy.engine.Engine or sqlite3.Connection
    Using SQLAlchemy makes it possible to use any DB supported by that library. Legacy support is provided for sqlite3.Connection objects.

  schema : string, optional
    Specify the schema (if database flavor supports this). If None, use default schema.

  if_exists : {‘fail’, ‘replace’, ‘append’}, default ‘fail’
    How to behave if the table already exists.
    + fail: Raise a ValueError.
• replace: Drop the table before inserting new values.
• append: Insert new values to the existing table.

**index**: boolean, default True

Write DataFrame index as a column. Uses `index_label` as the column name in the table.

**index_label**: string or sequence, default None

Column label for index column(s). If None is given (default) and `index` is True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.

**chunksize**: int, optional

Rows will be written in batches of this size at a time. By default, all rows will be written at once.

**dtype**: dict, optional

Specifying the datatype for columns. The keys should be the column names and the values should be the SQLAlchemy types or strings for the sqlite3 legacy mode.

**Raises ValueError**

When the table already exists and `if_exists` is 'fail' (the default).

**See also:**

`pandas.read_sql` read a DataFrame from a table

**References**

[R22], [R23]

**Examples**

Create an in-memory SQLite database.

```python
>>> from sqlalchemy import create_engine
>>> engine = create_engine('sqlite://', echo=False)
```

Create a table from scratch with 3 rows.

```python
>>> df = pd.DataFrame({'name': ['User 1', 'User 2', 'User 3']})
>>> df
   name
0  User 1
1  User 2
2  User 3

>>> df.to_sql('users', con=engine)
>>> engine.execute("SELECT * FROM users").fetchall()[(0, 'User 1'), (1, 'User 2'), (2, 'User 3')]
```
Overwrite the table with just df1.

```python
>>> df1.to_sql('users', con=engine, if_exists='replace',
             index_label='id')
```
>>> df
   A   B   C
0  1  foo  4.0
1  1  bar  5.0
2  2  foo  6.0

>>> df.to_xarray()
<xarray.Dataset>
Dimensions: (index: 3)
Coordinates:
  * index (index) int64 0 1 2
Data variables:
  A (index) int64 1 1 2
  B (index) object 'foo' 'bar' 'foo'
  C (index) float64 4.0 5.0 6.0

>>> df = pd.DataFrame({'A': [1, 1, 2],
                    'B': ['foo', 'bar', 'foo'],
                    'C': np.arange(4., 7)})
                     ).set_index(['B', 'A'])

>>> df
   A   B   C
foo 1  4.0
bar 1  5.0
foo 2  6.0

>>> df.to_xarray()
<xarray.Dataset>
Dimensions: (A: 2, B: 2)
Coordinates:
  * B (B) object 'bar' 'foo'
  * A (A) int64 1 2
Data variables:
  C (B, A) float64 5.0 nan 4.0 6.0

>>> p = pd.Panel(np.arange(24).reshape(4,3,2),
               items=list('ABCD'),
               major_axis=pd.date_range('20130101', periods=3),
               minor_axis=['first', 'second'])

>>> p
<class 'pandas.core.panel.Panel'>
Dimensions: 4 (items) x 3 (major_axis) x 2 (minor_axis)
Items axis: A to D
Major_axis axis: 2013-01-01 00:00:00 to 2013-01-03 00:00:00
Minor_axis axis: first to second

>>> p.to_xarray()
<xarray.DataArray (items: 4, major_axis: 3, minor_axis: 2)>
array([[[ 0, 1],
        [ 2, 3],
        [ 4, 5]],
       [[ 6, 7],
        [ 8, 9],
        [10, 11]],
       [[12, 13],
        [14, 15],
        [16, 17]],
       [[18, 19],
        [20, 21],
        [22, 23]]])

(continues on next page)
Coordinates:
* items (items) object 'A' 'B' 'C' 'D'
* major_axis (major_axis) datetime64[ns] 2013-01-01 2013-01-02 2013-01-03
* minor_axis (minor_axis) object 'first' 'second'

pandas.Panel.transpose

Panel.transpose(*args, **kwargs)

Permute the dimensions of the Panel

Parameters

args [three positional arguments: each one of]
{0, 1, 2, 'items', 'major_axis', 'minor_axis'}

copy [boolean, default False] Make a copy of the underlying data. Mixed-dtype
data will always result in a copy

Returns

y [same as input]

Examples

```python
>>> p.transpose(2, 0, 1)
```

pandas.Panel.truediv

Panel.truediv(other, axis=0)

Floating division of series and other, element-wise (binary operator truediv). Equivalent to panel / other.

Parameters

other [DataFrame or Panel]

axis : {items, major_axis, minor_axis}

Axis to broadcast over

Returns

Panel
See also:

*Panel.rtruediv*

**pandas.Panel.truncate**

Panel.truncate(before=None, after=None, axis=None, copy=True)

Truncate a Series or DataFrame before and after some index value.

This is a useful shorthand for boolean indexing based on index values above or below certain thresholds.

**Parameters**

*before*: date, string, int

Truncate all rows before this index value.

*after*: date, string, int

Truncate all rows after this index value.

*axis*: {0 or 'index', 1 or 'columns'}, optional

Axis to truncate. Truncates the index (rows) by default.

*copy*: boolean, default is True,

Return a copy of the truncated section.

**Returns**

*type of caller*

The truncated Series or DataFrame.

See also:

*DataFrame.loc* Select a subset of a DataFrame by label.

*DataFrame.iloc* Select a subset of a DataFrame by position.

**Notes**

If the index being truncated contains only datetime values, *before* and *after* may be specified as strings instead of Timestamps.

**Examples**

```python
>>> df = pd.DataFrame({'A': ['a', 'b', 'c', 'd', 'e'],
                      'B': ['f', 'g', 'h', 'i', 'j'],
                      'C': ['k', 'l', 'm', 'n', 'o']},
                      index=[1, 2, 3, 4, 5])
>>> df
   A  B  C
1  a  f  k
2  b  g  l
3  c  h  m
4  d  i  n
5  e  j  o
```
The columns of a DataFrame can be truncated.

```
>>> df.truncate(before="A", after="B", axis="columns")
   A   B
  0  a  f
  1  b  g
  2  c  h
  3  d  i
  4  e  j

For Series, only rows can be truncated.

```
```python
>>> df['A'].truncate(before=2, after=4)
2    b
3    c
4    d
Name: A, dtype: object
```

The index values in `truncate` can be datetimes or string dates.

```
>>> dates = pd.date_range('2016-01-01', '2016-02-01', freq='s')
>>> df = pd.DataFrame(index=dates, data={'A': 1})
>>> df.tail()
              A
2016-01-31  23:59:56  1
2016-01-31  23:59:57  1
2016-01-31  23:59:58  1
2016-01-31  23:59:59  1
2016-02-01  00:00:00  1
```

```
>>> df.truncate(before=pd.Timestamp('2016-01-05'),
... after=pd.Timestamp('2016-01-10')).tail()
              A
2016-01-09  23:59:56  1
2016-01-09  23:59:57  1
2016-01-09  23:59:58  1
2016-01-09  23:59:59  1
2016-01-10  00:00:00  1
```

Because the index is a DatetimeIndex containing only dates, we can specify `before` and `after` as strings. They will be coerced to Timestamps before truncation.

```
>>> df.truncate('2016-01-05', '2016-01-10').tail()
              A
2016-01-09  23:59:56  1
2016-01-09  23:59:57  1
2016-01-09  23:59:58  1
2016-01-09  23:59:59  1
2016-01-10  00:00:00  1
```

Note that `truncate` assumes a 0 value for any unspecified time component (midnight). This differs from partial string slicing, which returns any partially matching dates.
pandas: powerful Python data analysis toolkit, Release 0.23.2

```
>>> df.loc['2016-01-05':'2016-01-10', :].tail()
  A
2016-01-10 23:59:55 1
2016-01-10 23:59:56 1
2016-01-10 23:59:57 1
2016-01-10 23:59:58 1
2016-01-10 23:59:59 1
```

pandas.Panel.tshift

Panel.tshift (periods=1, freq=None, axis='major')
Shift the time index, using the index’s frequency if available.

Parameters

periods : int
    Number of periods to move, can be positive or negative
freq : DateOffset, timedelta, or time rule string, default None
    Increment to use from the tseries module or time rule (e.g. ‘EOM’)
axis : int or basestring
    Corresponds to the axis that contains the Index

Returns

shifted [NDFrame]

Notes

If freq is not specified then tries to use the freq or inferred_freq attributes of the index. If neither of those
attributes exist, a ValueError is thrown.

pandas.Panel.tz_convert

Panel.tz_convert (tz, axis=0, level=None, copy=True)
Convert tz-aware axis to target time zone.

Parameters

tz [string or pytz.timezone object]
axis [the axis to convert]
level : int, str, default None
    If axis ia a MultiIndex, convert a specific level. Otherwise must be None
copy : boolean, default True
    Also make a copy of the underlying data

Raises

TypeError
    If the axis is tz-naive.
pandas.Panel.tz_localize

Panel.tz_localize(tz, axis=0, level=None, copy=True, ambiguous='raise')

Localize tz-naive TimeSeries to target time zone.

Parameters

- **tz** [string or pytz.timezone object]
- **axis** [the axis to localize]
- **level** : int, str, default None
  
  If axis ia a MultiIndex, localize a specific level. Otherwise must be None

- **copy** : boolean, default True
  
  Also make a copy of the underlying data

- **ambiguous** : ‘infer’, bool-ndarray, ‘NaT’, default ‘raise’
  
  - ‘infer’ will attempt to infer fall dst-transition hours based on order
  - bool-ndarray where True signifies a DST time, False designates a non-DST time (note that this flag is only applicable for ambiguous times)
  - ‘NaT’ will return NaT where there are ambiguous times
  - ‘raise’ will raise an AmbiguousTimeError if there are ambiguous times

Raises TypeError

- If the TimeSeries is tz-aware and tz is not None.

pandas.Panel.update

Panel.update(other, join='left', overwrite=True, filter_func=None, raise_conflict=False)

Modify Panel in place using non-NA values from passed Panel, or object coercible to Panel. Aligns on items

Parameters

- **other** [Panel, or object coercible to Panel]
- **join** : How to join individual DataFrames
  
  {'left’, ‘right’, ‘outer’, ‘inner’}, default ‘left’

- **overwrite** : boolean, default True
  
  If True then overwrite values for common keys in the calling panel

- **filter_func** : callable(1d-array) -> 1d-array<boolean>, default None
  
  Can choose to replace values other than NA. Return True for values that should be updated

- **raise_conflict** : bool
  
  If True, will raise an error if a DataFrame and other both contain data in the same place.
**Pandas.Panel.var**

*Panel.var* (axis=None, skipna=None, level=None, ddof=1, numeric_only=None, **kwargs)

Return unbiased variance over requested axis.

Normalized by N-1 by default. This can be changed using the ddof argument.

**Parameters**

- **axis**: [items (0), major_axis (1), minor_axis (2)]
- **skipna**: boolean, default True
  - Exclude NA/null values. If an entire row/column is NA, the result will be NA
- **level**: int or level name, default None
  - If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a DataFrame
- **ddof**: int, default 1
  - Delta Degrees of Freedom. The divisor used in calculations is N - ddof, where N represents the number of elements.
- **numeric_only**: boolean, default None
  - Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

**Returns**

*var* [DataFrame or Panel (if level specified)]

**Pandas.Panel.where**

*Panel.where* (cond, other=nan, inplace=False, axis=None, level=None, errors='raise', try_cast=False, raise_on_error=None)

Return an object of same shape as self and whose corresponding entries are from self where *cond* is True and otherwise are from *other*.

**Parameters**

- **cond**: boolean NDFrame, array-like, or callable
  - Where *cond* is True, keep the original value. Where False, replace with corresponding value from *other*. If *cond* is callable, it is computed on the NDFrame and should return boolean NDFrame or array. The callable must not change input NDFrame (though pandas doesn’t check it).
  - New in version 0.18.1: A callable can be used as cond.
- **other**: scalar, NDFrame, or callable
  - Entries where *cond* is False are replaced with corresponding value from *other*. If other is callable, it is computed on the NDFrame and should return scalar or NDFrame. The callable must not change input NDFrame (though pandas doesn’t check it).
  - New in version 0.18.1: A callable can be used as other.
- **inplace**: boolean, default False
  - Whether to perform the operation in place on the data
where

axis [alignment axis if needed, default None]

level [alignment level if needed, default None]

default: raise
• raise: allow exceptions to be raised
• ignore: suppress exceptions. On error return original object

Note that currently this parameter won’t affect the results and will always coerce to a suitable dtype.

try_cast : boolean, default False

try to cast the result back to the input type (if possible),

raise_on_error : boolean, default True

Whether to raise on invalid data types (e.g. trying to where on strings)

Deprecation:

Returns

wh [same type as caller]

See also:

DataFrame.mask()

Notes

The where method is an application of the if-then idiom. For each element in the calling DataFrame, if cond is True the element is used; otherwise the corresponding element from the DataFrame other is used.

The signature for DataFrame.where() differs from numpy.where(). Roughly df1.where(m, df2) is equivalent to np.where(m, df1, df2).

For further details and examples see the where documentation in indexing.

Examples

```python
>>> s = pd.Series(range(5))
>>> s.where(s > 0)
0    NaN
1  1.0
2  2.0
3  3.0
4  4.0
```

```python
>>> s.mask(s > 0)
0  0.0
1  NaN
2  NaN
3  NaN
4  NaN
```
```
>>> s.where(s > 1, 10)
0   10.0
1   10.0
2    2.0
3    3.0
4    4.0

>>> df = pd.DataFrame(np.arange(10).reshape(-1, 2), columns=['A', 'B'])
>>> m = df % 3 == 0
>>> df.where(m, -df)
     A   B
0  0 -1
1 -2  3
2 -4 -5
3  6 -7
4 -8  9

```  

```
>>> df.where(m, -df) == np.where(m, df, -df)
     A   B
0  True  True
1  True  True
2  True  True
3  True  True
4  True  True

>>> df.where(m, -df) == df.mask(~m, -df)
     A   B
0  True  True
1  True  True
2  True  True
3  True  True
4  True  True

```

### pandas.Panel.xs

**Panel.xs(key, axis=1)**

Return slice of panel along selected axis

**Parameters**

- **key**: object
  - Label

- **axis**: ['items', 'major', 'minor'], default 1/'major'

**Returns**

- **y**: [ndim(self)-1]

**Notes**

xs is only for getting, not setting values.

MultIndex Slicers is a generic way to get/set values on any level or levels and is a superset of xs functionality, see MultIndex Slicers
34.5.2 Attributes and underlying data

Axes

- **items**: axis 0; each item corresponds to a DataFrame contained inside
- **major_axis**: axis 1; the index (rows) of each of the DataFrames
- **minor_axis**: axis 2; the columns of each of the DataFrames

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Panel.values</code></td>
<td>Return a Numpy representation of the DataFrame.</td>
</tr>
<tr>
<td><code>Panel.axes</code></td>
<td>Return index label(s) of the internal NDFrame</td>
</tr>
<tr>
<td><code>Panel.ndim</code></td>
<td>Return an int representing the number of axes / array dimensions.</td>
</tr>
<tr>
<td><code>Panel.size</code></td>
<td>Return an int representing the number of elements in this object.</td>
</tr>
<tr>
<td><code>Panel.shape</code></td>
<td>Return a tuple of axis dimensions</td>
</tr>
<tr>
<td><code>Panel.dtypes</code></td>
<td>Return the dtypes in the DataFrame.</td>
</tr>
<tr>
<td><code>Panel.ftypes</code></td>
<td>Return the ftypes (indication of sparse/dense and dtype) in DataFrame.</td>
</tr>
<tr>
<td><code>Panel.get_dtype_counts()</code></td>
<td>Return counts of unique dtypes in this object.</td>
</tr>
<tr>
<td><code>Panel.get_ftype_counts()</code></td>
<td>(DEPRECATED) Return counts of unique ftypes in this object.</td>
</tr>
</tbody>
</table>

34.5.3 Conversion

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Panel.astype</code></td>
<td>Cast a pandas object to a specified dtype <code>dtype</code>.</td>
</tr>
<tr>
<td><code>Panel.copy</code></td>
<td>Make a copy of this object’s indices and data.</td>
</tr>
<tr>
<td><code>Panel.isna()</code></td>
<td>Detect missing values.</td>
</tr>
<tr>
<td><code>Panel.notna()</code></td>
<td>Detect existing (non-missing) values.</td>
</tr>
</tbody>
</table>

34.5.4 Getting and setting

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Panel.get_value</code></td>
<td>(DEPRECATED) Quickly retrieve single value at (item, major, minor) location</td>
</tr>
<tr>
<td><code>Panel.set_value</code></td>
<td>(DEPRECATED) Quickly set single value at (item, major, minor) location</td>
</tr>
</tbody>
</table>

34.5.5 Indexing, iteration, slicing

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Panel.at</code></td>
<td>Access a single value for a row/column label pair.</td>
</tr>
<tr>
<td><code>Panel.iat</code></td>
<td>Access a single value for a row/column pair by integer position.</td>
</tr>
</tbody>
</table>
Table 85 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel.loc</td>
<td>Access a group of rows and columns by label(s) or a boolean array.</td>
</tr>
<tr>
<td>Panel.iloc</td>
<td>Purely integer-location based indexing for selection by position.</td>
</tr>
<tr>
<td>Panel.<strong>iter</strong>()</td>
<td>Iterate over infor axis</td>
</tr>
<tr>
<td>Panel.iteritems()</td>
<td>Iterate over (label, values) on info axis</td>
</tr>
<tr>
<td>Panel.pop(item)</td>
<td>Return item and drop from frame.</td>
</tr>
<tr>
<td>Panel.xs(key[, axis])</td>
<td>Return slice of panel along selected axis</td>
</tr>
<tr>
<td>Panel.major_xs(key)</td>
<td>Return slice of panel along major axis</td>
</tr>
<tr>
<td>Panel.minor_xs(key)</td>
<td>Return slice of panel along minor axis</td>
</tr>
</tbody>
</table>

34.5.5.1 pandas.Panel.__iter__

Panel.__iter__()
Iterate over infor axis

For more information on .at, .iat, .loc, and .iloc, see the indexing documentation.

34.5.6 Binary operator functions

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel.add</td>
<td>Addition of series and other, element-wise (binary operator add).</td>
</tr>
<tr>
<td>Panel.sub</td>
<td>Subtraction of series and other, element-wise (binary operator sub).</td>
</tr>
<tr>
<td>Panel.mul</td>
<td>Multiplication of series and other, element-wise (binary operator mul).</td>
</tr>
<tr>
<td>Panel.div</td>
<td>Floating division of series and other, element-wise (binary operator div).</td>
</tr>
<tr>
<td>Panel.truediv</td>
<td>Floating division of series and other, element-wise (binary operator truediv).</td>
</tr>
<tr>
<td>Panel.floordiv</td>
<td>Integer division of series and other, element-wise (binary operator floordiv).</td>
</tr>
<tr>
<td>Panel.mod</td>
<td>Modulo of series and other, element-wise (binary operator mod).</td>
</tr>
<tr>
<td>Panel.pow</td>
<td>Exponential power of series and other, element-wise (binary operator pow).</td>
</tr>
<tr>
<td>Panel.radd</td>
<td>Addition of series and other, element-wise (binary operator radd).</td>
</tr>
<tr>
<td>Panel.rsub</td>
<td>Subtraction of series and other, element-wise (binary operator rsub).</td>
</tr>
<tr>
<td>Panel.rmul</td>
<td>Multiplication of series and other, element-wise (binary operator rmul).</td>
</tr>
<tr>
<td>Panel.rdiv</td>
<td>Floating division of series and other, element-wise (binary operator rdiv).</td>
</tr>
<tr>
<td>Panel.rtruediv</td>
<td>Floating division of series and other, element-wise (binary operator rtruediv).</td>
</tr>
<tr>
<td>Panel.rfloordiv</td>
<td>Integer division of series and other, element-wise (binary operator rfloordiv).</td>
</tr>
<tr>
<td>Panel.rmod</td>
<td>Modulo of series and other, element-wise (binary operator rmod).</td>
</tr>
</tbody>
</table>

Continued on next page
**Table 86 – continued from previous page**

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel.rpow</td>
<td>Exponential power of series and other, element-wise (binary operator rpow).</td>
<td>other[, axis]</td>
</tr>
<tr>
<td>Panel.lt</td>
<td>Wrapper for comparison method lt</td>
<td>other[, axis]</td>
</tr>
<tr>
<td>Panel.gt</td>
<td>Wrapper for comparison method gt</td>
<td>other[, axis]</td>
</tr>
<tr>
<td>Panel.le</td>
<td>Wrapper for comparison method le</td>
<td>other[, axis]</td>
</tr>
<tr>
<td>Panel.ge</td>
<td>Wrapper for comparison method ge</td>
<td>other[, axis]</td>
</tr>
<tr>
<td>Panel.ne</td>
<td>Wrapper for comparison method ne</td>
<td>other[, axis]</td>
</tr>
<tr>
<td>Panel.eq</td>
<td>Wrapper for comparison method eq</td>
<td>other[, axis]</td>
</tr>
</tbody>
</table>

### 34.5.7 Function application, GroupBy

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel.apply</td>
<td>Applies function along axis (or axes) of the Panel</td>
<td>func[, axis]</td>
</tr>
<tr>
<td>Panel.groupby</td>
<td>Group data on given axis, returning GroupBy object</td>
<td>function[, axis]</td>
</tr>
</tbody>
</table>

### 34.5.8 Computations / Descriptive Stats

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel.abs</td>
<td>Return a Series/DataFrame with absolute numeric value of each element.</td>
<td></td>
</tr>
<tr>
<td>Panel.clip</td>
<td>Trim values at input threshold(s).</td>
<td>[lower, upper, axis, inplace]</td>
</tr>
<tr>
<td>Panel.clip_lower</td>
<td>Return copy of the input with values below a threshold truncated.</td>
<td>[threshold[, axis, inplace]]</td>
</tr>
<tr>
<td>Panel.clip_upper</td>
<td>Return copy of input with values above given value(s) truncated.</td>
<td>[threshold[, axis, inplace]]</td>
</tr>
<tr>
<td>Panel.count</td>
<td>Return number of observations over requested axis.</td>
<td>[axis[, axis]]</td>
</tr>
<tr>
<td>Panel.cummmax</td>
<td>Return cumulative maximum over a DataFrame or Series axis.</td>
<td>[axis, skipna]</td>
</tr>
<tr>
<td>Panel.cummin</td>
<td>Return cumulative minimum over a DataFrame or Series axis.</td>
<td>[axis, skipna]</td>
</tr>
<tr>
<td>Panel.cumprod</td>
<td>Return cumulative product over a DataFrame or Series axis.</td>
<td>[axis, skipna]</td>
</tr>
<tr>
<td>Panel.cumsum</td>
<td>Return cumulative sum over a DataFrame or Series axis.</td>
<td>[axis, skipna]</td>
</tr>
<tr>
<td>Panel.max</td>
<td>This method returns the maximum of the values in the object.</td>
<td>[axis, skipna, level, numeric_only]</td>
</tr>
<tr>
<td>Panel.median</td>
<td>Return the median of the values for the requested axis.</td>
<td>[axis, skipna, level, numeric_only]</td>
</tr>
<tr>
<td>Panel.min</td>
<td>This method returns the minimum of the values in the object.</td>
<td>[axis, skipna, level, numeric_only]</td>
</tr>
<tr>
<td>Panel.pct_change</td>
<td>Percentage change between the current and a prior element.</td>
<td>[periods, fill_method, . . . ]</td>
</tr>
<tr>
<td>Panel.prod</td>
<td>Return the product of the values for the requested axis.</td>
<td>[axis, skipna, level, . . . ]</td>
</tr>
<tr>
<td>Panel.sem</td>
<td>Return unbiased standard error of the mean over requested axis.</td>
<td>[axis, skipna, level, ddof, . . . ]</td>
</tr>
<tr>
<td>Panel.skew</td>
<td>Return unbiased skew over requested axis Normalized by N-1.</td>
<td>[axis, skipna, level, ddof, . . . ]</td>
</tr>
<tr>
<td>Panel.sum</td>
<td>Return the sum of the values for the requested axis.</td>
<td>[axis, skipna, level, . . . ]</td>
</tr>
<tr>
<td>Panel.std</td>
<td>Return sample standard deviation over requested axis.</td>
<td>[axis, skipna, level, ddof, . . . ]</td>
</tr>
<tr>
<td>Panel.var</td>
<td>Return unbiased variance over requested axis.</td>
<td>[axis, skipna, level, ddof, . . . ]</td>
</tr>
</tbody>
</table>
# 34.5.9 Reindexing / Selection / Label manipulation

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Panel.add_prefix(prefix)</code></td>
<td>Prefix labels with string <code>prefix</code>.</td>
</tr>
<tr>
<td><code>Panel.add_suffix(suffix)</code></td>
<td>Suffix labels with string <code>suffix</code>.</td>
</tr>
<tr>
<td><code>Panel.drop(labels, axis, index, columns, . . .)</code></td>
<td>Determines if two NDFrame objects contain the same elements.</td>
</tr>
<tr>
<td><code>Panel.equals(other)</code></td>
<td>Determines if two NDFrame objects contain the same elements.</td>
</tr>
<tr>
<td><code>Panel.filter([items, like, regex, axis])</code></td>
<td>Subset rows or columns of dataframe according to labels in the specified index.</td>
</tr>
<tr>
<td><code>Panel.first(offset)</code></td>
<td>Convenience method for subsetting initial periods of time series data based on a date offset.</td>
</tr>
<tr>
<td><code>Panel.last(offset)</code></td>
<td>Convenience method for subsetting final periods of time series data based on a date offset.</td>
</tr>
<tr>
<td><code>Panel.reindex(*args, **kwargs)</code></td>
<td>Conform Panel to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.</td>
</tr>
<tr>
<td><code>Panel.reindex_axis(labels[, axis, method, . . .])</code></td>
<td>Conform input object to new index with optional filling logic, placing NA/NaN in locations having no value in the previous index.</td>
</tr>
<tr>
<td><code>Panel.reindex_like(other[, method, copy, . . .])</code></td>
<td>Return an object with matching indices to myself.</td>
</tr>
<tr>
<td><code>Panel.rename([items, major_axis, minor_axis])</code></td>
<td>Alter axes input function or functions.</td>
</tr>
<tr>
<td><code>Panel.sample([n, frac, replace, weights, . . .])</code></td>
<td>Return a random sample of items from an axis of object.</td>
</tr>
<tr>
<td><code>Panel.select(crit[, axis])</code></td>
<td>(DEPRECATED) Return data corresponding to axis labels matching criteria</td>
</tr>
<tr>
<td><code>Panel.take(indices[, axis, convert, is_copy])</code></td>
<td>Return the elements in the given positional indices along an axis.</td>
</tr>
<tr>
<td><code>Panel.truncate([before, after, axis, copy])</code></td>
<td>Truncate a Series or DataFrame before and after some index value.</td>
</tr>
</tbody>
</table>

## 34.5.9.1 pandas.Panel.drop

```python
Panel.drop (labels=None, axis=0, index=None, columns=None, level=None, inplace=False, errors='raise')
```

## 34.5.10 Missing data handling

```python
Panel.dropna([axis, how, inplace])
```

## 34.5.11 Reshaping, sorting, transposing

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Panel.sort_index([axis, level, ascending, . . .])</code></td>
<td>Sort object by labels (along an axis)</td>
</tr>
<tr>
<td><code>Panel.swaplevel([i, j, axis])</code></td>
<td>Swap levels i and j in a MultiIndex on a particular axis</td>
</tr>
<tr>
<td><code>Panel.transpose(*args, **kwargs)</code></td>
<td>Permute the dimensions of the Panel</td>
</tr>
<tr>
<td><code>Panel.swapaxes(axis1, axis2[, copy])</code></td>
<td>Interchange axes and swap values axes appropriately</td>
</tr>
<tr>
<td><code>Panel.conform(frame[, axis])</code></td>
<td>Conform input DataFrame to align with chosen axis pair.</td>
</tr>
</tbody>
</table>
34.5.12 Combining / joining / merging

*Panel.join*(other[, how, lsuffix, rsuffix])  
Join items with other Panel either on major and minor axes column

*Panel.update*(other[, join, overwrite, …])  
Modify Panel in place using non-NA values from passed Panel, or object coercible to Panel.

34.5.13 Time series-related

*Panel.asfreq*(freq[, method, how, normalize, …])  
Convert TimeSeries to specified frequency.

*Panel.shift*([periods, freq, axis])  
Shift index by desired number of periods with an optional time freq.

*Panel.resample*(rule[, how, axis, …])  
Convenience method for frequency conversion and resampling of time series.

*Panel.tz_convert*(tz[, axis, level, copy])  
Convert tz-aware axis to target time zone.

*Panel.tz_localize*(tz[, axis, level, copy, …])  
Localize tz-naive TimeSeries to target time zone.

34.5.14 Serialization / IO / Conversion

*Panel.from_dict*(data[, intersect, orient, dtype])  
Construct Panel from dict of DataFrame objects

*Panel.to_pickle*(path[, compression, protocol])  
Pickle (serialize) object to file.

*Panel.to_excel*(path[, na_rep, engine])  
Write each DataFrame in Panel to a separate excel sheet

*Panel.to_hdf*(path_or_buf, key, **kwargs)  
Write the contained data to an HDF5 file using HDFStore.

*Panel.to_sparse*(*args, **kwargs)  
NOT IMPLEMENTED: do not call this method, as sparsifying is not supported for Panel objects and will raise an error.

*Panel.to_frame*([filter_observations])  
Transform wide format into long (stacked) format as DataFrame whose columns are the Panel’s items and whose index is a MultiIndex formed of the Panel’s major and minor axes.

*Panel.to_clipboard*([excel, sep])  
Copy object to the system clipboard.

34.6 Index

Many of these methods or variants thereof are available on the objects that contain an index (Series/DataFrame) and those should most likely be used before calling these methods directly.

*Index*  
Immutable ndarray implementing an ordered, sliceable set.

34.6.1 pandas.Index

*class pandas.Index*  
 Immutable ndarray implementing an ordered, sliceable set. The basic object storing axis labels for all pandas objects

*Parameters*
data [array-like (1-dimensional)]
dtype : NumPy dtype (default: object)
    If dtype is None, we find the dtype that best fits the data. If an actual dtype is
    provided, we coerce to that dtype if it’s safe. Otherwise, an error will be raised.
copy : bool
    Make a copy of input ndarray
name : object
    Name to be stored in the index
tupleize_cols : bool (default: True)
    When True, attempt to create a MultiIndex if possible

See also:

   RangeIndex   Index implementing a monotonic integer range
   CategoricalIndex   Index of Categoricals.
   MultiIndex      A multi-level, or hierarchical, Index
   IntervalIndex   an Index of Intervals.
   DatetimeIndex,  TimedeltaIndex,  PeriodIndex,  Int64Index,  UInt64Index,  Float64Index

Notes

   An Index instance can only contain hashable objects

Examples

>>> pd.Index([1, 2, 3])
Int64Index([1, 2, 3], dtype='int64')

>>> pd.Index(list('abc'))
Index(['a', 'b', 'c'], dtype='object')

Attributes

T
base
data
dtype
dtype_str
flags

Continued on next page
Table 96 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>hasnans</td>
<td>return if I have any nans; enables various perf speedups</td>
</tr>
<tr>
<td>inferred_type</td>
<td>return a string of the type inferred from the values</td>
</tr>
<tr>
<td>is_monotonic</td>
<td>alias for is_monotonic_increasing (deprecated)</td>
</tr>
<tr>
<td>is_monotonic_decreasing</td>
<td>return if the index is monotonic decreasing (only equal or decreasing) values.</td>
</tr>
<tr>
<td>is_monotonic_increasing</td>
<td>return if the index is monotonic increasing (only equal or increasing) values.</td>
</tr>
<tr>
<td>is_unique</td>
<td>return if the index has unique values</td>
</tr>
<tr>
<td>itemsize</td>
<td>return the size of the dtype of the item of the underlying data</td>
</tr>
<tr>
<td>nbytes</td>
<td>return the number of bytes in the underlying data</td>
</tr>
<tr>
<td>ndim</td>
<td>return the number of dimensions of the underlying data, by definition 1</td>
</tr>
<tr>
<td>shape</td>
<td>return a tuple of the shape of the underlying data</td>
</tr>
<tr>
<td>size</td>
<td>return the number of elements in the underlying data</td>
</tr>
<tr>
<td>strides</td>
<td>return the strides of the underlying data</td>
</tr>
<tr>
<td>values</td>
<td>return the underlying data as an ndarray</td>
</tr>
</tbody>
</table>

### 34.6.1.1 pandas.Index.T

Index.T

return the transpose, which is by definition self

### 34.6.1.2 pandas.Index.base

Index.base

return the base object if the memory of the underlying data is shared

### 34.6.1.3 pandas.Index.data

Index.data

return the data pointer of the underlying data

### 34.6.1.4 pandas.Index.dtype

Index.dtype

return the dtype object of the underlying data

### 34.6.1.5 pandas.Index.dtype_str

Index.dtype_str

return the dtype str of the underlying data

### 34.6.1.6 pandas.Index.flags

Index.flags
34.6.1.7 pandas.Index.hasnans

Index.hasnans

return if I have any nans; enables various perf speedups

34.6.1.8 pandas.Index.inferred_type

Index.inferred_type

return a string of the type inferred from the values

34.6.1.9 pandas.Index.is_monotonic

Index.is_monotonic

alias for is_monotonic_increasing (deprecated)

34.6.1.10 pandas.Index.is_monotonic_decreasing

Index.is_monotonic_decreasing

return if the index is monotonic decreasing (only equal or decreasing) values.

Examples

```python
>>> Index([3, 2, 1]).is_monotonic_decreasing
True
>>> Index([3, 2, 2]).is_monotonic_decreasing
True
>>> Index([3, 1, 2]).is_monotonic_decreasing
False
```

34.6.1.11 pandas.Index.is_monotonic_increasing

Index.is_monotonic_increasing

return if the index is monotonic increasing (only equal or increasing) values.

Examples

```python
>>> Index([1, 2, 3]).is_monotonic_increasing
True
>>> Index([1, 2, 2]).is_monotonic_increasing
True
>>> Index([1, 3, 2]).is_monotonic_increasing
False
```

34.6.1.12 pandas.Index.is_unique

Index.is_unique

return if the index has unique values
34.6.1.13 pandas.Index.itemsize

Index.itemsize
return the size of the dtype of the item of the underlying data

34.6.1.14 pandas.Index.nbytes

Index.nbytes
return the number of bytes in the underlying data

34.6.1.15 pandas.Index.ndim

Index.ndim
return the number of dimensions of the underlying data, by definition 1

34.6.1.16 pandas.Index.shape

Index.shape
return a tuple of the shape of the underlying data

34.6.1.17 pandas.Index.size

Index.size
return the number of elements in the underlying data

34.6.1.18 pandas.Index.strides

Index.strides
return the strides of the underlying data

34.6.1.19 pandas.Index.values

Index.values
return the underlying data as an ndarray

<table>
<thead>
<tr>
<th>asi8</th>
<th>empty</th>
<th>has_duplicates</th>
<th>is_all_dates</th>
<th>name</th>
<th>names</th>
<th>nlevels</th>
</tr>
</thead>
</table>

Methods

\[\text{all}(\ast\text{args}, \ast\ast\text{kwargs})\] Return whether all elements are True.

Continued on next page
Table 97 – continued from previous page

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>any(*args, **kwargs)</code></td>
<td>Return whether any element is True.</td>
</tr>
<tr>
<td><code>append(other)</code></td>
<td>Append a collection of Index options together</td>
</tr>
<tr>
<td><code>argmax([axis])</code></td>
<td>Return a ndarray of the maximum argument indexer</td>
</tr>
<tr>
<td><code>argmin([axis])</code></td>
<td>Return a ndarray of the minimum argument indexer</td>
</tr>
<tr>
<td><code>argsort(*args, **kwargs)</code></td>
<td>Return the integer indicies that would sort the index.</td>
</tr>
<tr>
<td><code>asof(label)</code></td>
<td>For a sorted index, return the most recent label up to and including the passed label.</td>
</tr>
<tr>
<td><code>asof_locs(where, mask)</code></td>
<td>where : array of timestamps mask : array of booleans where data is not NA</td>
</tr>
<tr>
<td><code>astype(dtype[, copy])</code></td>
<td>Create an Index with values cast to dtypes.</td>
</tr>
<tr>
<td><code>contains(key)</code></td>
<td>Return a boolean if this key is IN the index</td>
</tr>
<tr>
<td><code>copy([name, deep, dtype])</code></td>
<td>Make a copy of this object.</td>
</tr>
<tr>
<td><code>delete(loc)</code></td>
<td>Make new Index with passed location(-s) deleted</td>
</tr>
<tr>
<td><code>difference(other)</code></td>
<td>Return a new Index with elements from the index that are not in other.</td>
</tr>
<tr>
<td><code>drop(labels[, errors])</code></td>
<td>Make new Index with passed list of labels deleted</td>
</tr>
<tr>
<td><code>drop_duplicates([keep])</code></td>
<td>Return Index with duplicate values removed.</td>
</tr>
<tr>
<td><code>dropna([how])</code></td>
<td>Return Index without NA/NaN values</td>
</tr>
<tr>
<td><code>duplicated([keep])</code></td>
<td>Indicate duplicate index values.</td>
</tr>
<tr>
<td><code>equals(other)</code></td>
<td>Determines if two Index objects contain the same elements.</td>
</tr>
<tr>
<td><code>factorize([sort, na_sentinel])</code></td>
<td>Encode the object as an enumerated type or categorical variable.</td>
</tr>
<tr>
<td><code>fillna([value, downcast])</code></td>
<td>Fill NA/NaN values with the specified value</td>
</tr>
<tr>
<td><code>format([name, formatter])</code></td>
<td>Render a string representation of the Index</td>
</tr>
<tr>
<td><code>get_duplicates()</code></td>
<td>(DEPRECATED) Extract duplicated index elements.</td>
</tr>
<tr>
<td><code>get_indexer(target[, method, limit, tolerance])</code></td>
<td>Compute indexer and mask for new index given the current index.</td>
</tr>
<tr>
<td><code>get_indexer_for(target, **kwargs)</code></td>
<td>guaranteed return of an indexer even when non-unique This dispatches to get_indexer or get_indexer_nonunique as appropriate</td>
</tr>
<tr>
<td><code>get_indexer_non_unique(target)</code></td>
<td>Compute indexer and mask for new index given the current index.</td>
</tr>
<tr>
<td><code>get_level_values(level)</code></td>
<td>Return an Index of values for requested level, equal to the length of the index.</td>
</tr>
<tr>
<td><code>get_loc(key[, method, tolerance])</code></td>
<td>Get integer location, slice or boolean mask for requested label.</td>
</tr>
<tr>
<td><code>get_slice_bound(label, side, kind)</code></td>
<td>Calculate slice bound that corresponds to given label.</td>
</tr>
<tr>
<td><code>get_values(series, key)</code></td>
<td>Fast lookup of value from 1-dimensional ndarray.</td>
</tr>
<tr>
<td><code>groupby(values)</code></td>
<td>Group the index labels by a given array of values.</td>
</tr>
<tr>
<td><code>identical(other)</code></td>
<td>Similar to equals, but check that other comparable attributes are also equal</td>
</tr>
<tr>
<td><code>insert(loc, item)</code></td>
<td>Make new Index inserting new item at location.</td>
</tr>
<tr>
<td><code>intersection(other)</code></td>
<td>Form the intersection of two Index objects.</td>
</tr>
<tr>
<td><code>is_(other)</code></td>
<td>More flexible, faster check like is but that works through views</td>
</tr>
<tr>
<td><code>is_categorical()</code></td>
<td>Check if the Index holds categorical data.</td>
</tr>
<tr>
<td><code>isin(values[, level])</code></td>
<td>Return a boolean array where the index values are in values.</td>
</tr>
<tr>
<td><code>isna()</code></td>
<td>Detect missing values.</td>
</tr>
</tbody>
</table>

Continued on next page
Table 97 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>isnull()</code></td>
<td>Detect missing values.</td>
</tr>
<tr>
<td><code>item()</code></td>
<td>return the first element of the underlying data as a python scalar.</td>
</tr>
<tr>
<td><code>join(*other[, how, level, return_indexers, sort])</code></td>
<td>this is an internal non-public method</td>
</tr>
<tr>
<td><code>map(*mapper[, na_action])</code></td>
<td>Map values using input correspondence (a dict, Series, or function).</td>
</tr>
<tr>
<td><code>max()</code></td>
<td>Return the maximum value of the Index.</td>
</tr>
<tr>
<td><code>memory_usage([deep])</code></td>
<td>Memory usage of the values</td>
</tr>
<tr>
<td><code>min()</code></td>
<td>Return the minimum value of the Index.</td>
</tr>
<tr>
<td><code>notna()</code></td>
<td>Detect existing (non-missing) values.</td>
</tr>
<tr>
<td><code>notnull()</code></td>
<td>Detect existing (non-missing) values.</td>
</tr>
<tr>
<td><code>nunique([dropna])</code></td>
<td>Return number of unique elements in the object.</td>
</tr>
<tr>
<td><code>putmask(*mask, value)</code></td>
<td>return a new Index of the values set with the mask</td>
</tr>
<tr>
<td><code>ravel([order])</code></td>
<td>return an ndarray of the flattened values of the underlying data</td>
</tr>
<tr>
<td><code>reindex(*target[, method, level, limit, ...])</code></td>
<td>Create index with target’s values (move/add/delete values as necessary)</td>
</tr>
<tr>
<td><code>rename(*name[, inplace])</code></td>
<td>Set new names on index.</td>
</tr>
<tr>
<td><code>repeat(*repeats, *args, **kwargs)</code></td>
<td>Repeat elements of an Index.</td>
</tr>
<tr>
<td><code>searchsorted(*value[, side, sorter])</code></td>
<td>Find indices where elements should be inserted to maintain order.</td>
</tr>
<tr>
<td><code>set_names(*names[, level, inplace])</code></td>
<td>Set new names on index.</td>
</tr>
<tr>
<td><code>set_value(*arr, key, value)</code></td>
<td>Fast lookup of value from 1-dimensional ndarray.</td>
</tr>
<tr>
<td><code>shift(*periods, freq)</code></td>
<td>Shift index by desired number of time frequency increments.</td>
</tr>
<tr>
<td><code>slice_indexer(*[start, end, step, kind])</code></td>
<td>For an ordered or unique index, compute the slice indexer for input labels and step.</td>
</tr>
<tr>
<td><code>slice_locs(*[start, end, step, kind])</code></td>
<td>Compute slice locations for input labels.</td>
</tr>
<tr>
<td><code>sort_values(*[return_indexer, ascending])</code></td>
<td>Return a sorted copy of the index.</td>
</tr>
<tr>
<td><code>str</code></td>
<td>alias of pandas.core.strings.StringMethods</td>
</tr>
<tr>
<td><code>summary(*[name])</code></td>
<td>(DEPRECATED) Return a summarized representation ..</td>
</tr>
<tr>
<td><code>symmetric_difference(*other[, result_name])</code></td>
<td>Compute the symmetric difference of two Index objects.</td>
</tr>
<tr>
<td><code>take(*indices[, axis, allow_fill, fill_value])</code></td>
<td>return a new Index of the values selected by the indices</td>
</tr>
<tr>
<td><code>to_frame(*index)</code></td>
<td>Create a DataFrame with a column containing the Index.</td>
</tr>
<tr>
<td><code>to_native_types(*[slicer])</code></td>
<td>Format specified values of self and return them.</td>
</tr>
<tr>
<td><code>to_series(*[index, name])</code></td>
<td>Create a Series with both index and values equal to the index keys useful with map for returning an indexer based on an index</td>
</tr>
<tr>
<td><code>tolist()</code></td>
<td>Return a list of the values.</td>
</tr>
<tr>
<td><code>transpose(*args, **kwargs)</code></td>
<td>return the transpose, which is by definition self</td>
</tr>
<tr>
<td><code>union(*other)</code></td>
<td>Form the union of two Index objects and sorts if possible.</td>
</tr>
<tr>
<td><code>unique(*[level])</code></td>
<td>Return unique values in the index.</td>
</tr>
<tr>
<td><code>value_counts(*[normalize, sort, ascending, ...])</code></td>
<td>Returns object containing counts of unique values.</td>
</tr>
<tr>
<td><code>where(*cond[, other])</code></td>
<td></td>
</tr>
</tbody>
</table>
34.6.1.20 pandas.Index.all

Index.all(*args, **kwargs)

Return whether all elements are True.

Parameters *args

These parameters will be passed to numpy.all.

**kwargs

These parameters will be passed to numpy.all.

Returns all : bool or array_like (if axis is specified)

A single element array_like may be converted to bool.

See also:

pandas.Index.any Return whether any element in an Index is True.
pandas.Series.any Return whether any element in a Series is True.
pandas.Series.all Return whether all elements in a Series are True.

Notes

Not a Number (NaN), positive infinity and negative infinity evaluate to True because these are not equal to zero.

Examples

all

True, because nonzero integers are considered True.

```python
>>> pd.Index([1, 2, 3]).all()
True
```

False, because 0 is considered False.

```python
>>> pd.Index([0, 1, 2]).all()
False
```

any

True, because 1 is considered True.

```python
>>> pd.Index([0, 0, 1]).any()
True
```

False, because 0 is considered False.

```python
>>> pd.Index([0, 0, 0]).any()
False
```
34.6.1.21 pandas.Index.any

Index.any(*args, **kwargs)
Return whether any element is True.

Parameters
*args
These parameters will be passed to numpy.any.

**kwargs
These parameters will be passed to numpy.any.

Returns
any : bool or array_like (if axis is specified)
A single element array_like may be converted to bool.

See also:

pandas.Index.all Return whether all elements are True.
pandas.Series.all Return whether all elements are True.

Notes

Not a Number (NaN), positive infinity and negative infinity evaluate to True because these are not equal to zero.

Examples

```python
>>> index = pd.Index([0, 1, 2])
>>> index.any()
True
```

```python
>>> index = pd.Index([0, 0, 0])
>>> index.any()
False
```

34.6.1.22 pandas.Index.append

Index.append(other)
Append a collection of Index options together

Parameters
other [Index or list/tuple of indices]

Returns
appended [Index]

34.6.1.23 pandas.Index.argmax

Index.argmax(axis=None)
return a ndarray of the maximum argument indexer
See also:

numpy.ndarray.argmax

34.6.1.24 pandas.Index.argmin

Index.argmin(axis=None)
return a ndarray of the minimum argument indexer
See also:

numpy.ndarray.argmin

34.6.1.25 pandas.Index.argsort

Index.argsort(*args, **kwargs)
Return the integer indices that would sort the index.

Parameters
*args
Passed to numpy.ndarray.argsort.

**kwargs
Passed to numpy.ndarray.argsort.

Returns
numpy.ndarray
Integer indices that would sort the index if used as an indexer.
See also:

numpy.argsort Similar method for NumPy arrays.
Index.sort_values Return sorted copy of Index.

Examples

```python
>>> idx = pd.Index(['b', 'a', 'd', 'c'])
>>> idx
Index(['b', 'a', 'd', 'c'], dtype='object')

>>> order = idx.argsort()
>>> order
array([1, 0, 3, 2])

>>> idx[order]
Index(['a', 'b', 'c', 'd'], dtype='object')
```

34.6.1.26 pandas.Index.asof

Index.asof(label)
For a sorted index, return the most recent label up to and including the passed label. Return NaN if not found.
See also:
get_loc  asof is a thin wrapper around get_loc with method=’pad’

34.6.1.27 pandas.Index.asof_locs

Index.asof_locs(where, mask)
  where : array of timestamps
  mask : array of booleans where data is not NA

34.6.1.28 pandas.Index.astype

Index.astype(dtype, copy=True)
  Create an Index with values cast to dtypes. The class of a new Index is determined by dtype. When conversion is impossible, a ValueError exception is raised.

Parameters
  dtype [numpy dtypes or pandas type]
  copy : bool, default True
    By default, astype always returns a newly allocated object. If copy is set to False and internal requirements on dtype are satisfied, the original data is used to create a new Index or the original Index is returned.

New in version 0.19.0.

34.6.1.29 pandas.Index.contains

Index.contains(key)
  return a boolean if this key is IN the index

Parameters
  key [object]

Returns
  boolean

34.6.1.30 pandas.Index.copy

Index.copy(name=None, deep=False, dtype=None, **kwargs)
  Make a copy of this object. Name and dtype sets those attributes on the new object.

Parameters
  name [string, optional]
  deep [boolean, default False]
  dtype [numpy dtypes or pandas type]

Returns
  copy [Index]
Notes

In most cases, there should be no functional difference from using `deep`, but if `deep` is passed it will attempt to deepcopy.

34.6.1.31 pandas.Index.delete

`Index.delete(loc)`
Make new Index with passed location(-s) deleted

Returns

`new_index` [Index]

34.6.1.32 pandas.Index.difference

`Index.difference(other)`
Return a new Index with elements from the index that are not in `other`.
This is the set difference of two Index objects. It’s sorted if sorting is possible.

Parameters

`other` [Index or array-like]

Returns

`difference` [Index]

Examples

```python
>>> idx1 = pd.Index([1, 2, 3, 4])
>>> idx2 = pd.Index([3, 4, 5, 6])
>>> idx1.difference(idx2)
Int64Index([1, 2], dtype='int64')
```

34.6.1.33 pandas.Index.drop

`Index.drop(labels, errors='raise')`  
Make new Index with passed list of labels deleted

Parameters

`labels` [array-like]
`errors` : {'ignore', 'raise'}, default 'raise'
If ‘ignore’, suppress error and existing labels are dropped.

Returns

`dropped` [Index]

Raises `KeyError`
If not all of the labels are found in the selected axis
### pandas.Index.drop_duplicates

**`Index.drop_duplicates(keep='first')`**

Return Index with duplicate values removed.

**Parameters**

- `keep` : {'first', 'last', False}, default ‘first’
  - ‘first’ : Drop duplicates except for the first occurrence.
  - ‘last’ : Drop duplicates except for the last occurrence.
  - False : Drop all duplicates.

**Returns**

- `deduplicated` [Index]

**See also:**

- `Series.drop_duplicates` equivalent method on Series
- `DataFrame.drop_duplicates` equivalent method on DataFrame
- `Index.duplicated` related method on Index, indicating duplicate Index values.

**Examples**

Generate an pandas.Index with duplicate values.

```python
>>> idx = pd.Index(['lama', 'cow', 'lama', 'beetle', 'lama', 'hippo'])
```

The `keep` parameter controls which duplicate values are removed. The value ‘first’ keeps the first occurrence for each set of duplicated entries. The default value of keep is ‘first’.

```python
>>> idx.drop_duplicates(keep='first')
Index(['lama', 'cow', 'beetle', 'hippo'], dtype='object')
```

The value ‘last’ keeps the last occurrence for each set of duplicated entries.

```python
>>> idx.drop_duplicates(keep='last')
Index(['cow', 'beetle', 'lama', 'hippo'], dtype='object')
```

The value False discards all sets of duplicated entries.

```python
>>> idx.drop_duplicates(keep=False)
Index(['cow', 'beetle', 'hippo'], dtype='object')
```

### pandas.Index.dropna

**`Index.dropna(how='any')`**

Return Index without NA/NaN values.

**Parameters**

- `how` : {'any', 'all'}, default ‘any’
  - If the Index is a MultiIndex, drop the value when any or all levels are NaN.

**Returns**

- `valid` [Index]
34.6.1.36 pandas.Index.duplicated

Index.duplicated(keep='first')
Indicate duplicate index values.

Duplicated values are indicated as True values in the resulting array. Either all duplicates, all except the first, or all except the last occurrence of duplicates can be indicated.

Parameters keep : {'first', 'last', False}, default 'first'
The value or values in a set of duplicates to mark as missing.
• ‘first’ : Mark duplicates as True except for the first occurrence.
• ‘last’ : Mark duplicates as True except for the last occurrence.
• False : Mark all duplicates as True.

Returns
numpy.ndarray

See also:
pandas.Series.duplicated Equivalent method on pandas.Series
pandas.DataFrame.duplicated Equivalent method on pandas.DataFrame
pandas.Index.drop_duplicates Remove duplicate values from Index

Examples

By default, for each set of duplicated values, the first occurrence is set to False and all others to True:

```python
>>> idx = pd.Index(['lama', 'cow', 'lama', 'beetle', 'lama'])
>>> idx.duplicated()
array([False, False, True, False, True])
```

which is equivalent to

```python
>>> idx.duplicated(keep='first')
array([False, False, True, False, True])
```

By using ‘last’, the last occurrence of each set of duplicated values is set on False and all others on True:

```python
>>> idx.duplicated(keep='last')
array([ True, False, True, False, False])
```

By setting keep on False, all duplicates are True:

```python
>>> idx.duplicated(keep=False)
array([ True, False, True, False, True])
```

34.6.1.37 pandas.Index.equals

Index.equals(other)
Determines if two Index objects contain the same elements.
34.6.1.38 pandas.Index.factorize

Index.factorize(sort=False, na_sentinel=-1)

Encode the object as an enumerated type or categorical variable.

This method is useful for obtaining a numeric representation of an array when all that matters is identifying distinct values. factorize is available as both a top-level function pandas.factorize(), and as a method Series.factorize() and Index.factorize().

Parameters

- **sort**: boolean, default False
  
  Sort uniques and shuffle labels to maintain the relationship.

- **na_sentinel**: int, default -1
  
  Value to mark "not found".

Returns

- **labels**: ndarray
  
  An integer ndarray that's an indexer into uniques. uniques.take(labels) will have the same values as values.

- **uniques**: ndarray, Index, or Categorical
  
  The unique valid values. When values is Categorical, uniques is a Categorical. When values is some other pandas object, an Index is returned. Otherwise, a 1-D ndarray is returned.

Note: Even if there’s a missing value in values, uniques will not contain an entry for it.

See also:

- **pandas.cut** Discretize continuous-valued array.
- **pandas.unique** Find the unique value in an array.

Examples

These examples all show factorize as a top-level method like pd.factorize(values). The results are identical for methods like Series.factorize().

```python
>>> labels, uniques = pd.factorize(['b', 'b', 'a', 'c', 'b'])

>>> labels
array([0, 0, 1, 2, 0])

>>> uniques
array(['b', 'a', 'c'], dtype=object)
```

With sort=True, the uniques will be sorted, and labels will be shuffled so that the relationship is maintained.

```python
>>> labels, uniques = pd.factorize(['b', 'b', 'a', 'c', 'b'], sort=True)

>>> labels
array([1, 1, 0, 2, 1])

>>> uniques
array(['a', 'b', 'c'], dtype=object)
```
Missing values are indicated in labels with na_sentinel (-1 by default). Note that missing values are never included in uniques.

```python
>>> labels, uniques = pd.factorize([b', None, 'a', 'c', 'b'])
>>> labels
array([ 0, -1, 1, 2, 0])
>>> uniques
array(['b', 'a', 'c'], dtype=object)
```

Thus far, we’ve only factorized lists (which are internally coerced to NumPy arrays). When factorizing pandas objects, the type of uniques will differ. For Categoricals, a Categorical is returned.

```python
>>> cat = pd.Categorical(['a', 'a', 'c'], categories=['a', 'b', 'c'])
>>> labels, uniques = pd.factorize(cat)
>>> labels
array([0, 0, 1])
>>> uniques
[a, c]
Categories (3, object): [a, b, c]
```

Notice that 'b' is in uniques.categories, despite not being present in cat.values.

For all other pandas objects, an Index of the appropriate type is returned.

```python
>>> cat = pd.Series(['a', 'a', 'c'])
>>> labels, uniques = pd.factorize(cat)
>>> labels
array([0, 0, 1])
>>> uniques
Index(['a', 'c'], dtype='object')
```

### 34.6.1.39 pandas.Index.fillna

Index.fillna(value=None, downcast=None)

Fill NA/NaN values with the specified value

- **value**: scalar
  - Scalar value to use to fill holes (e.g. 0). This value cannot be a list-likes.
  - **downcast**: dict, default is None
    - a dict of item->dtype of what to downcast if possible, or the string ‘infer’ which will try to downcast to an appropriate equal type (e.g. float64 to int64 if possible)

- **Returns**
  - filled [%(klass)s]

### 34.6.1.40 pandas.Index.format

Index.format(name=False, formatter=None, **kwargs)

Render a string representation of the Index
Index.get_duplicates()

Extract duplicated index elements.

Returns a sorted list of index elements which appear more than once in the index.

Deprecated since version 0.23.0: Use idx[idx.duplicated()].unique() instead

Returns array-like

List of duplicated indexes.

See also:

- Index.duplicated: Return boolean array denoting duplicates.
- Index.drop_duplicates: Return Index with duplicates removed.

Examples

Works on different Index of types.

```python
>>> pd.Index([1, 2, 2, 3, 3, 3, 4]).get_duplicates()
[2, 3]
>>> pd.Index([1., 2., 2., 3., 3., 3., 4.]).get_duplicates()
[2.0, 3.0]
>>> pd.Index(['a', 'b', 'b', 'c', 'c', 'c', 'd']).get_duplicates()
['b', 'c']
```

Note that for a DatetimeIndex, it does not return a list but a new DatetimeIndex:

```python
>>> dates = pd.to_datetime(['2018-01-01', '2018-01-02', '2018-01-03',
...                        '2018-01-03', '2018-01-04', '2018-01-04'],
...                        format='%Y-%m-%d')
>>> pd.Index(dates).get_duplicates()
DatetimeIndex(['2018-01-03', '2018-01-04'],
              dtype='datetime64[ns]', freq=None)
```

Sorts duplicated elements even when indexes are unordered.

```python
>>> pd.Index([1, 2, 3, 2, 3, 4, 3]).get_duplicates()
[2, 3]
```

Return empty array-like structure when all elements are unique.

```python
>>> pd.Index([1, 2, 3, 4]).get_duplicates()
[]
>>> dates = pd.to_datetime(['2018-01-01', '2018-01-02', '2018-01-03'],
...                        format='%Y-%m-%d')
>>> pd.Index(dates).get_duplicates()
DatetimeIndex([],
              dtype='datetime64[ns]', freq=None)
```

Index.get_indexer(target, method=None, limit=None, tolerance=None)

Compute indexer and mask for new index given the current index. The indexer should be then used as an input to ndarray.take to align the current data to the new index.
Parameters

**target** [Index]

**method** : {None, ‘pad’/’ffill’, ‘backfill’/’bfill’, ‘nearest’}, optional
- default: exact matches only.
- pad / ffill: find the PREVIOUS index value if no exact match.
- backfill / bfill: use NEXT index value if no exact match
- nearest: use the NEAREST index value if no exact match. Tied distances are broken by preferring the larger index value.

**limit** : int, optional
Maximum number of consecutive labels in target to match for inexact matches.

**tolerance** : optional
Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations most satisfy the equation
\[
\text{abs(index[indexer] - target)} <= \text{tolerance}.
\]
Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index’s type.

New in version 0.21.0: (list-like tolerance)

**Returns**
**indexer** : ndarray of int
Integers from 0 to n - 1 indicating that the index at these positions matches the corresponding target values. Missing values in the target are marked by -1.

Examples

```python
>>> indexer = index.get_indexer(new_index)
>>> new_values = cur_values.take(indexer)
```

### 34.6.1.43 pandas.Index.get_indexer_for

Index.get_indexer_for(target, **kwargs)
guaranteed return of an indexer even when non-unique This dispatches to get_indexer or get_indexer_nonunique as appropriate

### 34.6.1.44 pandas.Index.get_indexer_non_unique

Index.get_indexer_non_unique(target)
Compute indexer and mask for new index given the current index. The indexer should be then used as an input to ndarray.take to align the current data to the new index.

**Parameters**

**target** [Index]
**Returns** indexer: ndarray of int

Integers from 0 to n - 1 indicating that the index at these positions matches the corresponding target values. Missing values in the target are marked by -1.

missing: ndarray of int

An indexer into the target of the values not found. These correspond to the -1 in the indexer array

### 34.6.1.45 pandas.Index.get_level_values

Index.get_level_values(level)

Return an Index of values for requested level, equal to the length of the index.

**Parameters** level: int or str

level is either the integer position of the level in the MultiIndex, or the name of the level.

**Returns** values: Index

self, as there is only one level in the Index.

See also:

pandas.MultiIndex.get_level_values get values for a level of a MultiIndex

### 34.6.1.46 pandas.Index.get_loc

Index.get_loc(key, method=None, tolerance=None)

Get integer location, slice or boolean mask for requested label.

**Parameters**

key [label]

**method**: {None, ‘pad’/’ffill’, ‘backfill’/’bfill’, ‘nearest’}, optional

- default: exact matches only.
  - pad / ffill: find the PREVIOUS index value if no exact match.
  - backfill / bfill: use NEXT index value if no exact match

- nearest: use the NEAREST index value if no exact match. Tied distances are broken by preferring the larger index value.

**tolerance**: optional

Maximum distance from index value for inexact matches. The value of the index at the matching location most satisfy the equation \( \text{abs(index[loc] - key)} \leq \text{tolerance} \).

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index’s type.

New in version 0.21.0: (list-like tolerance)

**Returns**
loc  [int if unique index, slice if monotonic index, else mask]

Examples

```python
>>> unique_index = pd.Index(list('abc'))
>>> unique_index.get_loc('b')
1

>>> monotonic_index = pd.Index(list('abbc'))
>>> monotonic_index.get_loc('b')
slice(1, 3, None)

>>> non_monotonic_index = pd.Index(list('abcb'))
>>> non_monotonic_index.get_loc('b')
array([False,  True, False,  True], dtype=bool)
```

34.6.1.47 pandas.Index.get_slice_bound

Index.get_slice_bound(label, side, kind)
Calculate slice bound that corresponds to given label.

Returns leftmost (one-past-the-rightmost if `side=='right'`) position of given label.

Parameters

- label  [object]
- side  [{‘left’, ‘right’}]
- kind  [{‘ix’, ‘loc’, ‘getitem’}]

34.6.1.48 pandas.Index.get_value

Index.get_value(series, key)
Fast lookup of value from 1-dimensional ndarray. Only use this if you know what you're doing.

34.6.1.49 pandas.Index.get_values

Index.get_values()
Return Index data as an numpy.ndarray.

Returns numpy.ndarray
A one-dimensional numpy array of the Index values.

See also:

- `Index.values` The attribute that get_values wraps.

Examples

Getting the Index values of a DataFrame:
```
>>> df = pd.DataFrame([[1, 2, 3], [4, 5, 6], [7, 8, 9]],
                   index=['a', 'b', 'c'], columns=['A', 'B', 'C'])
>>> df
   A B C
a 1 2 3
b 4 5 6
c 7 8 9
>>> df.index.get_values()
array(['a', 'b', 'c'], dtype=object)

Standalone Index values:
```
```
>>> idx = pd.Index(['1', '2', '3'])
>>> idx.get_values()
array(['1', '2', '3'], dtype=object)
```

```
MultiIndex arrays also have only one dimension:
```
```
>>> midx = pd.MultiIndex.from_arrays([[1, 2, 3], ['a', 'b', 'c']],
                                  names=('number', 'letter'))
>>> midx.get_values()
array([(1, 'a'), (2, 'b'), (3, 'c')], dtype=object)
>>> midx.get_values().ndim
1
```

### 34.6.1.50 pandas.Index.groupby

**Index.groupby**(values)

Group the index labels by a given array of values.

**Parameters** values: array

Values used to determine the groups.

**Returns** groups: dict

{group name -> group labels}

### 34.6.1.51 pandas.Index.identical

**Index.identical**(other)

Similar to equals, but check that other comparable attributes are also equal

### 34.6.1.52 pandas.Index.insert

**Index.insert**(loc, item)

Make new Index inserting new item at location. Follows Python list.append semantics for negative values

**Parameters**

loc [int]

item [object]

**Returns**

new_index [Index]
### 34.6.1.53 pandas.Index.intersection

**Index.intersection**(other)

Form the intersection of two Index objects.

This returns a new Index with elements common to the index and other, preserving the order of the calling index.

**Parameters**

- **other** [Index or array-like]

**Returns**

- **intersection** [Index]

**Examples**

```python
test = pd.Index([1, 2, 3, 4])
test.intersection(test)  # Int64Index([1, 2, 3, 4], dtype='int64')
```

### 34.6.1.54 pandas.Index.is_

**Index.is**(other)

More flexible, faster check like is but that works through views

Note: this is not the same as `Index.identical()`, which checks that metadata is also the same.

**Parameters**

- **other**: object

**Returns**

- True if both have same underlying data, False otherwise [bool]

### 34.6.1.55 pandas.Index.is_categorical

**Index.is_categorical**

Check if the Index holds categorical data.

**Returns**

- **boolean**

  True if the Index is categorical.

**See also:**

* `CategoricalIndex` Index for categorical data.

**Examples**
>>> idx = pd.Index(["Watermelon", "Orange", "Apple", ...
"Watermelon"]).astype("category")

>>> idx.is_categorical()
True

>>> idx = pd.Index([1, 3, 5, 7])

>>> idx.is_categorical()
False

>>> s = pd.Series(["Peter", "Victor", "Elisabeth", "Mar"])

>>> s
0    Peter
1    Victor
2  Elisabeth
3     Mar
dtype: object

>>> s.index.is_categorical()
False

34.6.1.56 pandas.Index.isin

Index.isin(values, level=None)
Return a boolean array where the index values are in values.
Compute boolean array of whether each index value is found in the passed set of values. The length of
the returned boolean array matches the length of the index.

Parameters values : set or list-like
Sought values.

New in version 0.18.1: Support for values as a set.

level : str or int, optional
Name or position of the index level to use (if the index is a MultiIndex).

Returns is_contained : ndarray
NumPy array of boolean values.

See also:
Series.isin Same for Series.
DataFrame.isin Same method for DataFrames.

Notes
In the case of MultiIndex you must either specify values as a list-like object containing tuples that are the
same length as the number of levels, or specify level. Otherwise it will raise a ValueError.
If level is specified:
• if it is the name of one and only one index level, use that level;
• otherwise it should be a number indicating level position.
Examples

```python
>>> idx = pd.Index([1, 2, 3])
>>> idx
Int64Index([1, 2, 3], dtype='int64')

Check whether each index value in a list of values. >>> idx.isin([1, 4]) array([ True, False, False])

>>> midx = pd.MultiIndex.from_arrays([[1, 2, 3], ['red', 'blue', 'green']], names=('number', 'color'))
>>> midx
MultiIndex(levels=[['blue', 'green', 'red']], labels=[[0, 1, 2], [2, 0, 1]], names=['number', 'color'])

Check whether the strings in the ‘color’ level of the MultiIndex are in a list of colors.

```python
>>> midx.isin(['red', 'orange', 'yellow'], level='color')
array([ True, False, False])

To check across the levels of a MultiIndex, pass a list of tuples:

```python
>>> midx.isin([(1, 'red'), (3, 'red')])
array([ True, False, False])
```

For a DatetimeIndex, string values in `values` are converted to Timestamps.

```python
>>> dates = ['2000-03-11', '2000-03-12', '2000-03-13']
>>> dti = pd.to_datetime(dates)
>>> dti
DatetimeIndex(['2000-03-11', '2000-03-12', '2000-03-13'], dtype='datetime64[ns]', freq=None)

>>> dti.isin(['2000-03-11'])
array([ True, False, False])
```
**pandas.Index.dropna** omit entries with missing values.

**pandas.isna** top-level isna.

**Series.isna** detect missing values in Series object.

**Examples**

Show which entries in a `pandas.Index` are NA. The result is an array.

```python
>>> idx = pd.Index([5.2, 6.0, np.NaN])
>>> idx
Float64Index([5.2, 6.0, nan], dtype='float64')
>>> idx.isna()
array([False, False, True], dtype=bool)
```

Empty strings are not considered NA values. None is considered an NA value.

```python
>>> idx = pd.Index(['black', '', 'red', None])
>>> idx
Index(['black', '', 'red', None], dtype='object')
>>> idx.isna()
array([False, False, False, True], dtype=bool)
```

For datetimes, `NaT` (Not a Time) is considered as an NA value.

```python
>>> idx = pd.DatetimeIndex([pd.Timestamp('1940-04-25'), ... pd.Timestamp(''), None, pd.NaT])
>>> idx
DatetimeIndex(['1940-04-25', 'NaT', 'NaT', 'NaT'], dtype='datetime64[ns]', freq=None)
>>> idx.isna()
array([False, True, True, True], dtype=bool)
```

### 34.6.1.58 pandas.Index.isnull

`Index.isnull()`

Detect missing values.

Return a boolean same-sized object indicating if the values are NA. NA values, such as `None`, `numpy.NaN` or `pd.NaT`, get mapped to `True` values. Everything else get mapped to `False` values. Characters such as empty strings `''` or `numpy.inf` are not considered NA values (unless you set `pandas.options.mode.use_inf_as_na = True`).

New in version 0.20.0.

**Returns** `numpy.ndarray`

A boolean array of whether my values are NA

**See also:**

- **pandas.Index.notna** boolean inverse of isna.
- **pandas.Index.dropna** omit entries with missing values.
- **pandas.isna** top-level isna.
- **Series.isna** detect missing values in Series object.
Examples

Show which entries in a pandas.Index are NA. The result is an array.

```python
>>> idx = pd.Index([5.2, 6.0, np.NaN])
>>> idx
Float64Index([5.2, 6.0, nan], dtype='float64')
```
```python
>>> idx.isna()
array([False, False, True], dtype=bool)
```

Empty strings are not considered NA values. None is considered an NA value.

```python
>>> idx = pd.Index(['black', '', 'red', None])
>>> idx
Index(['black', '', 'red', None], dtype='object')
```
```python
>>> idx.isna()
array([False, False, False, True], dtype=bool)
```

For datetimes, NaT (Not a Time) is considered as an NA value.

```python
>>> idx
DatetimeIndex(['1940-04-25', 'NaT', 'NaT', 'NaT'], dtype='datetime64[ns]', freq=None)
```
```python
>>> idx.isna()
array([False, True, True, True], dtype=bool)
```

34.6.1.59 pandas.Index.item

Index.item() return the first element of the underlying data as a python scalar

34.6.1.60 pandas.Index.join

Index.join(other, how='left', level=None, return_indexers=False, sort=False) this is an internal non-public method

Compute join_index and indexers to conform data structures to the new index.

Parameters

- **other** [Index]
- **how** [‘left’, ‘right’, ‘inner’, ‘outer’]
- **level** [int or level name, default None]
- **return_indexers** [boolean, default False]
- **sort** [boolean, default False]

Sort the join keys lexicographically in the result Index. If False, the order of the join keys depends on the join type (how keyword)

New in version 0.20.0.

Returns
join_index, (left_indexer, right_indexer)

34.6.1.61 pandas.Index.map

Index.map (mapper, na_action=None)
Map values using input correspondence (a dict, Series, or function).

Parameters mapper : function, dict, or Series
Mapping correspondence.

na_action : {None, ‘ignore’}
If ‘ignore’, propagate NA values, without passing them to the mapping correspondence.

Returns applied : Union[Index, MultiIndex], inferred
The output of the mapping function applied to the index. If the function returns a tuple with more than one element a MultiIndex will be returned.

34.6.1.62 pandas.Index.max

Index.max()
Return the maximum value of the Index.

Returns scalar
Maximum value.

See also:

Index.min Return the minimum value in an Index.
Series.max Return the maximum value in a Series.
DataFrame.max Return the maximum values in a DataFrame.

Examples

```python
>>> idx = pd.Index([3, 2, 1])
>>> idx.max()
3
```

```python
>>> idx = pd.Index(['c', 'b', 'a'])
>>> idx.max()
'c'
```

For a MultiIndex, the maximum is determined lexicographically.

```python
>>> idx = pd.MultiIndex.from_product([('a', 'b'), (2, 1)])
>>> idx.max()
('b', 2)
```
34.6.1.63 pandas.Index.memory_usage

`memory_usage(deep=False)`
Memory usage of the values

**Parameters**
- **deep**: bool
  - Introspect the data deeply, interrogate object dtypes for system-level memory consumption

**Returns**
- bytes used

**See also:**
- `numpy.ndarray.nbytes`

**Notes**
Memory usage does not include memory consumed by elements that are not components of the array if deep=False or if used on PyPy

34.6.1.64 pandas.Index.min

`min()`
Return the minimum value of the Index.

**Returns**
- scalar
  - Minimum value.

**See also:**
- `Index.max` Return the maximum value of the object.
- `Series.min` Return the minimum value in a Series.
- `DataFrame.min` Return the minimum values in a DataFrame.

**Examples**

```python
>>> idx = pd.Index([3, 2, 1])
>>> idx.min()
1

>>> idx = pd.Index(['c', 'b', 'a'])
>>> idx.min()
'a'
```

For a MultiIndex, the minimum is determined lexicographically.

```python
>>> idx = pd.MultiIndex.from_product([['a', 'b'], (2, 1)])
>>> idx.min()
('a', 1)
```
34.6.1.65 pandas.Index.notna

Index.notna()

Detect existing (non-missing) values.

Return a boolean same-sized object indicating if the values are not NA. Non-missing values get mapped to True. Characters such as empty strings '' or numpy.inf are not considered NA values (unless you set pandas.options.mode.use_inf_as_na = True). NA values, such as None or numpy.NaN, get mapped to False values.

New in version 0.20.0.

Returns numpy.ndarray

Boolean array to indicate which entries are not NA.

See also:

Index.notnull  alias of notna
Index.isna  inverse of notna
pandas.notna  top-level notna

Examples

Show which entries in an Index are not NA. The result is an array.

```python
>>> idx = pd.Index([5.2, 6.0, np.NaN])
```  
```python
>>> idx
Float64Index([5.2, 6.0, nan], dtype='float64')
```  
```python
>>> idx.notna()
array([ True, True, False])
```  
Empty strings are not considered NA values. None is considered a NA value.

```python
>>> idx = pd.Index(["black", '', 'red', None])
```  
```python
>>> idx
Index(["black", '', 'red', None], dtype='object')
```  
```python
>>> idx.notna()
array([ True, True, True, False])
```

34.6.1.66 pandas.Index.notnull

Index.notnull()

Detect existing (non-missing) values.

Return a boolean same-sized object indicating if the values are not NA. Non-missing values get mapped to True. Characters such as empty strings '' or numpy.inf are not considered NA values (unless you set pandas.options.mode.use_inf_as_na = True). NA values, such as None or numpy.NaN, get mapped to False values.

New in version 0.20.0.

Returns numpy.ndarray

Boolean array to indicate which entries are not NA.

See also:
Index.notnull alias of notna
Index.isna inverse of notna
pandas.notna top-level notna

Examples

Show which entries in an Index are not NA. The result is an array.

```python
>>> idx = pd.Index([5.2, 6.0, np.NaN])
>>> idx
Float64Index([5.2, 6.0, nan], dtype='float64')
>>> idx.notna()
array([ True, True, False])
```

Empty strings are not considered NA values. None is considered a NA value.

```python
>>> idx = pd.Index(['black', '', 'red', None])
>>> idx
Index(['black', '', 'red', None], dtype='object')
>>> idx.notna()
array([ True, True, True, False])
```

34.6.1.67 pandas.Index.nunique

Index.nunique (dropna=True)

Return number of unique elements in the object.

Excludes NA values by default.

Parameters dropna : boolean, default True

Don’t include NaN in the count.

Returns

nunique [int]

34.6.1.68 pandas.Index.putmask

Index.putmask (mask, value)

return a new Index of the values set with the mask

See also:

numpy.ndarray.putmask

34.6.1.69 pandas.Index.ravel

Index.ravel (order='C')

return an ndarray of the flattened values of the underlying data

See also:

numpy.ndarray.ravel
34.6.1.70 pandas.Index.reindex

Index.reindex (target, method=None, level=None, limit=None, tolerance=None)
Create index with target’s values (move/add/delete values as necessary)

Parameters

target [an iterable]

Returns new_index : pd.Index
Resulting index
indexer : np.ndarray or None
Indices of output values in original index

34.6.1.71 pandas.Index.rename

Index.rename (name, inplace=False)
Set new names on index. Defaults to returning new index.

Parameters name : str or list

inplace : bool
if True, mutates in place

Returns
new index (of same type and class...etc) [if inplace, returns None]

34.6.1.72 pandas.Index.repeat

Index.repeat (repeats, *args, **kwargs)
Repeat elements of an Index.

Returns a new index where each element of the current index is repeated consecutively a given number of times.

Parameters repeats : int
The number of repetitions for each element.

**kwargs
Additional keywords have no effect but might be accepted for compatibility with numpy.

Returns pandas.Index
Newly created Index with repeated elements.

See also:

Series.repeat Equivalent function for Series
numpy.repeat Underlying implementation
Examples

```python
>>> idx = pd.Index([1, 2, 3])
>>> idx
Int64Index([1, 2, 3], dtype='int64')
>>> idx.repeat(2)
Int64Index([1, 1, 2, 2, 3, 3], dtype='int64')
>>> idx.repeat(3)
Int64Index([1, 1, 1, 2, 2, 2, 3, 3, 3], dtype='int64')
```

34.6.1.73 pandas.Index.searchsorted

`Index.searchsorted(value, side='left', sorter=None)`

Find indices where elements should be inserted to maintain order.

Find the indices into a sorted IndexOpsMixIn `self` such that, if the corresponding elements in `value` were inserted before the indices, the order of `self` would be preserved.

**Parameters**

- `value`: array_like
  Values to insert into `self`.
- `side`: {'left', 'right'}, optional
  If ‘left’, the index of the first suitable location found is given. If ‘right’, return the last such index. If there is no suitable index, return either 0 or N (where N is the length of `self`).
- `sorter`: 1-D array_like, optional
  Optional array of integer indices that sort `self` into ascending order. They are typically the result of `np.argsort`.

**Returns**

- `indices`: array of ints
  Array of insertion points with the same shape as `value`.

**See also:**

`numpy.searchsorted`

**Notes**

Binary search is used to find the required insertion points.

**Examples**

```python
>>> x = pd.Series([1, 2, 3])
>>> x
0 1
1 2
2 3
dtype: int64

>>> x.searchsorted(4)
array([3])
```
>>> x.searchsorted([0, 4])
aarray([0, 3])

>>> x.searchsorted([1, 3], side='left')
aarray([0, 2])

>>> x.searchsorted([1, 3], side='right')
aarray([1, 3])

>>> x = pd.Categorical(['apple', 'bread', 'bread',
                        'cheese', 'milk'], ordered=True)
[apple, bread, bread, cheese, milk]
Categories (4, object): [apple < bread < cheese < milk]

>>> x.searchsorted('bread')
aarray([1]) # Note: an array, not a scalar

>>> x.searchsorted(['bread'], side='right')
aarray([3])

34.6.1.74 pandas.Index.set_names

Index.set_names(names, level=None, inplace=False)
Set new names on index. Defaults to returning new index.

Parameters

names : str or sequence
    name(s) to set

level : int, level name, or sequence of int/level names (default None)
    If the index is a MultiIndex (hierarchical), level(s) to set (None for all levels).
    Otherwise level must be None

inplace : bool
    if True, mutates in place

Returns

new index (of same type and class...etc) [if inplace, returns None]

Examples

    >>> Index([1, 2, 3, 4]).set_names('foo')
Int64Index([1, 2, 3, 4], dtype='int64', name='foo')

    >>> Index([1, 2, 3, 4]).set_names(['foo'])
Int64Index([1, 2, 3, 4], dtype='int64', name='foo')

    >>> idx = MultiIndex.from_tuples([(1, u'one'), (1, u'two'),
                                    (2, u'one'), (2, u'two')],
                                   names=['foo', 'bar'])

    >>> idx.set_names(['baz', 'quz'])
MultiIndex(levels=[[1, 2], [u'one', u'two']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=['baz', 'quz'])
idx.set_names('baz', level=0)
MultiIndex(levels=[[1, 2], ['one', 'two']],
          labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
          names=['baz', 'bar'])

34.6.1.75 pandas.Index.set_value

Index.set_value(arr, key, value)
   Fast lookup of value from 1-dimensional ndarray. Only use this if you know what you're doing

34.6.1.76 pandas.Index.shift

Index.shift(periods=1, freq=None)
   Shift index by desired number of time frequency increments.
   This method is for shifting the values of datetime-like indexes by a specified time increment a given
   number of times.

   Parameters
   periods : int, default 1
      Number of periods (or increments) to shift by, can be positive or negative.

   freq : pandas.DateOffset, pandas.Timedelta or string, optional
      Frequency increment to shift by. If None, the index is shifted by its own freq
      attribute. Offset aliases are valid strings, e.g., ‘D’, ‘W’, ‘M’ etc.

   Returns
   pandas.Index
      shifted index

   See also:

   Series.shift Shift values of Series.

Notes

This method is only implemented for datetime-like index classes, i.e., DatetimeIndex, PeriodIndex and
TimedeltaIndex.

Examples

Put the first 5 month starts of 2011 into an index.

>>> month_starts = pd.date_range('1/1/2011', periods=5, freq='MS')
>>> month_starts
DatetimeIndex(['2011-01-01', '2011-02-01', '2011-03-01', '2011-04-01',
               '2011-05-01'],
              dtype='datetime64[ns]', freq='MS')

Shift the index by 10 days.
The default value of `freq` is the `freq` attribute of the index, which is ‘MS’ (month start) in this example.

```
>>> month_starts.shift(10, freq='D')
              '2011-05-11'],
              dtype='datetime64[ns]', freq=None)
```

34.6.1.77 pandas.Index.slice_indexer

`Index.slice_indexer(start=None, end=None, step=None, kind=None)`

For an ordered or unique index, compute the slice indexer for input labels and step.

**Parameters**

- `start` : label, default None
  - If None, defaults to the beginning
- `end` : label, default None
  - If None, defaults to the end
- `step` : int, default None
- `kind` : string, default None

**Returns**

- `indexer` : slice

**Raises**

- `KeyError` : If key does not exist, or key is not unique and index is not ordered.

**Notes**

This function assumes that the data is sorted, so use at your own peril.

**Examples**

This is a method on all index types. For example you can do:

```
>>> idx = pd.Index(list('abcd'))
>>> idx.slice_indexer(start='b', end='c')
slice(1, 3)
```

```
>>> idx = pd.MultiIndex.from_arrays([list('abcd'), list('efgh')])
>>> idx.slice_indexer(start='b', end=('c', 'g'))
slice(1, 3)
```
34.6.1.78 pandas.Index.slice_locs

Index.slice_locs (start=None, end=None, step=None, kind=None)
Compute slice locations for input labels.

Parameters
start : label, default None
    If None, defaults to the beginning
end : label, default None
    If None, defaults to the end
step : int, defaults None
    If None, defaults to 1

kind [{‘ix’, ‘loc’, ‘getitem’} or None]

Returns
start, end [int]

See also:
Index.get_loc Get location for a single label

Notes
This method only works if the index is monotonic or unique.

Examples

>>> idx = pd.Index(list('abcd'))
>>> idx.slice_locs(start='b', end='c')
(1, 3)

34.6.1.79 pandas.Index.sort_values

Index.sort_values (return_indexer=False, ascending=True)
Return a sorted copy of the index.

Return a sorted copy of the index, and optionally return the indices that sorted the index itself.

Parameters
return_indexer : bool, default False
    Should the indices that would sort the index be returned.

ascending : bool, default True
    Should the index values be sorted in an ascending order.

Returns
sorted_index : pandas.Index
    Sorted copy of the index.

indexer : numpy.ndarray, optional
    The indices that the index itself was sorted by.
See also:

**pandas.Series.sort_values** Sort values of a Series.

**pandas.DataFrame.sort_values** Sort values in a DataFrame.

Examples

```python
>>> idx = pd.Index([10, 100, 1, 1000])
>>> idx
Int64Index([10, 100, 1, 1000], dtype='int64')

Sort values in ascending order (default behavior).

```python
>>> idx.sort_values()
Int64Index([1, 10, 100, 1000], dtype='int64')
``` 

Sort values in descending order, and also get the indices `idx` was sorted by.

```python
>>> idx.sort_values(ascending=False, return_indexer=True)
(Int64Index([1000, 100, 10, 1], dtype='int64'), array([3, 1, 0, 2]))
```

34.6.1.80 pandas.Index.sortlevel

Index.sortlevel(levell=None, ascending=True, sort_remaining=None)

For internal compatibility with with the Index API

Sort the Index. This is for compat with MultiIndex

Parameters ascending : boolean, default True

False to sort in descending order

level, sort_remaining are compat parameters

Returns

sorted_index [Index]

34.6.1.81 pandas.Index.str

Index.str()

Vectorized string functions for Series and Index. NAs stay NA unless handled otherwise by a particular method. Patterned after Python’s string methods, with some inspiration from R’s stringr package.

Examples

```python
>>> s.str.split('_')
```

```python
>>> s.str.replace('_', '')
```
**34.6.1.82 pandas.Index.summary**

`Index.summary(name=None)`

Return a summarized representation. .. deprecated:: 0.23.0

**34.6.1.83 pandas.Index.symmetric_difference**

`Index.symmetric_difference(other, result_name=None)`

Compute the symmetric difference of two Index objects. It's sorted if sorting is possible.

**Parameters**

- `other` [Index or array-like]
- `result_name` [str]

**Returns**

- `symmetric_difference` [Index]

**Notes**

`symmetric_difference` contains elements that appear in either `idx1` or `idx2` but not both. Equivalent to the Index created by `idx1.difference(idx2) | idx2.difference(idx1)` with duplicates dropped.

**Examples**

```python
>>> idx1 = Index([1, 2, 3, 4])
>>> idx2 = Index([2, 3, 4, 5])
>>> idx1.symmetric_difference(idx2)
Int64Index([1, 5], dtype='int64')
```

You can also use the `^` operator:

```python
>>> idx1 ^ idx2
Int64Index([1, 5], dtype='int64')
```

**34.6.1.84 pandas.Index.take**

`Index.take(indices, axis=0, allow_fill=True, fill_value=None, **kwargs)`

return a new Index of the values selected by the indices

For internal compatibility with numpy arrays.

**Parameters**

- `indices` : list
  - Indices to be taken
- `axis` : int, optional
  - The axis over which to select values, always 0.
- `allow_fill` [bool, default True]
fill_value : bool, default None

If allow_fill=True and fill_value is not None, indices specified by -1 is regarded as NA. If Index doesn’t hold NA, raise ValueError

See also:

numpy.ndarray.take

34.6.1.85 pandas.Index.to_frame

Index.to_frame(index=True)
Create a DataFrame with a column containing the Index.

New in version 0.21.0.

Parameters index : boolean, default True
Set the index of the returned DataFrame as the original Index.

Returns DataFrame
DataFrame containing the original Index data.

See also:

Index.to_series Convert an Index to a Series.
Series.to_frame Convert Series to DataFrame.

Examples

```python
>>> idx = pd.Index(['Ant', 'Bear', 'Cow'], name='animal')
>>> idx.to_frame()
     animal
    Ant   Ant
   Bear  Bear
  Cow   Cow
```

By default, the original Index is reused. To enforce a new Index:

```python
>>> idx.to_frame(index=False)
     animal
   0  Ant
   1  Bear
   2  Cow
```

34.6.1.86 pandas.Index.to_native_types

Index.to_native_types(slicer=None, **kwargs)
Format specified values of self and return them.

Parameters slicer : int, array-like
An indexer into self that specifies which values are used in the formatting process.

kwargs : dict
Options for specifying how the values should be formatted. These options include the following:

1. **na_rep** [str] The value that serves as a placeholder for NULL values
2. **quoting** [bool or None] Whether or not there are quoted values in `self`
3. **date_format** [str] The format used to represent date-like values

### 34.6.1.87 pandas.Index.to_series

**Index.to_series** *(index=None, name=None)*

Create a Series with both index and values equal to the index keys useful with map for returning an indexer based on an index

**Parameters**

- **index**: Index, optional
  - index of resulting Series. If None, defaults to original index
- **name**: string, optional
  - name of resulting Series. If None, defaults to name of original index

**Returns**

- **Series**: [dtype will be based on the type of the Index values.]

### 34.6.1.88 pandas.Index.tolist

**Index.tolist()**

Return a list of the values.

These are each a scalar type, which is a Python scalar (for str, int, float) or a pandas scalar (for Timestamp/Timedelta/Interval/Period)

**See also:**

- `numpy.ndarray.tolist`

### 34.6.1.89 pandas.Index.transpose

**Index.transpose(*args, **kwargs)**

return the transpose, which is by definition self

### 34.6.1.90 pandas.Index.union

**Index.union(other)**

Form the union of two Index objects and sorts if possible.

**Parameters**

- **other**: [Index or array-like]

**Returns**

- **union**: [Index]
Examples

```python
>>> idx1 = pd.Index([1, 2, 3, 4])
>>> idx2 = pd.Index([3, 4, 5, 6])
>>> idx1.union(idx2)
Int64Index([1, 2, 3, 4, 5, 6], dtype='int64')
```

34.6.1.91 pandas.Index.unique

`Index.unique(level=None)`

Return unique values in the index. Uniques are returned in order of appearance, this does NOT sort.

**Parameters**

- `level`: int or str, optional, default None
  
  Only return values from specified level (for MultiIndex)

**Returns**

- Index without duplicates

**See also:**

unique, Series.unique

34.6.1.92 pandas.Index.value_counts

`Index.value_counts(normalize=False, sort=True, ascending=False, bins=None, dropna=True)`

Returns object containing counts of unique values.

The resulting object will be in descending order so that the first element is the most frequently-occurring element. Excludes NA values by default.

**Parameters**

- `normalize`: boolean, default False
  
  If True then the object returned will contain the relative frequencies of the unique values.

- `sort`: boolean, default True
  
  Sort by values

- `ascending`: boolean, default False
  
  Sort in ascending order

- `bins`: integer, optional
  
  Rather than count values, group them into half-open bins, a convenience for pd.cut, only works with numeric data

- `dropna`: boolean, default True
  
  Don’t include counts of NaN.

**Returns**

- counts [Series]
### 34.6.1.93 pandas.Index.where

`Index.where (cond, other=None)`

New in version 0.19.0.

Return an Index of same shape as self and whose corresponding entries are from self where `cond` is True and otherwise are from other.

**Parameters**

- `cond` [boolean array-like with the same length as self]
- `other` [scalar, or array-like]

<table>
<thead>
<tr>
<th>holds_integer</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>is_boolean</td>
<td></td>
</tr>
<tr>
<td>is_float</td>
<td></td>
</tr>
<tr>
<td>is_integer</td>
<td></td>
</tr>
<tr>
<td>is_interval</td>
<td></td>
</tr>
<tr>
<td>is_lexsorted_for_tuple</td>
<td></td>
</tr>
<tr>
<td>is_mixed</td>
<td></td>
</tr>
<tr>
<td>is_numeric</td>
<td></td>
</tr>
<tr>
<td>is_object</td>
<td></td>
</tr>
<tr>
<td>is_type_compatible</td>
<td></td>
</tr>
<tr>
<td>sort</td>
<td></td>
</tr>
<tr>
<td>view</td>
<td></td>
</tr>
</tbody>
</table>

### 34.6.2 Attributes

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Index.values</code></td>
<td>return the underlying data as an ndarray</td>
</tr>
<tr>
<td><code>Index.is_monotonic</code></td>
<td>alias for <code>is_monotonic_increasing</code> (deprecated)</td>
</tr>
<tr>
<td><code>Index.is_monotonic_increasing</code></td>
<td>return if the index is monotonic increasing (only equal or increasing) values.</td>
</tr>
<tr>
<td><code>Index.is_monotonic_decreasing</code></td>
<td>return if the index is monotonic decreasing (only equal or decreasing) values.</td>
</tr>
<tr>
<td><code>Index.is_unique</code></td>
<td>return if the index has unique values</td>
</tr>
<tr>
<td><code>Index.has_duplicates</code></td>
<td>return if I have any nans; enables various perf speedups</td>
</tr>
<tr>
<td><code>Index.dtype</code></td>
<td>return the dtype object of the underlying data</td>
</tr>
<tr>
<td><code>Index.dtype_str</code></td>
<td>return the dtype str of the underlying data</td>
</tr>
<tr>
<td><code>Index.inferred_type</code></td>
<td>return a string of the type inferred from the values</td>
</tr>
<tr>
<td><code>Index.is_all_dates</code></td>
<td>return a tuple of the shape of the underlying data</td>
</tr>
<tr>
<td><code>Index.name</code></td>
<td></td>
</tr>
<tr>
<td><code>Index.names</code></td>
<td></td>
</tr>
<tr>
<td><code>Index.nbytes</code></td>
<td>return the number of bytes in the underlying data</td>
</tr>
<tr>
<td><code>Index.ndim</code></td>
<td>return the number of dimensions of the underlying data, by definition 1</td>
</tr>
<tr>
<td><code>Index.size</code></td>
<td>return the number of elements in the underlying data</td>
</tr>
<tr>
<td><code>Index.empty</code></td>
<td></td>
</tr>
<tr>
<td><code>Index.strides</code></td>
<td>return the strides of the underlying data</td>
</tr>
</tbody>
</table>

Continued on next page
Table 98 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index.itemsize</td>
<td>return the size of the dtype of the item of the underlying data</td>
</tr>
<tr>
<td>Index.base</td>
<td>return the base object if the memory of the underlying data is shared</td>
</tr>
<tr>
<td>Index.T</td>
<td>return the transpose, which is by definition self</td>
</tr>
<tr>
<td>Index.memory_usage([deep])</td>
<td>Memory usage of the values</td>
</tr>
</tbody>
</table>

34.6.2.1 pandas.Index.has_duplicates

Index.has_duplicates

34.6.2.2 pandas.Index.is_all_dates

Index.is_all_dates

34.6.2.3 pandas.Index.name

Index.name = None

34.6.2.4 pandas.Index.names

Index.names

34.6.2.5 pandas.Index.empty

Index.empty

34.6.3 Modifying and Computations

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index.all(*args, **kwargs)</td>
<td>Return whether all elements are True.</td>
</tr>
<tr>
<td>Index.any(*args, **kwargs)</td>
<td>Return whether any element is True.</td>
</tr>
<tr>
<td>Index.argmin([axis])</td>
<td>return a ndarray of the minimum argument indexer</td>
</tr>
<tr>
<td>Index.argmax([axis])</td>
<td>return a ndarray of the maximum argument indexer</td>
</tr>
<tr>
<td>Index.copy([name, deep, dtype])</td>
<td>Make a copy of this object</td>
</tr>
<tr>
<td>Index.delete(loc)</td>
<td>Make new Index with passed location(s) deleted</td>
</tr>
<tr>
<td>Index.drop(labels[, errors])</td>
<td>Make new Index with passed list of labels deleted</td>
</tr>
<tr>
<td>Index.drop_duplicates([keep])</td>
<td>Return Index with duplicate values removed.</td>
</tr>
<tr>
<td>Index.duplicated([keep])</td>
<td>Indicate duplicate index values.</td>
</tr>
<tr>
<td>Index.equals(other)</td>
<td>Determines if two Index objects contain the same elements.</td>
</tr>
<tr>
<td>Index.factorize([sort, na_sentinel])</td>
<td>Encode the object as an enumerated type or categorical variable.</td>
</tr>
<tr>
<td>Index.identical(other)</td>
<td>Similar to equals, but check that other comparable attributes are also equal</td>
</tr>
<tr>
<td>Index.insert(loc, item)</td>
<td>Make new Index inserting new item at location.</td>
</tr>
<tr>
<td>Index.is_(other)</td>
<td>More flexible, faster check like is but that works through views</td>
</tr>
</tbody>
</table>

Continued on next page
Table 99 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Index.is_boolean()</code></td>
<td>Check if the Index holds boolean data.</td>
</tr>
<tr>
<td><code>Index.is_categorical()</code></td>
<td></td>
</tr>
<tr>
<td><code>Index.is_integer()</code></td>
<td></td>
</tr>
<tr>
<td><code>Index.is_interval()</code></td>
<td></td>
</tr>
<tr>
<td><code>Index.is_lexsorted_for_tuple(tup)</code></td>
<td></td>
</tr>
<tr>
<td><code>Index.is_mixed()</code></td>
<td></td>
</tr>
<tr>
<td><code>Index.is_numeric()</code></td>
<td></td>
</tr>
<tr>
<td><code>Index.is_object()</code></td>
<td></td>
</tr>
<tr>
<td><code>Index.min()</code></td>
<td>Return the minimum value of the Index.</td>
</tr>
<tr>
<td><code>Index.max()</code></td>
<td>Return the maximum value of the Index.</td>
</tr>
<tr>
<td><code>Index.reindex(target[, method, level, ...])</code></td>
<td>Create index with target’s values (move/add/delete values as necessary)</td>
</tr>
<tr>
<td><code>Index.rename(name[, inplace])</code></td>
<td>Set new names on index.</td>
</tr>
<tr>
<td><code>Index.repeat(repeats, *args, **kwargs)</code></td>
<td>Repeat elements of an Index.</td>
</tr>
<tr>
<td><code>Index.where(cond[, other])</code></td>
<td></td>
</tr>
<tr>
<td><code>Index.take(indices[, axis, allow_fill, ...])</code></td>
<td>return a new Index of the values selected by the indices</td>
</tr>
<tr>
<td><code>Index.putmask(mask, value)</code></td>
<td></td>
</tr>
<tr>
<td><code>Index.set_names(names[, level, inplace])</code></td>
<td>Set new names on index.</td>
</tr>
<tr>
<td><code>Index.unique([level])</code></td>
<td>Return unique values in the index.</td>
</tr>
<tr>
<td><code>Index.nunique([dropna])</code></td>
<td>Return number of unique elements in the object.</td>
</tr>
<tr>
<td><code>Index.value_counts([normalize, sort, ...])</code></td>
<td>Returns object containing counts of unique values.</td>
</tr>
</tbody>
</table>

### 34.6.3.1 pandas.Index.is_boolean

Index.is_boolean()

### 34.6.3.2 pandas.Index.is_floating

Index.is_floating()

### 34.6.3.3 pandas.Index.is_integer

Index.is_integer()

### 34.6.3.4 pandas.Index.is_interval

Index.is_interval()

### 34.6.3.5 pandas.Index.is_lexsorted_for_tuple

Index.is_lexsorted_for_tuple(tup)

### 34.6.3.6 pandas.Index.is_mixed

Index.is_mixed()
34.6.3.7 pandas.Index.is_numeric

Index.is_numeric()

34.6.3.8 pandas.Index.is_object

Index.is_object()

34.6.4 Missing Values

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index.fillna()</td>
<td>Fill NA/NaN values with the specified value</td>
</tr>
<tr>
<td>Index.dropna()</td>
<td>Return Index without NA/NaN values</td>
</tr>
<tr>
<td>Index.isna()</td>
<td>Detect missing values</td>
</tr>
<tr>
<td>Index.notna()</td>
<td>Detect existing (non-missing) values</td>
</tr>
</tbody>
</table>

34.6.5 Conversion

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index.astype()</td>
<td>Create an Index with values cast to dtypes.</td>
</tr>
<tr>
<td>Index.item()</td>
<td>return the first element of the underlying data as a python scalar</td>
</tr>
<tr>
<td>Index.map()</td>
<td>Map values using input correspondence (a dict, Series, or function).</td>
</tr>
<tr>
<td>Index.ravel()</td>
<td>return an ndarray of the flattened values of the underlying data</td>
</tr>
<tr>
<td>Index.tolist()</td>
<td>Return a list of the values.</td>
</tr>
<tr>
<td>Index.to_native_types()</td>
<td>Format specified values of self and return them.</td>
</tr>
<tr>
<td>Index.to_series()</td>
<td>Create a Series with both index and values equal to the index keys useful with map for returning an indexer based on an index</td>
</tr>
<tr>
<td>Index.to_frame()</td>
<td>Create a DataFrame with a column containing the Index.</td>
</tr>
<tr>
<td>Index.view()</td>
<td></td>
</tr>
</tbody>
</table>

34.6.5.1 pandas.Index.view

Index.view(cls=None)

34.6.6 Sorting

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index.argsort()</td>
<td>Return the integer indicies that would sort the index.</td>
</tr>
<tr>
<td>Index.searchsorted()</td>
<td>Find indices where elements should be inserted to maintain order.</td>
</tr>
<tr>
<td>Index.sort_values()</td>
<td>Return a sorted copy of the index.</td>
</tr>
</tbody>
</table>

34.6.7 Time-specific operations

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
</table>
**Index.shift**([periods, freq])  
Shift index by desired number of time frequency increments.

### 34.6.8 Combining / joining / set operations

**Index.append**(other)  
Append a collection of Index options together

**Index.join**(other[, how, level, ...])  
*this is an internal non-public method*

**Index.intersection**(other)  
Form the intersection of two Index objects.

**Index.union**(other)  
Form the union of two Index objects and sorts if possible.

**Index.difference**(other)  
Return a new Index with elements from the index that are not in other.

**Index.symmetric_difference**(other[, result_name])  
Compute the symmetric difference of two Index objects.

### 34.6.9 Selecting

**Index.asof**(label)  
For a sorted index, return the most recent label up to and including the passed label.

**Index.asof_locs**(where, mask)  
where : array of timestamps  
mask : array of booleans  
where data is not NA

**Index.contains**(key)  
return a boolean if this key is IN the index

**Index.get_duplicates**()  
(DEPRECATED) Extract duplicated index elements.

**Index.get_indexer**(target[, method, limit, ...])  
Compute indexer and mask for new index given the current index.

**Index.get_indexer_non_unique**(target)  
Compute indexer and mask for new index given the current index.

**Index.get_level_values**(level)  
Return an Index of values for requested level, equal to the length of the index.

**Index.get_loc**(key[, method, tolerance])  
Get integer location, slice or boolean mask for requested label.

**Index.get_slice_bound**(label, side, kind)  
Calculate slice bound that corresponds to given label.

**Index.get_value**(series, key)  
Fast lookup of value from 1-dimensional ndarray.

**Index.get_values**()  
Return Index data as a numpy.ndarray.

**Index.set_value**(arr, key, value)  
Fast lookup of value from 1-dimensional ndarray.

**Index.isin**(values[, level])  
Return a boolean array where the index values are in values.

**Index.slice_indexer**([start, end, step, kind])  
For an ordered or unique index, compute the slice indexer for input labels and step.

**Index.slice_locs**([start, end, step, kind])  
Compute slice locations for input labels.

### 34.7 Numeric Index
RangeIndex

Immutable Index implementing a monotonic integer range.

Int64Index

Immutable ndarray implementing an ordered, sliceable set.

UInt64Index

Immutable ndarray implementing an ordered, sliceable set.

Float64Index

Immutable ndarray implementing an ordered, sliceable set.

34.7.1 pandas.RangeIndex

class pandas.RangeIndex

Immutable Index implementing a monotonic integer range.

RangeIndex is a memory-saving special case of Int64Index limited to representing monotonic ranges. Using RangeIndex may in some instances improve computing speed.

This is the default index type used by DataFrame and Series when no explicit index is provided by the user.

Parameters

- start : int (default: 0), or other RangeIndex instance.
  
  If int and “stop” is not given, interpreted as “stop” instead.

- stop [int (default: 0)]

- step [int (default: 1)]

- name : object, optional
  
  Name to be stored in the index

- copy : bool, default False
  
  Unused, accepted for homogeneity with other index types.

See also:

- Index The base pandas Index type
- Int64Index Index of int64 data

Attributes

None

Methods

from_range(data[, name, dtype])

create RangeIndex from a range (py3), or xrange (py2) object
34.7.1.1 pandas.RangeIndex.from_range

classmethod RangeIndex.from_range(data, name=None, dtype=None, **kwargs)
create RangeIndex from a range (py3), or xrange (py2) object

34.7.2 pandas.Int64Index

class pandas.Int64Index
Immutable ndarray implementing an ordered, sliceable set. The basic object storing axis labels for all pandas objects. Int64Index is a special case of Index with purely integer labels.

Parameters

data [array-like (1-dimensional)]
dtype [NumPy dtype (default: int64)]
copy : bool
    Make a copy of input ndarray
name : object
    Name to be stored in the index

See also:

Index The base pandas Index type

Notes

An Index instance can only contain hashable objects.

Attributes

| None |

Methods

| None |

34.7.3 pandas.UInt64Index

class pandas.UInt64Index
Immutable ndarray implementing an ordered, sliceable set. The basic object storing axis labels for all pandas objects. UInt64Index is a special case of Index with purely unsigned integer labels.

Parameters

data [array-like (1-dimensional)]
dtype [NumPy dtype (default: uint64)]
copy : bool
    Make a copy of input ndarray
name : object
    Name to be stored in the index

See also:

Index The base pandas Index type

Notes

An Index instance can only contain hashable objects.

Attributes

None

Methods

None

34.7.4 pandas.Float64Index

class pandas.Float64Index
    Immutable ndarray implementing an ordered, sliceable set. The basic object storing axis labels for all pandas objects. Float64Index is a special case of Index with purely float labels.

Parameters

data [array-like (1-dimensional)]
dtype [NumPy dtype (default: float64)]
copy : bool
    Make a copy of input ndarray
name : object
    Name to be stored in the index

See also:

Index The base pandas Index type

Notes

An Index instance can only contain hashable objects.
### Attributes

| None |

### Methods

| None |

### `RangeIndex.from_range(data[, name, dtype])` create RangeIndex from a range (py3), or xrange (py2) object

### 34.8 CategoricalIndex

CategoricalIndex

Immutable Index implementing an ordered, sliceable set.

### 34.8.1 pandas.CategoricalIndex

class pandas.CategoricalIndex

Immutable Index implementing an ordered, sliceable set. CategoricalIndex represents a sparsely populated Index with an underlying Categorical.

**Parameters**

- `data` [array-like or Categorical, (1-dimensional)]
- `categories` : optional, array-like
  - categories for the CategoricalIndex
- `ordered` : boolean,
  - designating if the categories are ordered
- `copy` : bool
  - Make a copy of input ndarray
- `name` : object
  - Name to be stored in the index

**See also:**

Categorical, Index

### Attributes

| codes |
| categories |
| ordered |
### Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>rename_categories(*args, **kwargs)</code></td>
<td>Renames categories.</td>
</tr>
<tr>
<td><code>reorder_categories(*args, **kwargs)</code></td>
<td>Reorders categories as specified in new_categories.</td>
</tr>
<tr>
<td><code>add_categories(*args, **kwargs)</code></td>
<td>Add new categories.</td>
</tr>
<tr>
<td><code>remove_categories(*args, **kwargs)</code></td>
<td>Removes the specified categories.</td>
</tr>
<tr>
<td><code>remove_unused_categories(*args, **kwargs)</code></td>
<td>Removes categories which are not used.</td>
</tr>
<tr>
<td><code>set_categories(*args, **kwargs)</code></td>
<td>Sets the categories to the specified new_categories.</td>
</tr>
<tr>
<td><code>as_ordered(*args, **kwargs)</code></td>
<td>Sets the Categorical to be ordered</td>
</tr>
<tr>
<td><code>as_unordered(*args, **kwargs)</code></td>
<td>Sets the Categorical to be unordered</td>
</tr>
<tr>
<td><code>map(mapper)</code></td>
<td>Map values using input correspondence (a dict, Series, or function).</td>
</tr>
</tbody>
</table>

### 34.8.1 pandas.CategoricalIndex.rename_categories

CategoricalIndex.rename_categories(*args, **kwargs)

Renames categories.

**Parameters new_categories**: list-like, dict-like or callable

- list-like: all items must be unique and the number of items in the new categories must match the existing number of categories.
- dict-like: specifies a mapping from old categories to new. Categories not contained in the mapping are passed through and extra categories in the mapping are ignored.
  
  New in version 0.21.0.

- callable: a callable that is called on all items in the old categories and whose return values comprise the new categories.
  
  New in version 0.23.0.

**Warning**: Currently, Series are considered list like. In a future version of pandas they’ll be considered dict-like.

**inplace**: boolean (default: False)

Whether or not to rename the categories in-place or return a copy of this categorical with renamed categories.

**Returns cat**: Categorical or None

With inplace=False, the new categorical is returned. With inplace=True, there is no return value.

**Raises ValueError**

If new categories are list-like and do not have the same number of items than the current categories or do not validate as categories.

**See also:**

`reorder_categories`, `add_categories`, `remove_categories`, `remove_unused_categories`, `set_categories`
Examples

```python
>>> c = Categorical(['a', 'a', 'b'])
>>> c.rename_categories([0, 1])
[0, 0, 1]
Categories (2, int64): [0, 1]
```

For dict-like `new_categories`, extra keys are ignored and categories not in the dictionary are passed through

```python
>>> c.rename_categories({'a': 'A', 'c': 'C'})
[A, A, b]
Categories (2, object): [A, b]
```

You may also provide a callable to create the new categories

```python
>>> c.rename_categories(lambda x: x.upper())
[A, A, B]
Categories (2, object): [A, B]
```

### 34.8.1.2 pandas.CategoricalIndex.reorder_categories

CategoricalIndex.reorder_categories(*args, **kwargs)
Reorders categories as specified in new_categories.

- **new_categories**: Index-like
  The categories in new order.
- **ordered**: boolean, optional
  Whether or not the categorical is treated as a ordered categorical. If not given, do not change the ordered information.
- **inplace**: boolean (default: False)
  Whether or not to reorder the categories inplace or return a copy of this categorical with reordered categories.

**Returns**

- **cat**: [Categorical with reordered categories or None if inplace.]

**Raises**

- ValueError
  If the new categories do not contain all old category items or any new ones

**See also:**

- rename_categories
- add_categories
- remove_categories
- remove_unused_categories
- set_categories

### 34.8.1.3 pandas.CategoricalIndex.add_categories

CategoricalIndex.add_categories(*args, **kwargs)
Add new categories.
new_categories will be included at the last/highest place in the categories and will be unused directly after this call.

Parameters new_categories : category or list-like of category
   The new categories to be included.

inplace : boolean (default: False)
   Whether or not to add the categories inplace or return a copy of this categorical with added categories.

Returns
   cat [Categorical with new categories added or None if inplace.]

Raises ValueError
   If the new categories include old categories or do not validate as categories

See also:
rename_categories, reorder_categories, remove_categories, remove_unused_categories, set_categories

34.8.1.4 pandas.CategoricalIndex.remove_categories

CategoricalIndex.remove_categories(*args, **kwargs)
Removes the specified categories.
removals must be included in the old categories. Values which were in the removed categories will be set to NaN

Parameters removals : category or list of categories
   The categories which should be removed.

inplace : boolean (default: False)
   Whether or not to remove the categories inplace or return a copy of this categorical with removed categories.

Returns
   cat [Categorical with removed categories or None if inplace.]

Raises ValueError
   If the removals are not contained in the categories

See also:
rename_categories, reorder_categories, add_categories, remove_unused_categories, set_categories

34.8.1.5 pandas.CategoricalIndex.remove_unused_categories

CategoricalIndex.remove_unused_categories(*args, **kwargs)
Removes categories which are not used.

Parameters inplace : boolean (default: False)
   Whether or not to drop unused categories inplace or return a copy of this categorical with unused categories dropped.
Returns

cat [Categorical with unused categories dropped or None if inplace.]

See also:
rename_categories, reorder_categories, add_categories, remove_categories, set_categories

34.8.1.6 pandas.CategoricalIndex.set_categories

CategoricalIndex.set_categories(*args, **kwargs)

Sets the categories to the specified new_categories.

new_categories can include new categories (which will result in unused categories) or remove old categories (which results in values set to NaN). If rename=True, the categories will simply be renamed (less or more items than in old categories will result in values set to NaN or in unused categories respectively).

This method can be used to perform more than one action of adding, removing, and reordering simultaneously and is therefore faster than performing the individual steps via the more specialised methods.

On the other hand this methods does not do checks (e.g., whether the old categories are included in the new categories on a reorder), which can result in surprising changes, for example when using special string dtypes on python3, which does not considers a S1 string equal to a single char python string.

Parameters new_categories : Index-like

The categories in new order.

ordered : boolean, (default: False)

Whether or not the categorical is treated as a ordered categorical. If not given, do not change the ordered information.

rename : boolean (default: False)

Whether or not the new_categories should be considered as a rename of the old categories or as reordered categories.

inplace : boolean (default: False)

Whether or not to reorder the categories inplace or return a copy of this categorical with reordered categories.

Returns

cat [Categorical with reordered categories or None if inplace.]

Raises ValueError

If new_categories does not validate as categories

See also:
rename_categories, reorder_categories, add_categories, remove_categories, remove_unused_categories

34.8.1.7 pandas.CategoricalIndex.as_ordered

CategoricalIndex.as_ordered(*args, **kwargs)

Sets the Categorical to be ordered

Parameters inplace : boolean (default: False)
Whether or not to set the ordered attribute inplace or return a copy of this categorical with ordered set to True

34.8.1.8 pandas.CategoricalIndex.as_unordered

CategoricalIndex.as_unordered(*args, **kwargs)
Sets the Categorical to be unordered

Parameters inplace : boolean (default: False)
Whether or not to set the ordered attribute inplace or return a copy of this categorical with ordered set to False

34.8.1.9 pandas.CategoricalIndex.map

CategoricalIndex.map(mapper)
Map values using input correspondence (a dict, Series, or function).
Maps the values (their categories, not the codes) of the index to new categories. If the mapping correspondence is one-to-one the result is a CategoricalIndex which has the same order property as the original, otherwise an Index is returned.
If a dict or Series is used any unmapped category is mapped to NaN. Note that if this happens an Index will be returned.

Parameters mapper : function, dict, or Series
Mapping correspondence.

Returns pandas.CategoricalIndex or pandas.Index
Mapped index.

See also:

Index.map Apply a mapping correspondence on an Index.
Series.map Apply a mapping correspondence on a Series.
Series.apply Apply more complex functions on a Series.

Examples

```
>>> idx = pd.CategoricalIndex(['a', 'b', 'c'])
>>> idx
CategoricalIndex(['a', 'b', 'c'], categories=['a', 'b', 'c'], ordered=False, dtype='category')
>>> idx.map(lambda x: x.upper())
CategoricalIndex(['A', 'B', 'C'], categories=['A', 'B', 'C'], ordered=False, dtype='category')
>>> idx.map({'a': 'first', 'b': 'second', 'c': 'third'})
CategoricalIndex(['first', 'second', 'third'], categories=['first', 'second', 'third'], ordered=False, dtype='category')
```

If the mapping is one-to-one the ordering of the categories is preserved:
```python
>>> idx = pd.CategoricalIndex(['a', 'b', 'c'], ordered=True)
>>> idx
CategoricalIndex(['a', 'b', 'c'], categories=['a', 'b', 'c'], ordered=True, dtype='category')
>>> idx.map({'a': 3, 'b': 2, 'c': 1})
CategoricalIndex([3, 2, 1], categories=[3, 2, 1], ordered=True, dtype='category')

If the mapping is not one-to-one an `Index` is returned:

```python
>>> idx.map({'a': 'first', 'b': 'second', 'c': 'first'})
Index(['first', 'second', 'first'], dtype='object')
```

If a `dict` is used, all unmapped categories are mapped to `NaN` and the result is an `Index`:

```python
>>> idx.map({'a': 'first', 'b': 'second'})
Index(['first', 'second', nan], dtype='object')
```

### 34.8.2 Categorical Components

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>CategoricalIndex.codes</code></td>
<td></td>
</tr>
<tr>
<td><code>CategoricalIndex.categories</code></td>
<td></td>
</tr>
<tr>
<td><code>CategoricalIndex.ordered</code></td>
<td></td>
</tr>
<tr>
<td><code>rename_categories(*args, ...)</code></td>
<td>Renames categories.</td>
</tr>
<tr>
<td><code>reorder_categories(*args, ...)</code></td>
<td>Reorders categories as specified in new_categories.</td>
</tr>
<tr>
<td><code>add_categories(*args, **kwargs)</code></td>
<td>Add new categories.</td>
</tr>
<tr>
<td><code>remove_categories(*args, ...)</code></td>
<td>Removes the specified categories.</td>
</tr>
<tr>
<td><code>remove_unused_categories(...)</code></td>
<td>Removes categories which are not used.</td>
</tr>
<tr>
<td><code>set_categories(*args, **kwargs)</code></td>
<td>Sets the categories to the specified new_categories.</td>
</tr>
<tr>
<td><code>as_ordered(*args, **kwargs)</code></td>
<td>Sets the Categorical to be ordered</td>
</tr>
<tr>
<td><code>as_unordered(*args, **kwargs)</code></td>
<td>Sets the Categorical to be unordered</td>
</tr>
<tr>
<td><code>map(mapper)</code></td>
<td>Map values using input correspondence (a dict, Series, or function).</td>
</tr>
</tbody>
</table>

### 34.8.2.1 pandas.CategoricalIndex.codes

`CategoricalIndex.codes`

### 34.8.2.2 pandas.CategoricalIndex.categories

`CategoricalIndex.categories`
34.8.2.3 pandas.CategoricalIndex.ordered

CategoricalIndex.ordered

34.9 IntervalIndex

```
IntervalIndex
```

Immutable Index implementing an ordered, sliceable set.

34.9.1 pandas.IntervalIndex

class pandas.IntervalIndex

Immutable Index implementing an ordered, sliceable set. IntervalIndex represents an Index of Interval objects that are all closed on the same side.

New in version 0.20.0.

**Warning:** The indexing behaviors are provisional and may change in a future version of pandas.

**Parameters**

- **data**: array-like (1-dimensional)
  - Array-like containing Interval objects from which to build the IntervalIndex

- **closed**: {'left', 'right', 'both', 'neither' }, default 'right'
  - Whether the intervals are closed on the left-side, right-side, both or neither.

- **name**: object, optional
  - Name to be stored in the index.

- **copy**: boolean, default False
  - Copy the meta-data

- **dtype**: dtype or None, default None
  - If None, dtype will be inferred
  - New in version 0.23.0.

**See also:**

- **Index** The base pandas Index type
- **Interval** A bounded slice-like interval; the elements of an IntervalIndex
- **interval_range** Function to create a fixed frequency IntervalIndex
- **cut, qcut**

**Notes**

See the user guide for more.
Examples

A new IntervalIndex is typically constructed using `interval_range()`:

```python
>>> pd.interval_range(start=0, end=5)
IntervalIndex([(0, 1], (1, 2], (2, 3], (3, 4], (4, 5],
closed='right', dtype='interval[int64]')
```

It may also be constructed using one of the constructor methods: `IntervalIndex.from_arrays()`, `IntervalIndex.from_breaks()`, and `IntervalIndex.from_tuples()`.

See further examples in the doc strings of `interval_range` and the mentioned constructor methods.

Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>closed</code></td>
<td>Whether the intervals are closed on the left-side, right-side, both or neither</td>
</tr>
<tr>
<td><code>is_non_overlapping_monotonic</code></td>
<td>Return True if the IntervalIndex is non-overlapping (no Intervals share points) and is either monotonic increasing or monotonic decreasing, else False</td>
</tr>
<tr>
<td><code>left</code></td>
<td>Return the left endpoints of each Interval in the IntervalIndex as an Index</td>
</tr>
<tr>
<td><code>length</code></td>
<td>Return an Index with entries denoting the length of each Interval in the IntervalIndex</td>
</tr>
<tr>
<td><code>mid</code></td>
<td>Return the midpoint of each Interval in the IntervalIndex as an Index</td>
</tr>
<tr>
<td><code>right</code></td>
<td>Return the right endpoints of each Interval in the IntervalIndex as an Index</td>
</tr>
<tr>
<td><code>values</code></td>
<td>Return the IntervalIndex’s data as a numpy array of Interval objects (with dtype='object')</td>
</tr>
</tbody>
</table>

34.9.1.1 pandas.IntervalIndex.closed

IntervalIndex.closed
Whether the intervals are closed on the left-side, right-side, both or neither

34.9.1.2 pandas.IntervalIndex.is_non_overlapping_monotonic

IntervalIndex.is_non_overlapping_monotonic
Return True if the IntervalIndex is non-overlapping (no Intervals share points) and is either monotonic increasing or monotonic decreasing, else False

34.9.1.3 pandas.IntervalIndex.left

IntervalIndex.left
Return the left endpoints of each Interval in the IntervalIndex as an Index
34.9.1.4 pandas.IntervalIndex.length

IntervalIndex.length
Return an Index with entries denoting the length of each Interval in the IntervalIndex

34.9.1.5 pandas.IntervalIndex.mid

IntervalIndex.mid
Return the midpoint of each Interval in the IntervalIndex as an Index

34.9.1.6 pandas.IntervalIndex.right

IntervalIndex.right
Return the right endpoints of each Interval in the IntervalIndex as an Index

34.9.1.7 pandas.IntervalIndex.values

IntervalIndex.values
Return the IntervalIndex’s data as a numpy array of Interval objects (with dtype='object')

Methods

contains(key)  Return a boolean indicating if the key is IN the index
from_arrays(left, right[, closed, name, ...])  Construct from two arrays defining the left and right bounds.
from_breaks(breaks[, closed, name, copy, dtype])  Construct an IntervalIndex from an array of splits
from_tuples(data[, closed, name, copy, dtype])  Construct an IntervalIndex from a list/array of tuples
get_indexer(target[, method, limit, tolerance])  Compute indexer and mask for new index given the current index.
get_loc(key[, method])  Get integer location, slice or boolean mask for requested label.

34.9.1.8 pandas.IntervalIndex.contains

IntervalIndex.contains(key)
Return a boolean indicating if the key is IN the index

We accept / allow keys to be not just actual objects.

Parameters
key [int, float, Interval]

Returns
boolean
34.9.1.9 pandas.IntervalIndex.from_arrays

**classmethod IntervalIndex.from_arrays** (left, right, closed='right', name=None, copy=False, dtype=None)

Construct from two arrays defining the left and right bounds.

**Parameters**

- **left**: array-like (1-dimensional)
  - Left bounds for each interval.
- **right**: array-like (1-dimensional)
  - Right bounds for each interval.
- **closed**: {'left', 'right', 'both', 'neither'}, default 'right'
  - Whether the intervals are closed on the left-side, right-side, both or neither.
- **name**: object, optional
  - Name to be stored in the index.
- **copy**: boolean, default False
  - Copy the data.
- **dtype**: dtype, optional
  - If None, dtype will be inferred.
  - New in version 0.23.0.

**Returns**

- **index**: [IntervalIndex]

**Raises** ValueError

- When a value is missing in only one of left or right. When a value in left is greater than the corresponding value in right.

**See also:**

- **interval_range** Function to create a fixed frequency IntervalIndex.
- **IntervalIndex.from_breaks** Construct an IntervalIndex from an array of splits.
- **IntervalIndex.from_tuples** Construct an IntervalIndex from a list/array of tuples.

**Notes**

Each element of left must be less than or equal to the right element at the same position. If an element is missing, it must be missing in both left and right. A TypeError is raised when using an unsupported type for left or right. At the moment, ‘category’, ‘object’, and ‘string’ subtypes are not supported.

**Examples**

```python
>>> pd.IntervalIndex.from_arrays([[0, 1, 2], [1, 2, 3]])
IntervalIndex([(0, 1], (1, 2], (2, 3]],
closed='right',
dtype='interval[int64]')
```
If you want to segment different groups of people based on ages, you can apply the method as follows:

```python
>>> ages = pd.IntervalIndex.from_arrays([0, 2, 13],
...                                       [2, 13, 19], closed='left')
>>> ages
IntervalIndex([[0, 2), [2, 13), [13, 19)),
               closed='left',
               dtype='interval[int64]')
>>> s = pd.Series(['baby', 'kid', 'teen'], ages)
>>> s
[0, 2) baby
[2, 13) kid
[13, 19) teen
dtype: object
```

Values may be missing, but they must be missing in both arrays.

```python
>>> pd.IntervalIndex.from_arrays([0, np.nan, 13],
...                               [2, np.nan, 19])
IntervalIndex([(0.0, 2.0], nan, (13.0, 19.0]],
               closed='right',
               dtype='interval[float64]')
```

### 34.9.1.10 pandas.IntervalIndex.from_breaks

**classmethod** `IntervalIndex.from_breaks` *(breaks, closed='right', name=None, copy=False, dtype=None)*

Construct an IntervalIndex from an array of splits

**Parameters**

- `breaks` : array-like (1-dimensional)
  Left and right bounds for each interval.

- `closed` : {'left', 'right', 'both', 'neither'}, default 'right'
  Whether the intervals are closed on the left-side, right-side, both or neither.

- `name` : object, optional
  Name to be stored in the index.

- `copy` : boolean, default False
  Copy the data

- `dtype` : dtype or None, default None
  If None, dtype will be inferred
  New in version 0.23.0.

**See also:**

- `interval_range` Function to create a fixed frequency IntervalIndex
- `IntervalIndex.from_arrays` Construct an IntervalIndex from a left and right array
- `IntervalIndex.from_tuples` Construct an IntervalIndex from a list/array of tuples
Examples

```python
>>> pd.IntervalIndex.from_breaks([0, 1, 2, 3])
IntervalIndex([(0, 1], (1, 2], (2, 3]], closed='right', dtype='interval[int64]')
```

34.9.1.11 pandas.IntervalIndex.from_tuples

classmethod IntervalIndex.from_tuples(data, closed='right', name=None, copy=False, dtype=None)

Construct an IntervalIndex from a list/array of tuples

Parameters

- **data**: array-like (1-dimensional)
  Array of tuples

- **closed**: {'left', 'right', 'both', 'neither'}, default 'right'
  Whether the intervals are closed on the left-side, right-side, both or neither.

- **name**: object, optional
  Name to be stored in the index.

- **copy**: boolean, default False
  by-default copy the data, this is compat only and ignored

- **dtype**: dtype or None, default None
  If None, dtype will be inferred

New in version 0.23.0.

See also:

- **interval_range** Function to create a fixed frequency IntervalIndex
- **IntervalIndex.from_arrays** Construct an IntervalIndex from a left and right array
- **IntervalIndex.from_breaks** Construct an IntervalIndex from an array of splits

Examples

```python
>>> pd.IntervalIndex.from_tuples([(0, 1), (1, 2)])
IntervalIndex([(0, 1], (1, 2]], closed='right', dtype='interval[int64]')
```

34.9.1.12 pandas.IntervalIndex.get_indexer

IntervalIndex.get_indexer(target, method=None, limit=None, tolerance=None)

Compute indexer and mask for new index given the current index. The indexer should be then used as an input to ndarray.take to align the current data to the new index.

Parameters

- **target**: [IntervalIndex or list of Intervals]
method : [None, ‘pad’/’ffill’, ‘backfill’/’bfill’, ‘nearest’], optional

- default: exact matches only.
- pad / ffill: find the PREVIOUS index value if no exact match.
- backfill / bfill: use NEXT index value if no exact match
- nearest: use the NEAREST index value if no exact match. Tied distances are broken by preferring the larger index value.

limit : int, optional

Maximum number of consecutive labels in target to match for inexact matches.

tolerance : optional

Maximum distance between original and new labels for inexact matches. The values of the index at the matching locations most satisfy the equation abs(index[indexer] - target) <= tolerance.

Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index’s type.

New in version 0.21.0: (list-like tolerance)

Returns indexer : ndarray of int

Integers from 0 to n - 1 indicating that the index at these positions matches the corresponding target values. Missing values in the target are marked by -1.

Examples

```python
>>> indexer = index.get_indexer(new_index)
>>> new_values = cur_values.take(indexer)
```

34.9.1.13 pandas.IntervalIndex.get_loc

IntervalIndex.get_loc(key, method=None)

Get integer location, slice or boolean mask for requested label.

Parameters

key [label]

method : [None], optional

- default: matches where the label is within an interval only.

Returns

loc [int if unique index, slice if monotonic index, else mask]
Examples

```python
>>> i1, i2 = pd.Interval(0, 1), pd.Interval(1, 2)
>>> index = pd.IntervalIndex([i1, i2])
>>> index.get_loc(1)
0
```

You can also supply an interval or an location for a point inside an interval.

```python
>>> index.get_loc(pd.Interval(0, 2))
array([0, 1], dtype=int64)
```

```python
>>> index.get_loc(1.5)
1
```

If a label is in several intervals, you get the locations of all the relevant intervals.

```python
>>> i3 = pd.Interval(0, 2)
>>> overlapping_index = pd.IntervalIndex([i2, i3])
>>> overlapping_index.get_loc(1.5)
array([0, 1], dtype=int64)
```

### 34.9.2 IntervalIndex Components

- `IntervalIndex.from_arrays(left, right[, . . .])` Construct from two arrays defining the left and right bounds.
- `IntervalIndex.from_tuples(data[, closed, . . .])` Construct an IntervalIndex from a list/array of tuples.
- `IntervalIndex.from_breaks(breaks[, closed, . . .])` Construct an IntervalIndex from an array of splits.
- `IntervalIndex.contains(key)` Return a boolean indicating if the key is IN the index.
- `IntervalIndex.left` Return the left endpoints of each Interval in the IntervalIndex as an Index.
- `IntervalIndex.right` Return the right endpoints of each Interval in the IntervalIndex as an Index.
- `IntervalIndex.mid` Return the midpoint of each Interval in the IntervalIndex as an Index.
- `IntervalIndex.closed` Whether the intervals are closed on the left-side, right-side, both or neither.
- `IntervalIndex.length` Return an Index with entries denoting the length of each Interval in the IntervalIndex.
- `IntervalIndex.values` Return the IntervalIndex’s data as a numpy array of Interval objects (with dtype=’object’).
- `IntervalIndex.is_non_overlapping_monotonic` Return True if the IntervalIndex is non-overlapping (no Intervals share points) and is either monotonic increasing or monotonic decreasing, else False.
- `IntervalIndex.get_loc(key[, method])` Get integer location, slice or boolean mask for requested label.
- `IntervalIndex.get_indexer(target[, method, . . .])` Compute indexer and mask for new index given the current index.
34.10 MultiIndex

**MultiIndex**
A multi-level, or hierarchical, index object for pandas objects

34.10.1 pandas.MultiIndex

class pandas.MultiIndex
A multi-level, or hierarchical, index object for pandas objects

**Parameters**

- **levels**: sequence of arrays
  - The unique labels for each level
- **labels**: sequence of arrays
  - Integers for each level designating which label at each location
- **sortorder**: optional int
  - Level of sortedness (must be lexicographically sorted by that level)
- **names**: optional sequence of objects
  - Names for each of the index levels. (name is accepted for compat)
- **copy**: boolean, default False
  - Copy the meta-data
- **verify_integrity**: boolean, default True
  - Check that the levels/labels are consistent and valid

**See also:**

- **MultiIndex.from_arrays** Convert list of arrays to MultiIndex
- **MultiIndex.from_product** Create a MultiIndex from the cartesian product of iterables
- **MultiIndex.from_tuples** Convert list of tuples to a MultiIndex
- **Index** The base pandas Index type

**Notes**

See the user guide for more.

**Examples**

A new MultiIndex is typically constructed using one of the helper methods `MultiIndex.from_arrays()`, `MultiIndex.from_product()` and `MultiIndex.from_tuples()`. For example (using `from_arrays`):

```python
>>> arrays = [[1, 1, 2, 2], ['red', 'blue', 'red', 'blue']]
>>> pd.MultiIndex.from_arrays(arrays, names=('number', 'color'))
MultiIndex(levels=[[[1, 2], ['blue', 'red']], [[1, 2], ['blue', 'red']]], 
...
(continues on next page)
```
labels=[[0, 0, 1, 1], [1, 0, 1, 0]],
names=['number', 'color'])

See further examples for how to construct a MultiIndex in the doc strings of the mentioned helper methods.

**Attributes**

<table>
<thead>
<tr>
<th>names</th>
<th>Names of levels in MultiIndex</th>
</tr>
</thead>
<tbody>
<tr>
<td>nlevels</td>
<td>Integer number of levels in this MultiIndex.</td>
</tr>
<tr>
<td>levshape</td>
<td>A tuple with the length of each level.</td>
</tr>
</tbody>
</table>

**34.10.1.1 pandas.MultiIndex.names**

`MultiIndex.names`  
Names of levels in MultiIndex

**34.10.1.2 pandas.MultiIndex.nlevels**

`MultiIndex.nlevels`  
Integer number of levels in this MultiIndex.

**34.10.1.3 pandas.MultiIndex.levshape**

`MultiIndex.levshape`  
A tuple with the length of each level.

<table>
<thead>
<tr>
<th>levels</th>
<th>labels</th>
</tr>
</thead>
</table>

**Methods**

<table>
<thead>
<tr>
<th>from_arrays(arrays[, sortorder, names])</th>
<th>Convert arrays to MultiIndex</th>
</tr>
</thead>
<tbody>
<tr>
<td>from_tuples(tuples[, sortorder, names])</td>
<td>Convert list of tuples to MultiIndex</td>
</tr>
<tr>
<td>from_product(iterables[, sortorder, names])</td>
<td>Make a MultiIndex from the cartesian product of multiple iterables</td>
</tr>
<tr>
<td>set_levels(levels[, level, inplace, ...])</td>
<td>Set new levels on MultiIndex.</td>
</tr>
<tr>
<td>set_labels(labels[, level, inplace, ...])</td>
<td>Set new labels on MultiIndex.</td>
</tr>
<tr>
<td>to_hierarchical(n_repeat[, n_shuffle])</td>
<td>Return a MultiIndex reshaped to conform to the shapes given by n_repeat and n_shuffle.</td>
</tr>
<tr>
<td>to_frame(index)</td>
<td>Create a DataFrame with the levels of the MultiIndex as columns.</td>
</tr>
<tr>
<td>is_lexsorted()</td>
<td>Return True if the labels are lexicographically sorted</td>
</tr>
<tr>
<td>sortlevel([level, ascending, sort_remaining])</td>
<td>Sort MultiIndex at the requested level.</td>
</tr>
<tr>
<td>droplevel([level])</td>
<td>Return Index with requested level removed.</td>
</tr>
<tr>
<td>swaplevel([i, j])</td>
<td>Swap level i with level j.</td>
</tr>
<tr>
<td>reorder_levels(order)</td>
<td>Rearrange levels using input order.</td>
</tr>
</tbody>
</table>
Table 118 – continued from previous page

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>remove_unused_levels()</code></td>
<td>create a new MultiIndex from the current that removing unused levels, meaning that they are not expressed in the labels</td>
</tr>
</tbody>
</table>

### 34.10.1.4 pandas.MultiIndex.from_arrays

**classmethod** `MultiIndex.from_arrays(arrays, sortorder=None, names=None)`

Convert arrays to MultiIndex

**Parameters**

- `arrays`: list / sequence of array-likes
  - Each array-like gives one level’s value for each data point. len(arrays) is the number of levels.

- `sortorder`: int or None
  - Level of sortedness (must be lexicographically sorted by that level)

**Returns**

- `index` [MultiIndex]

**See also:**

- `MultiIndex.from_tuples` Convert list of tuples to MultiIndex
- `MultiIndex.from_product` Make a MultiIndex from cartesian product of iterables

**Examples**

```python
>>> arrays = [[1, 1, 2, 2], ['red', 'blue', 'red', 'blue']]
>>> MultiIndex.from_arrays(arrays, names=('number', 'color'))
```

### 34.10.1.5 pandas.MultiIndex.from_tuples

**classmethod** `MultiIndex.from_tuples(tuples, sortorder=None, names=None)`

Convert list of tuples to MultiIndex

**Parameters**

- `tuples`: list / sequence of tuple-likes
  - Each tuple is the index of one row/column.

- `sortorder`: int or None
  - Level of sortedness (must be lexicographically sorted by that level)

**Returns**

- `index` [MultiIndex]

**See also:**

- `MultiIndex.from_arrays` Convert list of arrays to MultiIndex
- `MultiIndex.from_product` Make a MultiIndex from cartesian product of iterables
Examples

```python
>>> tuples = [(1, u'red'), (1, u'blue'),
            (2, u'red'), (2, u'blue')]
>>> MultiIndex.from_tuples(tuples, names=('number', 'color'))
```

34.10.1.6 pandas.MultiIndex.from_product

classmethod MultiIndex.from_product( iterables, sortorder=None, names=None)
Make a MultiIndex from the cartesian product of multiple iterables

Parameters:
- iterables : list / sequence of iterables
  Each iterable has unique labels for each level of the index.
- sortorder : int or None
  Level of sortedness (must be lexicographically sorted by that level).
- names : list / sequence of strings or None
  Names for the levels in the index.

Returns:
- index [MultiIndex]

See also:
- **MultiIndex.from_arrays** Convert list of arrays to MultiIndex
- **MultiIndex.from_tuples** Convert list of tuples to MultiIndex

Examples

```python
>>> numbers = [0, 1, 2]
>>> colors = [u'green', u'purple']
>>> MultiIndex.from_product([numbers, colors], names=['number', 'color'])
MultiIndex(levels=[[0, 1, 2], [u'green', u'purple']], labels=[[0, 0, 1, 1, 2, 2], [0, 1, 0, 1, 0, 1]], names=['number', 'color'])
```

34.10.1.7 pandas.MultiIndex.set_levels

MultiIndex.set_levels( levels, level=None, inplace=False, verify_integrity=True)
Set new levels on MultiIndex. Defaults to returning new index.

Parameters:
- levels : sequence or list of sequence
  new level(s) to apply
- level : int, level name, or sequence of int/level names (default None)
  level(s) to set (None for all levels)
- inplace : bool

34.10. MultiIndex
if True, mutates in place

**verify_integrity** : bool (default True)

if True, checks that levels and labels are compatible

**Returns**

new index (of same type and class...etc)

### Examples

```python
>>> idx = MultiIndex.from_tuples([(1, 'one'), (1, 'two'),
                                (2, 'one'), (2, 'two')],
                               names=['foo', 'bar'])
>>> idx.set_levels([['a', 'b'], [1, 2]],
                 names=['foo', 'bar'])
MultiIndex(levels=[['a', 'b'], [1, 2]],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]],
           names=['foo', 'bar'])
```

#### 34.10.1.8 pandas.MultiIndex.set_labels

**MultiIndex.set_labels** *(labels, level=None, inplace=False, verify_integrity=True)*

Set new labels on MultiIndex. Defaults to returning new index.

**Parameters**

- **labels** : sequence or list of sequence
  new labels to apply

- **level** : int, level name, or sequence of int/level names (default None)
  level(s) to set (None for all levels)

- **inplace** : bool
  if True, mutates in place

- **verify_integrity** : bool (default True)
  if True, checks that levels and labels are compatible

**Returns**

new index (of same type and class...etc)
Examples

```python
>>> idx = MultiIndex.from_tuples([(1, u'one'), (1, u'two'),
                                (2, u'one'), (2, u'two')],
                               names=['foo', 'bar'])
>>> idx.set_labels(([1,0,1,0], [0,0,1,1]),
                 names=['foo', 'bar'])
MultiIndex(levels=[[1, 2], [u'one', u'two']],
          labels=[[1, 0, 1, 0], [0, 0, 1, 1]],
          names=['foo', 'bar'])
>>> idx.set_labels([0,0,1,1], level='bar')
MultiIndex(levels=[[1, 2], [u'one', u'two']],
          labels=[[0, 0, 1, 1], [0, 0, 1, 1]],
          names=['foo', 'bar'])
```

34.10.1.9 pandas.MultiIndex.to_hierarchical

`MultiIndex.to_hierarchical(n_repeat, n_shuffle=1)`

Return a MultiIndex reshaped to conform to the shapes given by `n_repeat` and `n_shuffle`.

Useful to replicate and rearrange a MultiIndex for combination with another Index with `n_repeat` items.

Parameters

- **`n_repeat`**: int
  Number of times to repeat the labels on self

- **`n_shuffle`**: int
  Controls the reordering of the labels. If the result is going to be an inner level in a MultiIndex, `n_shuffle` will need to be greater than one. The size of each label must divisible by `n_shuffle`.

Returns

- MultiIndex

Examples

```python
>>> idx = MultiIndex.from_tuples([(1, u'one'), (1, u'two'),
                                (2, u'one'), (2, u'two')],
                               names=['foo', 'bar'])
>>> idx.to_hierarchical(3)
MultiIndex(levels=[[1, 2], [u'one', u'two']],
          labels=[[0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1],
                  [0, 0, 0, 1, 1, 1, 0, 0, 0, 1, 1, 1]])
```
### 34.10.1.10 pandas.MultiIndex.to_frame

`MultiIndex.to_frame(index=True)`

Create a DataFrame with the levels of the MultiIndex as columns.

New in version 0.20.0.

**Parameters**

- `index` : boolean, default True
  
  Set the index of the returned DataFrame as the original MultiIndex.

**Returns**

- `DataFrame` [a DataFrame containing the original MultiIndex data.]

### 34.10.1.11 pandas.MultiIndex.is_lexsorted

`MultiIndex.is_lexsorted()`

Return True if the labels are lexicographically sorted.

### 34.10.1.12 pandas.MultiIndex.sortlevel

`MultiIndex.sortlevel(level=0, ascending=True, sort_remaining=True)`

Sort MultiIndex at the requested level. The result will respect the original ordering of the associated factor at that level.

**Parameters**

- `level` : list-like, int or str, default 0
  
  If a string is given, must be a name of the level If list-like must be names or ints of levels.

- `ascending` : boolean, default True
  
  False to sort in descending order Can also be a list to specify a directed ordering

- `sort_remaining` [sort by the remaining levels after level.]

**Returns**

- `sorted_index` : pd.MultiIndex
  
  Resulting index

- `indexer` : np.ndarray
  
  Indices of output values in original index

### 34.10.1.13 pandas.MultiIndex.droplevel

`MultiIndex.droplevel(level=0)`

Return Index with requested level removed. If MultiIndex has only 2 levels, the result will be of Index type not MultiIndex.

**Parameters**

- `level` [int/level name or list thereof]

**Returns**

- `index` [Index or MultiIndex]
Notes

Does not check if result index is unique or not

34.10.1.14 pandas.MultiIndex.swaplevel

MultiIndex.swaplevel(i=-2, j=-1)

Swap level i with level j.

Calling this method does not change the ordering of the values.

Parameters i : int, str, default -2
First level of index to be swapped. Can pass level name as string. Type of parameters can be mixed.

j : int, str, default -1
Second level of index to be swapped. Can pass level name as string. Type of parameters can be mixed.

Returns MultiIndex

A new MultiIndex

.. versionchanged:: 0.18.1

The indexes i and j are now optional, and default to the two innermost levels of the index.

See also:

Series.swaplevel Swap levels i and j in a MultiIndex

Dataframe.swaplevel Swap levels i and j in a MultiIndex on a particular axis

Examples

```python
>>> mi = pd.MultiIndex(levels=[['a', 'b'], ['bb', 'aa']],
                      labels=[[0, 0, 1, 1], [0, 1, 0, 1]])
>>> mi
MultiIndex(levels=[['a', 'b'], ['bb', 'aa']],
           labels=[[0, 0, 1, 1], [0, 1, 0, 1]])
>>> mi.swaplevel(0, 1)
MultiIndex(levels=[['bb', 'aa'], ['a', 'b']],
           labels=[[0, 1, 0, 1], [0, 0, 1, 1]])
```

34.10.1.15 pandas.MultiIndex.reorder_levels

MultiIndex.reorder_levels(order)
Rearrange levels using input order. May not drop or duplicate levels
34.10.1.16 pandas.MultiIndex.remove_unused_levels

MultiIndex.remove_unused_levels()
create a new MultiIndex from the current that removing unused levels, meaning that they are not expressed
in the labels

The resulting MultiIndex will have the same outward appearance, meaning the same .values and ordering.
It will also be .equals() to the original.

New in version 0.20.0.

Returns
MultiIndex

Examples

```python
>>> i = pd.MultiIndex.from_product([range(2), list('ab')])
MultiIndex(levels=[[0, 1], ['a', 'b']],
labels=[[0, 0, 1, 1], [0, 1, 0, 1]])

>>> i[2:]
MultiIndex(levels=[[0, 1], ['a', 'b']],
labels=[[1, 1], [0, 1]])

The 0 from the first level is not represented and can be removed

>>> i[2:].remove_unused_levels()
MultiIndex(levels=[[1], ['a', 'b']],
labels=[[0, 0], [0, 1]])
```

IndexSlice

Create an object to more easily perform multi-index slicing

34.10.2 pandas.IndexSlice

pandas.IndexSlice = <pandas.core.indexing._IndexSlice object>
Create an object to more easily perform multi-index slicing

Examples

```python
>>> midx = pd.MultiIndex.from_product([('A0','A1'), ['B0','B1','B2','B3']])
>>> columns = ['foo', 'bar']
>>> dfmi = pd.DataFrame(np.arange(16).reshape((len(midx), len(columns))),
index=midx, columns=columns)
```

Using the default slice command:

```python
>>> dfmi.loc[(slice(None), slice('B0', 'B1')), :]
   foo  bar
A0  B0   0   1
B1   2   3
```
Using the IndexSlice class for a more intuitive command:

```python
>>> idx = pd.IndexSlice
>>> dfmi.loc[idx[:, 'B0':'B1'], :]
  foo  bar
A0 B0  0  1
  B1  2  3
A1 B0  8  9
  B1 10 11
```

### 34.10.3 MultiIndex Constructors

- `MultiIndex.from_arrays(arrays[, sortorder, ...])` Convert arrays to MultiIndex
- `MultiIndex.from_tuples(tuples[, sortorder, ...])` Convert list of tuples to MultiIndex
- `MultiIndex.from_product(iterables[, ...])` Make a MultiIndex from the cartesian product of multiple iterables

### 34.10.4 MultiIndex Attributes

- `MultiIndex.names` Names of levels in MultiIndex
- `MultiIndex.levels` MultiIndex labels
- `MultiIndex.nlevels` Integer number of levels in this MultiIndex.
- `MultiIndex.levshape` A tuple with the length of each level.

#### 34.10.4.1 pandas.MultiIndex.levels

MultiIndex `levels`

#### 34.10.4.2 pandas.MultiIndex.labels

MultiIndex `labels`

### 34.10.5 MultiIndex Components

- `MultiIndex.set_levels(levels[, level, ...])` Set new levels on MultiIndex.
- `MultiIndex.set_labels(labels[, level, ...])` Set new labels on MultiIndex.
- `MultiIndex.to_hierarchical(n_repeat[, n_shuffle])` Return a MultiIndex reshaped to conform to the shapes given by n_repeat and n_shuffle.
- `MultiIndex.to_frame([index])` Create a DataFrame with the levels of the MultiIndex as columns.
Table 122 – continued from previous page

- **MultiIndex.is_lexsorted()**: Return True if the labels are lexicographically sorted.
- **MultiIndex.sortlevel([level, ascending, ...])**: Sort MultiIndex at the requested level.
- **MultiIndex.droplevel([level])**: Return Index with requested level removed.
- **MultiIndex.swaplevel([i, j])**: Swap level i with level j.
- **MultiIndex.reorder_levels(order)**: Rearrange levels using input order.
- **MultiIndex.remove_unused_levels()**: Create a new MultiIndex from the current that removing unused levels, meaning that they are not expressed in the labels.
- **MultiIndex.unique([level])**: Return unique values in the index.

### 34.10.5.1 pandas.MultiIndex.unique

**MultiIndex.unique (level=None)**
Return unique values in the index. Uniques are returned in order of appearance, this does NOT sort.

- **Parameters**
  - `level`: int or str, optional, default None
    - Only return values from specified level (for MultiIndex)
    - New in version 0.23.0.

- **Returns**
  - Index without duplicates

- **See also:**
  - unique, Series.unique

### 34.10.6 MultiIndex Selecting

- **MultiIndex.get_loc(key[, method])**: Get location for a label or a tuple of labels as an integer, slice or boolean mask.
- **MultiIndex.get_indexer(target[, method, ...])**: Compute indexer and mask for new index given the current index.
- **MultiIndex.get_level_values(level)**: Return vector of label values for requested level, equal to the length of the index.

#### 34.10.6.1 pandas.MultiIndex.get_loc

**MultiIndex.get_loc(key, method=None)**
Get location for a label or a tuple of labels as an integer, slice or boolean mask.

- **Parameters**
  - `key` [label or tuple of labels (one for each level)]
  - `method` [None]

- **Returns**
  - `loc`: int, slice object or boolean mask
    - If the key is past the lexsort depth, the return may be a boolean mask array, otherwise it is always a slice or int.

- **See also:**
  - Index.get_loc get_loc method for (single-level) index.
**MultiIndex.slice_locs** Get slice location given start label(s) and end label(s).

**MultiIndex.get_locs** Get location for a label/slice/list/mask or a sequence of such.

**Notes**

The key cannot be a slice, list of same-level labels, a boolean mask, or a sequence of such. If you want to use those, use `MultiIndex.get_locs()` instead.

**Examples**

```python
>>> mi = pd.MultiIndex.from_arrays([list('abb'), list('def')])

>>> mi.get_loc('b')
slice(1, 3, None)

>>> mi.get_loc(('b', 'e'))
1
```

## 34.10.6.2 pandas.MultiIndex.get_indexer

**MultiIndex.get_indexer**(target, method=None, limit=None, tolerance=None)

Compute indexer and mask for new index given the current index. The indexer should be then used as an input to `ndarray.take` to align the current data to the new index.

**Parameters**

- **target** [MultiIndex or list of tuples]
- **method** : {None, ‘pad’/’ffill’, ‘backfill’/’bfill’, ‘nearest’}, optional
  - default: exact matches only.
  - pad / ffill: find the PREVIOUS index value if no exact match.
  - backfill / bfill: use NEXT index value if no exact match
  - nearest: use the NEAREST index value if no exact match. Tied distances are broken by preferring the larger index value.
- **limit** : int, optional
  - Maximum number of consecutive labels in `target` to match for inexact matches.
- **tolerance** : optional
  - Maximum distance between original and new labels for inexact matches.
    - The values of the index at the matching locations most satisfy the equation `abs(index[indexer] - target) <= tolerance`.
    - Tolerance may be a scalar value, which applies the same tolerance to all values, or list-like, which applies variable tolerance per element. List-like includes list, tuple, array, Series, and must be the same size as the index and its dtype must exactly match the index’s type.

**Returns**

- **indexer** : ndarray of int
Integers from 0 to n - 1 indicating that the index at these positions matches the corresponding target values. Missing values in the target are marked by -1.

Examples

```python
>>> indexer = index.get_indexer(new_index)
>>> new_values = cur_values.take(indexer)
```

### 34.10.6.3 pandas.MultiIndex.get_level_values

MultiIndex.get_level_values(level)

Return vector of label values for requested level, equal to the length of the index.

Parameters:
- `level` : int or str
  - `level` is either the integer position of the level in the MultiIndex, or the name of the level.

Returns:
- `values` : Index
  - `values` is a level of this MultiIndex converted to a single Index (or subclass thereof).

Examples

Create a MultiIndex:

```python
>>> mi = pd.MultiIndex.from_arrays((list('abc'), list('def')))
>>> mi.names = ['level_1', 'level_2']
```

Get level values by supplying level as either integer or name:

```python
>>> mi.get_level_values(0)
Index(['a', 'b', 'c'], dtype='object', name='level_1')
>>> mi.get_level_values('level_2')
Index(['d', 'e', 'f'], dtype='object', name='level_2')
```

### 34.11 DatetimeIndex

Immutable ndarray of datetime64 data, represented internally as int64, and which can be boxed to Timestamp objects that are subclasses of datetime and carry metadata such as frequency information.

#### 34.11.1 pandas.DatetimeIndex

class pandas.DatetimeIndex

Immutable ndarray of datetime64 data, represented internally as int64, and which can be boxed to Timestamp objects that are subclasses of datetime and carry metadata such as frequency information.

Parameters:
- `data` : array-like (1-dimensional), optional
Optional datetime-like data to construct index with

**copy**: bool

Make a copy of input ndarray

**freq**: string or pandas offset object, optional

One of pandas date offset strings or corresponding objects

**start**: starting value, datetime-like, optional

If data is None, start is used as the start point in generating regular timestamp data.

**periods**: int, optional, > 0

Number of periods to generate, if generating index. Takes precedence over end argument

**end**: end time, datetime-like, optional

If periods is none, generated index will extend to first conforming time on or just past end argument

**closed**: string or None, default None

Make the interval closed with respect to the given frequency to the ‘left’, ‘right’, or both sides (None)

**tz**: [pytz.timezone or dateutil.tz.tzfile]

**ambiguous**: ‘infer’, bool-ndarray, ‘NaT’, default ‘raise’

- ‘infer’ will attempt to infer fall dst-transition hours based on order
- bool-ndarray where True signifies a DST time, False signifies a non-DST time (note that this flag is only applicable for ambiguous times)
- ‘NaT’ will return NaT where there are ambiguous times
- ‘raise’ will raise an AmbiguousTimeError if there are ambiguous times

**name**: object

Name to be stored in the index

**dayfirst**: bool, default False

If True, parse dates in `data` with the day first order

**yearfirst**: bool, default False

If True parse dates in `data` with the year first order

See also:

- **Index** The base pandas Index type
- **TimedeltaIndex** Index of timedelta64 data
- **PeriodIndex** Index of Period data
- **pandas.to_datetime** Convert argument to datetime
Notes

To learn more about the frequency strings, please see this link.

Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>year</td>
<td>The year of the datetime</td>
</tr>
<tr>
<td>month</td>
<td>The month as January=1, December=12</td>
</tr>
<tr>
<td>day</td>
<td>The days of the datetime</td>
</tr>
<tr>
<td>hour</td>
<td>The hours of the datetime</td>
</tr>
<tr>
<td>minute</td>
<td>The minutes of the datetime</td>
</tr>
<tr>
<td>second</td>
<td>The seconds of the datetime</td>
</tr>
<tr>
<td>microsecond</td>
<td>The microseconds of the datetime</td>
</tr>
<tr>
<td>nanosecond</td>
<td>The nanoseconds of the datetime</td>
</tr>
<tr>
<td>date</td>
<td>Returns numpy array of python datetime.date objects (namely, the date part of Timestamps without timezone information).</td>
</tr>
<tr>
<td>time</td>
<td>Returns numpy array of datetime.time.</td>
</tr>
<tr>
<td>dayofyear</td>
<td>The ordinal day of the year</td>
</tr>
<tr>
<td>weekofyear</td>
<td>The week ordinal of the year</td>
</tr>
<tr>
<td>week</td>
<td>The week ordinal of the year</td>
</tr>
<tr>
<td>dayofweek</td>
<td>The day of the week with Monday=0, Sunday=6</td>
</tr>
<tr>
<td>weekday</td>
<td>The day of the week with Monday=0, Sunday=6</td>
</tr>
<tr>
<td>quarter</td>
<td>The quarter of the date</td>
</tr>
<tr>
<td>freq</td>
<td>Return the frequency object if it is set, otherwise None</td>
</tr>
<tr>
<td>freqstr</td>
<td>Return the frequency object as a string if it is set, otherwise None</td>
</tr>
<tr>
<td>is_month_start</td>
<td>Logical indicating if first day of month (defined by frequency)</td>
</tr>
<tr>
<td>is_month_end</td>
<td>Indicator for whether the date is the last day of the month.</td>
</tr>
<tr>
<td>is_quarter_start</td>
<td>Indicator for whether the date is the first day of a quarter.</td>
</tr>
<tr>
<td>is_quarter_end</td>
<td>Indicator for whether the date is the last day of a quarter.</td>
</tr>
<tr>
<td>is_year_start</td>
<td>Indicate whether the date is the first day of a year.</td>
</tr>
<tr>
<td>is_year_end</td>
<td>Indicate whether the date is the last day of the year.</td>
</tr>
<tr>
<td>is_leap_year</td>
<td>Boolean indicator if the date belongs to a leap year.</td>
</tr>
<tr>
<td>inferred_freq</td>
<td>Tries to return a string representing a frequency guess, generated by infer_freq.</td>
</tr>
</tbody>
</table>

34.11.11 pandas.DatetimeIndex.year

DatetimeIndex.**year**

The year of the datetime
34.11.1.2 pandas.DatetimeIndex.month

```
DatetimeIndex.month
  The month as January=1, December=12
```

34.11.1.3 pandas.DatetimeIndex.day

```
DatetimeIndex.day
  The days of the datetime
```

34.11.1.4 pandas.DatetimeIndex.hour

```
DatetimeIndex.hour
  The hours of the datetime
```

34.11.1.5 pandas.DatetimeIndex.minute

```
DatetimeIndex.minute
  The minutes of the datetime
```

34.11.1.6 pandas.DatetimeIndex.second

```
DatetimeIndex.second
  The seconds of the datetime
```

34.11.1.7 pandas.DatetimeIndex.microsecond

```
DatetimeIndex.microsecond
  The microseconds of the datetime
```

34.11.1.8 pandas.DatetimeIndex.nanosecond

```
DatetimeIndex.nanosecond
  The nanoseconds of the datetime
```

34.11.1.9 pandas.DatetimeIndex.date

```
DatetimeIndex.date
  Returns numpy array of python datetime.date objects (namely, the date part of Timestamps without time-zone information).
```

34.11.1.10 pandas.DatetimeIndex.time

```
DatetimeIndex.time
  Returns numpy array of datetime.time. The time part of the Timestamps.
```
34.11.1.11 pandas.DatetimeIndex.dayofyear

DatetimeIndex.dayofyear
The ordinal day of the year

34.11.1.12 pandas.DatetimeIndex.weekofyear

DatetimeIndex.weekofyear
The week ordinal of the year

34.11.1.13 pandas.DatetimeIndex.week

DatetimeIndex.week
The week ordinal of the year

34.11.1.14 pandas.DatetimeIndex.dayofweek

DatetimeIndex.dayofweek
The day of the week with Monday=0, Sunday=6

34.11.1.15 pandas.DatetimeIndex.weekday

DatetimeIndex.weekday
The day of the week with Monday=0, Sunday=6

34.11.1.16 pandas.DatetimeIndex.quarter

DatetimeIndex.quarter
The quarter of the date

34.11.1.17 pandas.DatetimeIndex.freq

DatetimeIndex.freq
Return the frequency object if it is set, otherwise None

34.11.1.18 pandas.DatetimeIndex.freqstr

DatetimeIndex.freqstr
Return the frequency object as a string if it is set, otherwise None

34.11.1.19 pandas.DatetimeIndex.is_month_start

DatetimeIndex.is_month_start
Logical indicating if first day of month (defined by frequency)
34.11.1.20 pandas.DatetimeIndex.is_month_end

```
DatetimeIndex.is_month_end
Indicator for whether the date is the last day of the month.

Returns Series or array

For Series, returns a Series with boolean values. For DatetimeIndex, returns a boolean array.
```

See also:

**is_month_start** Indicator for whether the date is the first day of the month.

Examples

This method is available on Series with datetime values under the .dt accessor, and directly on DatetimeIndex.

```
>>> dates = pd.Series(pd.date_range("2018-02-27", periods=3))
>>> dates
0    2018-02-27
1    2018-02-28
2    2018-03-01
dtype: datetime64[ns]
>>> dates.dt.is_month_end
0   False
1   True
2  False
dtype: bool
```

```
>>> idx = pd.date_range("2018-02-27", periods=3)
>>> idx.is_month_end
array([False, True, False], dtype=bool)
```

34.11.1.21 pandas.DatetimeIndex.is_quarter_start

```
DatetimeIndex.is_quarter_start
Indicator for whether the date is the first day of a quarter.

Returns is_quarter_start : Series or DatetimeIndex

The same type as the original data with boolean values. Series will have the same name and index. DatetimeIndex will have the same name.
```

See also:

**quarter** Return the quarter of the date.

**is_quarter_end** Similar property for indicating the quarter start.

Examples

This method is available on Series with datetime values under the .dt accessor, and directly on DatetimeIndex.
>>> df = pd.DataFrame({'dates': pd.date_range("2017-03-30", ... periods=4)})
>>> df.assign(quarter=df.dates.dt.quarter, ... is_quarter_start=df.dates.dt.is_quarter_start)
<table>
<thead>
<tr>
<th>dates</th>
<th>quarter</th>
<th>is_quarter_start</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017-03-30</td>
<td>1</td>
<td>False</td>
</tr>
<tr>
<td>2017-03-31</td>
<td>1</td>
<td>False</td>
</tr>
<tr>
<td>2017-04-01</td>
<td>2</td>
<td>True</td>
</tr>
<tr>
<td>2017-04-02</td>
<td>2</td>
<td>False</td>
</tr>
</tbody>
</table>

>>> idx = pd.date_range('2017-03-30', periods=4)
>>> idx
DatetimeIndex(['2017-03-30', '2017-03-31', '2017-04-01', '2017-04-02'], dtype='datetime64[ns]', freq='D')

>>> idx.is_quarter_start
array([False, False, True, False])

### 34.11.1.22 pandas.DatetimeIndex.is_quarter_end

DatetimeIndex.<code>is_quarter_end</code>

Indicator for whether the date is the last day of a quarter.

**Returns**

<code>is_quarter_end</code> : Series or DatetimeIndex

The same type as the original data with boolean values. Series will have the same name and index. DatetimeIndex will have the same name.

**See also:**

<code>quarter</code> Return the quarter of the date.

<code>is_quarter_start</code> Similar property indicating the quarter start.

### Examples

This method is available on Series with datetime values under the .dt accessor, and directly on DatetimeIndex.

>>> df = pd.DataFrame({'dates': pd.date_range("2017-03-30", ... periods=4)})
>>> df.assign(quarter=df.dates.dt.quarter, ... is_quarter_end=df.dates.dt.is_quarter_end)
<table>
<thead>
<tr>
<th>dates</th>
<th>quarter</th>
<th>is_quarter_end</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017-03-30</td>
<td>1</td>
<td>False</td>
</tr>
<tr>
<td>2017-03-31</td>
<td>1</td>
<td>True</td>
</tr>
<tr>
<td>2017-04-01</td>
<td>2</td>
<td>False</td>
</tr>
<tr>
<td>2017-04-02</td>
<td>2</td>
<td>False</td>
</tr>
</tbody>
</table>

>>> idx = pd.date_range('2017-03-30', periods=4)
>>> idx
DatetimeIndex(['2017-03-30', '2017-03-31', '2017-04-01', '2017-04-02'], dtype='datetime64[ns]', freq='D')
>>> idx.is_quarter_end
array([False,  True, False, False])

34.11.1.23 pandas.DatetimeIndex.is_year_start

DatetimeIndex.is_year_start
Indicate whether the date is the first day of a year.

Returns Series or DatetimeIndex

The same type as the original data with boolean values. Series will have the same
name and index. DatetimeIndex will have the same name.

See also:

is_year_end Similar property indicating the last day of the year.

Examples

This method is available on Series with datetime values under the .dt accessor, and directly on Date-
timeIndex.

>>> dates = pd.Series(pd.date_range("2017-12-30", periods=3))
>>> dates
0  2017-12-30
1  2017-12-31
2  2018-01-01
dtype: datetime64[ns]

>>> dates.dt.is_year_start
0   False
1   False
2    True
dtype: bool

>>> idx = pd.date_range("2017-12-30", periods=3)
>>> idx
DatetimeIndex(['2017-12-30', '2017-12-31', '2018-01-01'],
dtype='datetime64[ns]', freq='D')

>>> idx.is_year_start
array([False, False,  True])

34.11.1.24 pandas.DatetimeIndex.is_year_end

DatetimeIndex.is_year_end
Indicate whether the date is the last day of the year.

Returns Series or DatetimeIndex

The same type as the original data with boolean values. Series will have the same
name and index. DatetimeIndex will have the same name.

See also:
**is_year_start**  Similar property indicating the start of the year.

**Examples**

This method is available on Series with datetime values under the `.dt` accessor, and directly on DatetimeIndex.

```python
>>> dates = pd.Series(pd.date_range("2017-12-30", periods=3))
>>> dates
0  2017-12-30
1  2017-12-31
2  2018-01-01
dtype: datetime64[ns]

>>> dates.dt.is_year_end
0   False
1    True
2   False
dtype: bool
```

```python
>>> idx = pd.date_range("2017-12-30", periods=3)
>>> idx
DatetimeIndex(['2017-12-30', '2017-12-31', '2018-01-01'],
              dtype='datetime64[ns]', freq='D')

>>> idx.is_year_end
array([False,  True, False])
```

### 34.11.1.25 pandas.DatetimeIndex.is_leap_year

**DatetimeIndex.is_leap_year**

Boolean indicator if the date belongs to a leap year.

A leap year is a year, which has 366 days (instead of 365) including 29th of February as an intercalary day. Leap years are years which are multiples of four with the exception of years divisible by 100 but not by 400.

**Returns**  Series or ndarray

Booleans indicating if dates belong to a leap year.

**Examples**

This method is available on Series with datetime values under the `.dt` accessor, and directly on DatetimeIndex.

```python
>>> idx = pd.date_range("2012-01-01", "2015-01-01", freq="Y")
>>> idx
DatetimeIndex(['2012-12-31', '2013-12-31', '2014-12-31'],
              dtype='datetime64[ns]', freq='A-DEC')

>>> idx.is_leap_year
array([ True, False, False], dtype=bool)
```
>>> dates = pd.Series(idx)
>>> dates_series
0  2012-12-31
1  2013-12-31
2  2014-12-31
dtype: datetime64[ns]
>>> dates_series.dt.is_leap_year
0    True
1   False
2   False
dtype: bool

34.11.1.26 pandas.DatetimeIndex.inferred_freq

DatetimeIndex.inferred_freq
Tries to return a string representing a frequency guess, generated by infer_freq. Returns None if it can’t autodetect the frequency.

Methods

normalize() Convert times to midnight.

strftime(date_format) Convert to Index using specified date_format.

snap(freq) Snap time stamps to nearest occurring frequency

tz_convert(tz) Convert tz-aware DatetimeIndex from one time zone to another.

tz_localize(tz[, ambiguous, errors]) Localize tz-naive DatetimeIndex to tz-aware DatetimeIndex.

round(freq, *args, **kwargs) round the data to the specified freq.

floor(freq) floor the data to the specified freq.

ceil(freq) ceil the data to the specified freq.

to_period([freq]) Cast to PeriodIndex at a particular frequency.

to_perioddelta(freq) Calculate TimedeltaIndex of difference between index values and index converted to periodIndex at specified freq.

to_pydatetime() Return DatetimeIndex as object ndarray of datetime.datetime objects

to_series([keep_tz, index, name]) Create a Series with both index and values equal to the index keys useful with map for returning an indexer based on an index

to_frame([index]) Create a DataFrame with a column containing the Index.

month_name([locale]) Return the month names of the DateTimeIndex with specified locale.

day_name([locale]) Return the day names of the DateTimeIndex with specified locale.
34.11.1.27 pandas.DatetimeIndex.normalize

DatetimeIndex.normalize()
Convert times to midnight.
The time component of the date-time is converted to midnight i.e. 00:00:00. This is useful in cases, when the time does not matter. Length is unaltered. The timezones are unaffected.

This method is available on Series with datetime values under the .dt accessor, and directly on DatetimeIndex.

Returns DatetimeIndex or Series
The same type as the original data. Series will have the same name and index. DatetimeIndex will have the same name.

See also:

floor Floor the datetimes to the specified freq.
ceil Ceil the datetimes to the specified freq.
round Round the datetimes to the specified freq.

Examples

```python
>>> idx = pd.DatetimeIndex(start='2014-08-01 10:00', freq='H',
... periods=3, tz='Asia/Calcutta')
>>> idx
DatetimeIndex(['2014-08-01 10:00:00+05:30',
              '2014-08-01 11:00:00+05:30',
              '2014-08-01 12:00:00+05:30'],
              dtype='datetime64[ns, Asia/Calcutta]', freq='H')
>>> idx.normalize()
DatetimeIndex(['2014-08-01 00:00:00+05:30',
              '2014-08-01 00:00:00+05:30',
              '2014-08-01 00:00:00+05:30'],
              dtype='datetime64[ns, Asia/Calcutta]', freq=None)
```

34.11.1.28 pandas.DatetimeIndex.strftime

DatetimeIndex.strftime(date_format)
Convert to Index using specified date_format.
Return an Index of formatted strings specified by date_format, which supports the same string format as the python standard library. Details of the string format can be found in python string format doc

Parameters date_format : str
Date format string (e.g. "%Y-%m-%d")

Returns Index
Index of formatted strings

See also:
pandas.to_datetime Convert the given argument to datetime
`DatetimeIndex.normalize` Return DatetimeIndex with times to midnight.

`DatetimeIndex.round` Round the DatetimeIndex to the specified freq.

`DatetimeIndex.floor` Floor the DatetimeIndex to the specified freq.

**Examples**

```python
>>> rng = pd.date_range(pd.Timestamp("2018-03-10 09:00"),
                      periods=3, freq='s')
>>> rng.strftime('%B %d, %Y, %r')
Index(['March 10, 2018, 09:00:00 AM', 'March 10, 2018, 09:00:01 AM',
       'March 10, 2018, 09:00:02 AM'],
      dtype='object')
```

34.11.1.29 pandas.DatetimeIndex.snap

`DatetimeIndex.snap(freq='S')`

Snap time stamps to nearest occurring frequency

34.11.1.30 pandas.DatetimeIndex.tz_convert

`DatetimeIndex.tz_convert(tz)`  
Convert tz-aware DatetimeIndex from one time zone to another.

**Parameters**  
`tz` : string, pytz.timezone, dateutil.tz.tzfile or None

Time zone for time. Corresponding timestamps would be converted to this time zone of the DatetimeIndex. A `tz` of None will convert to UTC and remove the timezone information.

**Returns**

`normalized` [DatetimexIndex]

`Raises` `TypeError`

If DatetimeIndex is tz-naive.

**See also:**

`DatetimeIndex.tz` A timezone that has a variable offset from UTC

`DatetimeIndex.tz_localize` Localize tz-naive DatetimeIndex to a given time zone, or remove timezone from a tz-aware DatetimeIndex.

**Examples**

With the `tz` parameter, we can change the DatetimeIndex to other time zones:

```python
>>> dti = pd.DatetimeIndex(start='2014-08-01 09:00',
                         freq='H', periods=3, tz='Europe/Berlin')
```
In [1]:
import pandas as pd

dti = pd.DatetimeIndex(
    ['2014-08-01 09:00:00+02:00',
     '2014-08-01 10:00:00+02:00',
     '2014-08-01 11:00:00+02:00'],
    dtype='datetime64[ns, Europe/Berlin]', freq='H')

In [2]:
dti.tz_convert('US/Central')
Out[2]:
DatetimeIndex(['2014-08-01 02:00:00-05:00',
               '2014-08-01 03:00:00-05:00',
               '2014-08-01 04:00:00-05:00'],
              dtype='datetime64[ns, US/Central]', freq='H')

With the tz=None, we can remove the timezone (after converting to UTC if necessary):

In [3]:
dti = pd.DatetimeIndex(
    ['2014-08-01 09:00', freq='H',
     periods=3, tz='Europe/Berlin')

In [4]:
dti
Out[4]:
DatetimeIndex(['2014-08-01 09:00:00+02:00',
               '2014-08-01 10:00:00+02:00',
               '2014-08-01 11:00:00+02:00'],
              dtype='datetime64[ns, Europe/Berlin]', freq='H')

In [5]:
dti.tz_convert(None)
Out[5]:
DatetimeIndex(['2014-08-01 07:00:00',
               '2014-08-01 08:00:00',
               '2014-08-01 09:00:00'],
              dtype='datetime64[ns]', freq='H')

### 34.11.1.31 pandas.DatetimeIndex.tz_localize

```
DatetimeIndex.tz_localize(tz, ambiguous='raise', errors='raise')
```

Localize tz-naive DatetimeIndex to tz-aware DatetimeIndex.

This method takes a time zone (tz) naive DatetimeIndex object and makes this time zone aware. It does not move the time to another time zone. Time zone localization helps to switch from time zone aware to time zone unaware objects.

**Parameters**

- **tz**: string, pytz.timezone, dateutil.tz.tzfile or None
  
  Time zone to convert timestamps to. Passing None will remove the time zone information preserving local time.

- **ambiguous**: str (`'infer'`, `'NaT'`, `'raise'`) or bool array, default `'raise'`
  
  - `'infer'` will attempt to infer fall dst-transition hours based on order
  
  - bool-ndarray where True signifies a DST time, False signifies a non-DST time (note that this flag is only applicable for ambiguous times)

  - `'NaT'` will return NaT where there are ambiguous times

  - `'raise'` will raise an AmbiguousTimeError if there are ambiguous times

- **errors**: ( `'raise'`, `'coerce'` ), default `'raise'`
  
  - `'raise'` will raise a NonExistentTimeError if a timestamp is not valid in the specified time zone (e.g. due to a transition from or to DST time)
• ‘coerce’ will return NaT if the timestamp can not be converted to the specified
time zone

New in version 0.19.0.

Returns DatetimeIndex

Index converted to the specified time zone.

Raises TypeError

If the DatetimeIndex is tz-aware and tz is not None.

See also:

DatetimeIndex.tz_convert Convert tz-aware DatetimeIndex from one time zone to another.

Examples

```py
>>> tz_naive = pd.date_range('2018-03-01 09:00', periods=3)
>>> tz_naive
DatetimeIndex(['2018-03-01 09:00:00', '2018-03-02 09:00:00',
              '2018-03-03 09:00:00'],
dtype='datetime64[ns]', freq='D')

Localize DatetimeIndex in US/Eastern time zone:

```py
>>> tz_aware = tz_naive.tz_localize(tz='US/Eastern')
```py

```py
>>> tz_aware
DatetimeIndex(['2018-03-01 09:00:00-05:00',
              '2018-03-02 09:00:00-05:00',
              '2018-03-03 09:00:00-05:00'],
dtype='datetime64[ns, US/Eastern]', freq='D')
```

With the tz=None, we can remove the time zone information while keeping the local time (not converted
to UTC):

```py
>>> tz_aware.tz_localize(None)
```py

```py
DatetimeIndex(['2018-03-01 09:00:00', '2018-03-02 09:00:00',
              '2018-03-03 09:00:00'],
dtype='datetime64[ns]', freq='D')
```

34.11.1.32 pandas.DatetimeIndex.round

DatetimeIndex.round(freq, *args, **kwargs)

round the data to the specified freq.

Parameters freq : str or Offset

The frequency level to round the index to. Must be a fixed frequency like ‘S’
(second) not ‘ME’ (month end). See frequency aliases for a list of possible freq
values.

Returns DatetimeIndex, TimedeltaIndex, or Series

Index of the same type for a DatetimeIndex or TimedeltaIndex, or a Series with
the same index for a Series.

Raises
ValueError if the ‘freq’ cannot be converted.

Examples

DatetimeIndex

```python
>>> rng = pd.date_range('1/1/2018 11:59:00', periods=3, freq='min')
>>> rng
DatetimeIndex(['2018-01-01 11:59:00', '2018-01-01 12:00:00',
               '2018-01-01 12:01:00'],
              dtype='datetime64[ns]', freq='T')
>>> rng.round('H')
DatetimeIndex(['2018-01-01 12:00:00', '2018-01-01 12:00:00',
               '2018-01-01 12:00:00'],
              dtype='datetime64[ns]', freq=None)
```

Series

```python
>>> pd.Series(rng).dt.round("H")
0  2018-01-01 12:00:00
1  2018-01-01 12:00:00
2  2018-01-01 12:00:00
dtype: datetime64[ns]
```

34.11.1.33 pandas.DatetimeIndex.floor

`DatetimeIndex.floor(freq)`

floor the data to the specified `freq`.

Parameters  

- `freq` : str or Offset

  The frequency level to floor the index to. Must be a fixed frequency like ‘S’ (second) not ‘ME’ (month end). See `frequency aliases` for a list of possible `freq` values.

Returns  

- DatetimeIndex, TimedeltaIndex, or Series

  Index of the same type for a DatetimeIndex or TimedeltaIndex, or a Series with the same index for a Series.

Raises  

- ValueError if the ‘freq’ cannot be converted.

Examples

DatetimeIndex

```python
>>> rng = pd.date_range('1/1/2018 11:59:00', periods=3, freq='min')
>>> rng
DatetimeIndex(['2018-01-01 11:59:00', '2018-01-01 12:00:00',
               '2018-01-01 12:01:00'],
              dtype='datetime64[ns]', freq='T')
>>> rng.floor('H')
DatetimeIndex(['2018-01-01 11:00:00', '2018-01-01 12:00:00',
               '2018-01-01 12:00:00'],
              dtype='datetime64[ns]', freq=None)
```
Series

```python
pd.Series(rng).dt.floor("H")
```

0 2018-01-01 11:00:00
1 2018-01-01 12:00:00
2 2018-01-01 12:00:00
dtype: datetime64[ns]

34.11.1.34 pandas.DatetimeIndex.ceil

**DatetimeIndex.ceil** *(freq)*

ceil the data to the specified *freq*.

Parameters

- **freq**: str or Offset
  
  The frequency level to ceil the index to. Must be a fixed frequency like `S` (second) not `ME` (month end). See *frequency aliases* for a list of possible *freq* values.

Returns

- DatetimeIndex, TimedeltaIndex, or Series

Index of the same type for a DatetimeIndex or TimedeltaIndex, or a Series with the same index for a Series.

Raises

- ValueError if the `freq` cannot be converted.

Examples

**DatetimeIndex**

```python
rng = pd.date_range('1/1/2018 11:59:00', periods=3, freq='min')
rng
```

DatetimeIndex(['2018-01-01 11:59:00', '2018-01-01 12:00:00',
                '2018-01-01 12:01:00'],
               dtype='datetime64[ns]', freq='T')

```python
rng.ceil('H')
```

DatetimeIndex(['2018-01-01 12:00:00', '2018-01-01 12:00:00',
                '2018-01-01 13:00:00'],
               dtype='datetime64[ns]', freq=None)

**Series**

```python
pd.Series(rng).dt.ceil("H")
```

0 2018-01-01 12:00:00
1 2018-01-01 12:00:00
2 2018-01-01 13:00:00
dtype: datetime64[ns]
34.11.1.35 pandas.DatetimeIndex.to_period

DatetimeIndex.to_period(freq=None)

Cast to PeriodIndex at a particular frequency.

Converts DatetimeIndex to PeriodIndex.

Parameters freq : string or Offset, optional

One of pandas’ offset strings or an Offset object. Will be inferred by default.

Returns

PeriodIndex

Raises ValueError

When converting a DatetimeIndex with non-regular values, so that a frequency cannot be inferred.

See also:

pandas.PeriodIndex Immutable ndarray holding ordinal values

pandas.DatetimeIndex.to_pydatetime Return DatetimeIndex as object

Examples

```python
>>> df = pd.DataFrame({"y": [1,2,3]},
...                   index=pd.to_datetime(["2000-03-31 00:00:00",
...                               "2000-05-31 00:00:00",
...                               "2000-08-31 00:00:00"]))

>>> df.index.to_period("M")
PeriodIndex(['2000-03', '2000-05', '2000-08'],
            dtype='period[M]', freq='M')
```

Infer the daily frequency

```python
>>> idx = pd.date_range("2017-01-01", periods=2)
>>> idx.to_period()
PeriodIndex(['2017-01-01', '2017-01-02'],
            dtype='period[D]', freq='D')
```

34.11.1.36 pandas.DatetimeIndex.to_perioddelta

DatetimeIndex.to_perioddelta(freq)

Calculate TimedeltaIndex of difference between index values and index converted to periodIndex at specified freq. Used for vectorized offsets

Parameters

freq: Period frequency

Returns

y: TimedeltaIndex
34.11.1.37 pandas.DatetimeIndex.to_pydatetime

DatetimeIndex.to_pydatetime()
Return DatetimeIndex as object ndarray of datetime.datetime objects

Returns

datetimes [ndarray]

34.11.1.38 pandas.DatetimeIndex.to_series

DatetimeIndex.to_series(keep_tz=False, index=None, name=None)
Create a Series with both index and values equal to the index keys useful with map for returning an indexer based on an index

Parameters keep_tz : optional, defaults False.
return the data keeping the timezone.
If keep_tz is True:
If the timezone is not set, the resulting Series will have a datetime64[ns] dtype.
Otherwise the Series will have an datetime64[ns, tz] dtype; the tz will be preserved.
If keep_tz is False:
Series will have a datetime64[ns] dtype. TZ aware objects will have the tz removed.

index : Index, optional
index of resulting Series. If None, defaults to original index

name : string, optional
name of resulting Series. If None, defaults to name of original index

Returns

Series

34.11.1.39 pandas.DatetimeIndex.to_frame

DatetimeIndex.to_frame(index=True)
Create a DataFrame with a column containing the Index.
New in version 0.21.0.

Parameters index : boolean, default True
Set the index of the returned DataFrame as the original Index.

Returns DataFrame
DataFrame containing the original Index data.

See also:

Index.to_series Convert an Index to a Series.
Series.to_frame Convert Series to DataFrame.
Examples

```python
>>> idx = pd.Index(['Ant', 'Bear', 'Cow'], name='animal')
>>> idx.to_frame()
       animal
    0   Ant
    1   Bear
    2   Cow
```

By default, the original Index is reused. To enforce a new Index:

```python
>>> idx.to_frame(index=False)
       animal
       0   Ant
       1   Bear
       2   Cow
```

### 34.11.1.40 pandas.DatetimeIndex.month_name

The month names of the DateTimeIndex with specified locale.

- **Parameters**
  - `locale` : string, default None (English locale)
  - locale determining the language in which to return the month name

- **Returns**
  - `month_names` : Index
  - Index of month names

  .. versionadded:: 0.23.0

### 34.11.1.41 pandas.DatetimeIndex.day_name

The day names of the DateTimeIndex with specified locale.

- **Parameters**
  - `locale` : string, default None (English locale)
  - locale determining the language in which to return the day name

- **Returns**
  - `month_names` : Index
  - Index of day names

  .. versionadded:: 0.23.0

### 34.11.2 Time/Date Components

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>DatetimeIndex.year</code></td>
<td>The year of the datetime</td>
</tr>
<tr>
<td><code>DatetimeIndex.month</code></td>
<td>The month as January=1, December=12</td>
</tr>
<tr>
<td><code>DatetimeIndex.day</code></td>
<td>The days of the datetime</td>
</tr>
<tr>
<td><code>DatetimeIndex.hour</code></td>
<td>The hours of the datetime</td>
</tr>
</tbody>
</table>

Continued on next page
Table 127 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DatetimeIndex.minute</td>
<td>The minutes of the datetime</td>
</tr>
<tr>
<td>DatetimeIndex.second</td>
<td>The seconds of the datetime</td>
</tr>
<tr>
<td>DatetimeIndex.microsecond</td>
<td>The microseconds of the datetime</td>
</tr>
<tr>
<td>DatetimeIndex.nanosecond</td>
<td>The nanoseconds of the datetime</td>
</tr>
<tr>
<td>DatetimeIndex.date</td>
<td>Returns numpy array of python datetime.date objects (namely, the date part of Timestamps without timezone information).</td>
</tr>
<tr>
<td>DatetimeIndex.time</td>
<td>Returns numpy array of datetime.time.</td>
</tr>
<tr>
<td>DatetimeIndex.dayofyear</td>
<td>The ordinal day of the year</td>
</tr>
<tr>
<td>DatetimeIndex.weekofyear</td>
<td>The week ordinal of the year</td>
</tr>
<tr>
<td>DatetimeIndex.week</td>
<td>The week ordinal of the year</td>
</tr>
<tr>
<td>DatetimeIndex.dayofweek</td>
<td>The day of the week with Monday=0, Sunday=6</td>
</tr>
<tr>
<td>DatetimeIndex.weekday</td>
<td>The day of the week with Monday=0, Sunday=6</td>
</tr>
<tr>
<td>DatetimeIndex.quarter</td>
<td>The quarter of the date</td>
</tr>
<tr>
<td>DatetimeIndex.tz</td>
<td></td>
</tr>
<tr>
<td>DatetimeIndex.freq</td>
<td>Return the frequency object if it is set, otherwise None</td>
</tr>
<tr>
<td>DatetimeIndex.freqstr</td>
<td>Return the frequency object as a string if it is set, otherwise None</td>
</tr>
<tr>
<td>DatetimeIndex.is_month_start</td>
<td>Logical indicating if first day of month (defined by frequency)</td>
</tr>
<tr>
<td>DatetimeIndex.is_month_end</td>
<td>Indicator for whether the date is the last day of the month.</td>
</tr>
<tr>
<td>DatetimeIndex.is_quarter_start</td>
<td>Indicator for whether the date is the first day of a quarter.</td>
</tr>
<tr>
<td>DatetimeIndex.is_quarter_end</td>
<td>Indicator for whether the date is the last day of a quarter.</td>
</tr>
<tr>
<td>DatetimeIndex.is_year_start</td>
<td>Indicate whether the date is the first day of a year.</td>
</tr>
<tr>
<td>DatetimeIndex.is_year_end</td>
<td>Indicate whether the date is the last day of the year.</td>
</tr>
<tr>
<td>DatetimeIndex.is_leap_year</td>
<td>Boolean indicator if the date belongs to a leap year.</td>
</tr>
<tr>
<td>DatetimeIndex.inferred_freq</td>
<td>Tries to return a string representing a frequency guess, generated by infer_freq.</td>
</tr>
</tbody>
</table>

### 34.11.2.1 pandas.DatetimeIndex.tz

DatetimeIndex.tz

### 34.11.3 Selecting

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DatetimeIndex.indexer_at_time(time[, asof])</td>
<td>Returns index locations of index values at particular time of day (e.g. 9:30AM).</td>
</tr>
<tr>
<td>DatetimeIndex.indexer_between_time(...[, ...])</td>
<td>Return index locations of values between particular times of day (e.g., 9:00-9:30AM).</td>
</tr>
</tbody>
</table>

### 34.11.3.1 pandas.DatetimeIndex.indexer_at_time

DatetimeIndex.indexer_at_time(time, asof=False)

Returns index locations of index values at particular time of day (e.g. 9:30AM).

**Parameters**

- **time**: datetime.time or string
  - datetime.time or string in appropriate format ("%H:%M", "%H%M", "%I:%M%p", "%I%M%p", "%H:%M:%S", "%H%M%S", "%I:%M:%S%p", "%I%M%S%p").

**Returns**
values_at_time  [array of integers]

See also:

indexer_between_time, DataFrame.at_time

34.11.3.2 pandas.DatetimeIndex.indexer_between_time

DatetimeIndex.indexer_between_time(start_time, end_time, include_start=True, include_end=True)

Return index locations of values between particular times of day (e.g., 9:00-9:30AM).

Parameters

- **start_time, end_time**: datetime.time, str
datetime.time or string in appropriate format (“%H:%M”, “%H%M”, “%I:%M%p”,
“%I%M%p”, “%H:%M:%S”, “%H%M%S”, “%I:%M:%S%p”, “%I%M%S%p”).

- **include_start** [boolean, default True]

- **include_end** [boolean, default True]

Returns

values_between_time  [array of integers]

See also:

indexer_at_time, DataFrame.between_time

34.11.4 Time-specific operations

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DatetimeIndex.normalize()</td>
<td>Convert times to midnight.</td>
</tr>
<tr>
<td>DatetimeIndex.strftime(date_format)</td>
<td>Convert to Index using specified date_format.</td>
</tr>
<tr>
<td>DatetimeIndex.snap([freq])</td>
<td>Snap time stamps to nearest occurring frequency</td>
</tr>
<tr>
<td>DatetimeIndex.tz_convert(tz)</td>
<td>Convert tz-aware DatetimeIndex from one time zone to another.</td>
</tr>
<tr>
<td>DatetimeIndex.tz_localize([tz], ambiguous, ...)</td>
<td>Localize tz-naive DatetimeIndex to tz-aware DatetimeIndex.</td>
</tr>
<tr>
<td>DatetimeIndex.round(freq, *args, **kwargs)</td>
<td>Round the data to the specified freq.</td>
</tr>
<tr>
<td>DatetimeIndex.floor(freq)</td>
<td>Floor the data to the specified freq.</td>
</tr>
<tr>
<td>DatetimeIndex.ceil(freq)</td>
<td>Ceil the data to the specified freq.</td>
</tr>
<tr>
<td>DatetimeIndex.month_name([locale])</td>
<td>Return the month names of the DateTimeIndex with specified locale.</td>
</tr>
<tr>
<td>DatetimeIndex.day_name([locale])</td>
<td>Return the day names of the DateTimeIndex with specified locale.</td>
</tr>
</tbody>
</table>

34.11.5 Conversion

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DatetimeIndex.to_period([freq])</td>
<td>Cast to PeriodIndex at a particular frequency.</td>
</tr>
<tr>
<td>DatetimeIndex.to_perioddelta(freq)</td>
<td>Calculate TimedeltaIndex of difference between index values and index converted to periodIndex at specified freq.</td>
</tr>
</tbody>
</table>

Continued on next page
Table 130 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>DatetimeIndex.to_pydatetime()</code></td>
<td>Return DatetimeIndex as object ndarray of datetime.datetime</td>
</tr>
<tr>
<td><code>DatetimeIndex.to_series([keep_tz, index])</code></td>
<td>Create a Series with both index and values equal to the index keys useful with map for returning an indexer based on an index</td>
</tr>
<tr>
<td><code>DatetimeIndex.to_frame([index])</code></td>
<td>Create a DataFrame with a column containing the Index.</td>
</tr>
</tbody>
</table>

### 34.12 TimedeltaIndex

**TimedeltaIndex**

Immutable ndarray of timedelta64 data, represented internally as int64, and which can be boxed to timedelta objects

### 34.12.1 pandas.TimedeltaIndex

**class pandas.TimedeltaIndex**

Immutable ndarray of timedelta64 data, represented internally as int64, and which can be boxed to timedelta objects

**Parameters**
- `data` : array-like (1-dimensional), optional
  - Optional timedelta-like data to construct index with
  - **unit**: unit of the arg (D,h,m,s,ms,us,ns) denote the unit, optional
    - which is an integer/float number
  - **freq**: a frequency for the index, optional
  - **copy**: bool
    - Make a copy of input ndarray
  - **start**: starting value, timedelta-like, optional
    - If data is None, start is used as the start point in generating regular timedelta data.
  - **periods**: int, optional, > 0
    - Number of periods to generate, if generating index. Takes precedence over end argument
  - **end**: end time, timedelta-like, optional
    - If periods is none, generated index will extend to first conforming time on or just past end argument
  - **closed**: string or None, default None
    - Make the interval closed with respect to the given frequency to the ‘left’, ‘right’, or both sides (None)
  - **name**: object
    - Name to be stored in the index

**See also:**
Index  The base pandas Index type
Timedelta  Represents a duration between two dates or times.
DatetimeIndex  Index of datetime64 data
PeriodIndex  Index of Period data

Notes
To learn more about the frequency strings, please see this link.

Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>days</td>
<td>Number of days for each element.</td>
</tr>
<tr>
<td>seconds</td>
<td>Number of seconds (&gt;= 0 and less than 1 day) for each element.</td>
</tr>
<tr>
<td>microseconds</td>
<td>Number of microseconds (&gt;= 0 and less than 1 second) for each element.</td>
</tr>
<tr>
<td>nanoseconds</td>
<td>Number of nanoseconds (&gt;= 0 and less than 1 microsecond) for each element.</td>
</tr>
<tr>
<td>components</td>
<td>Return a dataframe of the components (days, hours, minutes, seconds, milliseconds, microseconds, nanoseconds) of the Timedeltas.</td>
</tr>
<tr>
<td>inferred_freq</td>
<td>Tries to return a string representing a frequency guess, generated by infer_freq.</td>
</tr>
</tbody>
</table>

34.12.1.1 pandas.TimedeltaIndex.days

TimedeltaIndex.days
Number of days for each element.

34.12.1.2 pandas.TimedeltaIndex.seconds

TimedeltaIndex.seconds
Number of seconds (>= 0 and less than 1 day) for each element.

34.12.1.3 pandas.TimedeltaIndex.microseconds

TimedeltaIndex.microseconds
Number of microseconds (>= 0 and less than 1 second) for each element.

34.12.1.4 pandas.TimedeltaIndex.nanoseconds

TimedeltaIndex.nanoseconds
Number of nanoseconds (>= 0 and less than 1 microsecond) for each element.
34.12.1.5 pandas.TimedeltaIndex.components

TimedeltaIndex.components

Return a dataframe of the components (days, hours, minutes, seconds, milliseconds, microseconds, nanoseconds) of the Timedeltas.

Returns

a DataFrame

34.12.1.6 pandas.TimedeltaIndex.inferred_freq

TimedeltaIndex.inferred_freq

Tries to return a string representing a frequency guess, generated by infer_freg. Returns None if it can’t autodetect the frequency.

Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>to_pytimedelta()</td>
<td>Return TimedeltaIndex as object ndarray of datetime.timedelta objects</td>
</tr>
<tr>
<td>to_series([index, name])</td>
<td>Create a Series with both index and values equal to the index keys useful with map for returning an indexer based on an index</td>
</tr>
<tr>
<td>round(freq, *args, **kwargs)</td>
<td>round the data to the specified freq.</td>
</tr>
<tr>
<td>floor(freq)</td>
<td>floor the data to the specified freq.</td>
</tr>
<tr>
<td>ceil(freq)</td>
<td>ceil the data to the specified freq.</td>
</tr>
<tr>
<td>to_frame([index])</td>
<td>Create a DataFrame with a column containing the Index.</td>
</tr>
</tbody>
</table>

34.12.1.7 pandas.TimedeltaIndex.to_pytimedelta

TimedeltaIndex.to_pytimedelta()

Return TimedeltaIndex as object ndarray of datetime.timedelta objects

Returns

datetimes [ndarray]

34.12.1.8 pandas.TimedeltaIndex.to_series

TimedeltaIndex.to_series(index=None, name=None)

Create a Series with both index and values equal to the index keys useful with map for returning an indexer based on an index

Parameters

index : Index, optional

index of resulting Series. If None, defaults to original index

name : string, optional

name of resulting Series. If None, defaults to name of original index

Returns

Series [dtype will be based on the type of the Index values.]
34.12.1.9 pandas.TimedeltaIndex.round

TimedeltaIndex.round(freq, *args, **kwargs)
round the data to the specified freq.

Parameters freq : str or Offset
The frequency level to round the index to. Must be a fixed frequency like ‘S’ (second) not ‘ME’ (month end). See frequency aliases for a list of possible freq values.

Returns DatetimeIndex, TimedeltaIndex, or Series
Index of the same type for a DatetimeIndex or TimedeltaIndex, or a Series with the same index for a Series.

Raises
ValueError if the ‘freq’ cannot be converted.

Examples

DatetimeIndex

```python
>>> rng = pd.date_range('1/1/2018 11:59:00', periods=3, freq='min')
>>> rng
DatetimeIndex(['2018-01-01 11:59:00', '2018-01-01 12:00:00',
               '2018-01-01 12:01:00'],
              dtype='datetime64[ns]', freq='T')
```

```python
>>> rng.round('H')
DatetimeIndex(['2018-01-01 12:00:00', '2018-01-01 12:00:00',
               '2018-01-01 12:00:00'],
              dtype='datetime64[ns]', freq=None)
```

Series

```python
>>> pd.Series(rng).dt.round("H")
0  2018-01-01 12:00:00
1  2018-01-01 12:00:00
2  2018-01-01 12:00:00
dtype: datetime64[ns]
```

34.12.1.10 pandas.TimedeltaIndex.floor

TimedeltaIndex.floor(freq)
floor the data to the specified freq.

Parameters freq : str or Offset
The frequency level to floor the index to. Must be a fixed frequency like ‘S’ (second) not ‘ME’ (month end). See frequency aliases for a list of possible freq values.

Returns DatetimeIndex, TimedeltaIndex, or Series
Index of the same type for a DatetimeIndex or TimedeltaIndex, or a Series with the same index for a Series.

Raises
ValueError if the ‘freq’ cannot be converted.

Examples

DatetimeIndex

```python
>>> rng = pd.date_range('1/1/2018 11:59:00', periods=3, freq='min')
>>> rng
DatetimeIndex(['2018-01-01 11:59:00', '2018-01-01 12:00:00',
               '2018-01-01 12:01:00'],
               dtype='datetime64[ns]', freq='T')
```

```python
>>> rng.floor('H')
DatetimeIndex(['2018-01-01 11:00:00', '2018-01-01 12:00:00',
               '2018-01-01 12:00:00'],
               dtype='datetime64[ns]', freq=None)
```

Series

```python
>>> pd.Series(rng).dt.floor("H")
0 2018-01-01 11:00:00
1 2018-01-01 12:00:00
2 2018-01-01 12:00:00
dtype: datetime64[ns]
```

34.12.1.11 pandas.TimedeltaIndex.ceil

TimedeltaIndex.ceil(freq)

ceil the data to the specified freq.

Parameters freq : str or Offset

The frequency level to ceil the index to. Must be a fixed frequency like ‘S’ (second) not ‘ME’ (month end). See frequency aliases for a list of possible freq values.

Returns DatetimeIndex, TimedeltaIndex, or Series

Index of the same type for a DatetimeIndex or TimedeltaIndex, or a Series with the same index for a Series.

Raises ValueError if the ‘freq’ cannot be converted.

Examples

DatetimeIndex

```python
>>> rng = pd.date_range('1/1/2018 11:59:00', periods=3, freq='min')
>>> rng
DatetimeIndex(['2018-01-01 11:59:00', '2018-01-01 12:00:00',
               '2018-01-01 12:01:00'],
               dtype='datetime64[ns]', freq='T')
```

```python
>>> rng.ceil('H')
DatetimeIndex(['2018-01-01 12:00:00', '2018-01-01 12:00:00',
               '2018-01-01 12:00:00'],
               dtype='datetime64[ns]', freq=None)
```
Series

```python
>>> pd.Series(rng).dt.ceil("H")
0 2018-01-01 12:00:00
1 2018-01-01 12:00:00
2 2018-01-01 13:00:00
dtype: datetime64[ns]
```

### 34.12.12 pandas.TimedeltaIndex.to_frame

TimedeltaIndex.to_frame(index=True)

Create a DataFrame with a column containing the Index.

New in version 0.21.0.

**Parameters**

- **index** : boolean, default True
  
  Set the index of the returned DataFrame as the original Index.

**Returns**

DataFrame

DataFrame containing the original Index data.

**See also:**

- Index.to_series: Convert an Index to a Series.
- Series.to_frame: Convert Series to DataFrame.

**Examples**

```python
>>> idx = pd.Index(['Ant', 'Bear', 'Cow'], name='animal')
>>> idx.to_frame()

animal
animal
Ant   Ant
Bear  Bear
Cow   Cow
```

By default, the original Index is reused. To enforce a new Index:

```python
>>> idx.to_frame(index=False)
animal
animal
0   Ant
1   Bear
2   Cow
```

### 34.12.2 Components
TimedeltaIndex.days
Number of days for each element.

TimedeltaIndex.seconds
Number of seconds (>= 0 and less than 1 day) for each element.

TimedeltaIndex.microseconds
Number of microseconds (>= 0 and less than 1 second) for each element.

TimedeltaIndex.nanoseconds
Number of nanoseconds (>= 0 and less than 1 microsecond) for each element.

TimedeltaIndex.components
Return a dataframe of the components (days, hours, minutes, seconds, milliseconds, microseconds, nanoseconds) of the Timedeltas.

TimedeltaIndex.inferred_freq
Tries to return a string representing a frequency guess, generated by infer_freq.

34.12.3 Conversion

TimedeltaIndex.to_pytdedelta()
Return TimedeltaIndex as object ndarray of date-time.timedelta objects

TimedeltaIndex.to_series([index, name])
Create a Series with both index and values equal to the index keys useful with map for returning an indexer based on an index

TimedeltaIndex.round(freq, *args, **kwargs)
round the data to the specified freq.

TimedeltaIndex.floor(freq)
floor the data to the specified freq.

TimedeltaIndex.ceil(freq)
ceil the data to the specified freq.

TimedeltaIndex.to_frame([index])
Create a DataFrame with a column containing the Index.

34.13 PeriodIndex

PeriodIndex
Immutable ndarray holding ordinal values indicating regular periods in time such as particular years, quarters, months, etc.

34.13.1 pandas.PeriodIndex

class pandas.PeriodIndex
   Immutable ndarray holding ordinal values indicating regular periods in time such as particular years, quarters, months, etc.

   Index keys are boxed to Period objects which carries the metadata (eg, frequency information).

   Parameters data : array-like (1-dimensional), optional
      Optional period-like data to construct index with

      copy : bool
         Make a copy of input ndarray

      freq : string or period object, optional
         One of pandas period strings or corresponding objects

      start : starting value, period-like, optional
         If data is None, used as the start point in generating regular period data.

34.13. PeriodIndex
periods : int, optional, > 0

Number of periods to generate, if generating index. Takes precedence over end argument

end : end value, period-like, optional

If periods is none, generated index will extend to first conforming period on or just past end argument

year [int, array, or Series, default None]
month [int, array, or Series, default None]
quarter [int, array, or Series, default None]
day [int, array, or Series, default None]
hour [int, array, or Series, default None]
minute [int, array, or Series, default None]
second [int, array, or Series, default None]
tz : object, default None

Timezone for converting datetime64 data to Periods

dtype [str or PeriodDtype, default None]

See also:

Index The base pandas Index type
Period Represents a period of time
DatetimeIndex Index with datetime64 data
TimedeltaIndex Index of timedelta64 data

Examples

```python
>>> idx = PeriodIndex(year=year_arr, quarter=q_arr)

>>> idx2 = PeriodIndex(start='2000', end='2010', freq='A')
```

Attributes

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>day</td>
<td>The days of the period</td>
</tr>
<tr>
<td>dayofweek</td>
<td>The day of the week with Monday=0, Sunday=6</td>
</tr>
<tr>
<td>dayofyear</td>
<td>The ordinal day of the year</td>
</tr>
<tr>
<td>days_in_month</td>
<td>The number of days in the month</td>
</tr>
<tr>
<td>daysinmonth</td>
<td>The number of days in the month</td>
</tr>
<tr>
<td>freq</td>
<td>Return the frequency object if it is set, otherwise None</td>
</tr>
</tbody>
</table>

Continued on next page
Table 137 – continued from previous page

<table>
<thead>
<tr>
<th>freqstr</th>
<th>Return the frequency object as a string if it is set, otherwise None</th>
</tr>
</thead>
<tbody>
<tr>
<td>hour</td>
<td>The hour of the period</td>
</tr>
<tr>
<td>is_leap_year</td>
<td>Logical indicating if the date belongs to a leap year</td>
</tr>
<tr>
<td>minute</td>
<td>The minute of the period</td>
</tr>
<tr>
<td>month</td>
<td>The month as January=1, December=12</td>
</tr>
<tr>
<td>quarter</td>
<td>The quarter of the date</td>
</tr>
<tr>
<td>second</td>
<td>The second of the period</td>
</tr>
<tr>
<td>week</td>
<td>The week ordinal of the year</td>
</tr>
<tr>
<td>weekofyear</td>
<td>The week ordinal of the year</td>
</tr>
<tr>
<td>year</td>
<td>The year of the period</td>
</tr>
</tbody>
</table>

34.13.1.1 pandas.PeriodIndex.day

PeriodIndex.day
  The days of the period

34.13.1.2 pandas.PeriodIndex.dayofweek

PeriodIndex.dayofweek
  The day of the week with Monday=0, Sunday=6

34.13.1.3 pandas.PeriodIndex.dayofyear

PeriodIndex.dayofyear
  The ordinal day of the year

34.13.1.4 pandas.PeriodIndex.days_in_month

PeriodIndex.days_in_month
  The number of days in the month

34.13.1.5 pandas.PeriodIndex.daysinmonth

PeriodIndex.daysinmonth
  The number of days in the month

34.13.1.6 pandas.PeriodIndex.freq

PeriodIndex.freq
  Return the frequency object if it is set, otherwise None

34.13.1.7 pandas.PeriodIndex.freqstr

PeriodIndex.freqstr
  Return the frequency object as a string if it is set, otherwise None
34.13.1.8 pandas.PeriodIndex.hour

PeriodIndex.hour
The hour of the period

34.13.1.9 pandas.PeriodIndex.is_leap_year

PeriodIndex.is_leap_year
Logical indicating if the date belongs to a leap year

34.13.1.10 pandas.PeriodIndex.minute

PeriodIndex.minute
The minute of the period

34.13.1.11 pandas.PeriodIndex.month

PeriodIndex.month
The month as January=1, December=12

34.13.1.12 pandas.PeriodIndex.quarter

PeriodIndex.quarter
The quarter of the date

34.13.1.13 pandas.PeriodIndex.second

PeriodIndex.second
The second of the period

34.13.1.14 pandas.PeriodIndex.week

PeriodIndex.week
The week ordinal of the year

34.13.1.15 pandas.PeriodIndex.weekday

PeriodIndex.weekday
The day of the week with Monday=0, Sunday=6

34.13.1.16 pandas.PeriodIndex.weekofyear

PeriodIndex.weekofyear
The week ordinal of the year
34.13.1.17 pandas.PeriodIndex.year

PeriodIndex.year
The year of the period

| end_time | qyear | start_time |

Methods

- `asfreq([freq, how])`: Convert the PeriodIndex to the specified frequency `freq`.
- `strftime(date_format)`: Convert to Index using specified `date_format`.
- `to_timestamp([freq, how])`: Cast to DatetimeIndex.
- `tz_convert(tz)`: Convert tz-aware DatetimeIndex from one time zone to another (using pytz/dateutil).
- `tz_localize(tz[, ambiguous])`: Localize tz-naive DatetimeIndex to given time zone (using pytz/dateutil), or remove timezone from tz-aware DatetimeIndex.

34.13.1.18 pandas.PeriodIndex.asfreq

PeriodIndex.asfreq(freq=None, how='E')
Convert the PeriodIndex to the specified frequency `freq`.

**Parameters**

- `freq`: str
  a frequency
- `how`: str {'E', 'S'}
  ‘E’, ‘END’, or ‘FINISH’ for end, ‘S’, ‘START’, or ‘BEGIN’ for start. Whether the elements should be aligned to the end or start within a period. January 31st (‘END’) vs. January 1st (‘START’) for example.

**Returns**

- `new` : [PeriodIndex with the new frequency]

**Examples**

```python
>>> pidx = pd.period_range('2010-01-01', '2015-01-01', freq='A')
>>> pidx
<class 'pandas.core.indexes.period.PeriodIndex'>
[2010, ..., 2015]
Length: 6, Freq: A-DEC

>>> pidx.asfreq('M')
<class 'pandas.core.indexes.period.PeriodIndex'>
[2010-12, ..., 2015-12]
Length: 6, Freq: M
```
>>> pdx.asfreq('M', how='S')
<class 'pandas.core.indexes.period.PeriodIndex'>
[2010-01, ..., 2015-01]
Length: 6, Freq: M

34.13.19 pandas.PeriodIndex.strftime

PeriodIndex.strftime(date_format)

Convert to Index using specified date_format.

Return an Index of formatted strings specified by date_format, which supports the same string format as the python standard library. Details of the string format can be found in python string format doc

Parameters date_format : str

Date format string (e.g. “%Y-%m-%d”).

Returns Index

Index of formatted strings

See also:

pandas.to_datetime Convert the given argument to datetime

DatetimeIndex.normalize Return DatetimeIndex with times to midnight.

DatetimeIndex.round Round the DatetimeIndex to the specified freq.

DatetimeIndex.floor Floor the DatetimeIndex to the specified freq.

Examples

```python
>>> rng = pd.date_range(pd.Timestamp("2018-03-10 09:00"),
                 ...              periods=3, freq='s')
>>> rng.strftime('%B %d, %Y, %r')
Index(['March 10, 2018, 09:00:00 AM', 'March 10, 2018, 09:00:01 AM',
      'March 10, 2018, 09:00:02 AM'],
      dtype='object')
```

34.13.120 pandas.PeriodIndex.to_timestamp

PeriodIndex.to_timestamp(freq=None, how='start')

Cast to DatetimeIndex

Parameters freq : string or DateOffset, optional

Target frequency. The default is ‘D’ for week or longer, ‘S’ otherwise

how [‘s’, ‘e’, ‘start’, ‘end’]

Returns

DatetimeIndex
### 34.13.1.21 pandas.PeriodIndex.tz_convert

PeriodIndex.tz_convert(tz)  
Convert tz-aware DatetimeIndex from one time zone to another (using pytz/dateutil)  

**Parameters**  
tz : string, pytz.timezone, dateutil.tz.tzfile or None  
Time zone for time. Corresponding timestamps would be converted to time zone of the TimeSeries. None will remove timezone holding UTC time.  

**Returns**  
normalized [DatetimeIndex]  

**Notes**  
Not currently implemented for PeriodIndex

### 34.13.1.22 pandas.PeriodIndex.tz_localize

PeriodIndex.tz_localize(tz, ambiguous='raise')  
Localize tz-naive DatetimeIndex to given time zone (using pytz/dateutil), or remove timezone from tz-aware DatetimeIndex  

**Parameters**  
tz : string, pytz.timezone, dateutil.tz.tzfile or None  
Time zone for time. Corresponding timestamps would be converted to time zone of the TimeSeries. None will remove timezone holding local time.  

**Returns**  
localized [DatetimeIndex]  

**Notes**  
Not currently implemented for PeriodIndex

### 34.13.2 Attributes

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PeriodIndex.day</td>
<td>The days of the period</td>
</tr>
<tr>
<td>PeriodIndex.dayofweek</td>
<td>The day of the week with Monday=0, Sunday=6</td>
</tr>
<tr>
<td>PeriodIndex.dayofyear</td>
<td>The ordinal day of the year</td>
</tr>
<tr>
<td>PeriodIndex.days_in_month</td>
<td>The number of days in the month</td>
</tr>
<tr>
<td>PeriodIndex.daysinmonth</td>
<td>The number of days in the month</td>
</tr>
<tr>
<td>PeriodIndex.end_time</td>
<td></td>
</tr>
<tr>
<td>PeriodIndex.freq</td>
<td>Return the frequency object if it is set, otherwise None</td>
</tr>
<tr>
<td>PeriodIndex.freqstr</td>
<td>Return the frequency object as a string if it is set, otherwise None</td>
</tr>
<tr>
<td>PeriodIndex.hour</td>
<td>The hour of the period</td>
</tr>
<tr>
<td>PeriodIndex.is_leap_year</td>
<td>Logical indicating if the date belongs to a leap year</td>
</tr>
<tr>
<td>PeriodIndex.minute</td>
<td>The minute of the period</td>
</tr>
<tr>
<td>PeriodIndex.month</td>
<td>The month as January=1, December=12</td>
</tr>
</tbody>
</table>

Continued on next page
Table 139 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>PeriodIndex.quarter</code></td>
<td>The quarter of the date</td>
</tr>
<tr>
<td><code>PeriodIndex.qyear</code></td>
<td>The year of the period</td>
</tr>
<tr>
<td><code>PeriodIndex.second</code></td>
<td>The second of the period</td>
</tr>
<tr>
<td><code>PeriodIndex.start_time</code></td>
<td>Period of the period</td>
</tr>
<tr>
<td><code>PeriodIndex.week</code></td>
<td>The week ordinal of the year</td>
</tr>
<tr>
<td><code>PeriodIndex.weekday</code></td>
<td>The day of the week with Monday=0, Sunday=6</td>
</tr>
<tr>
<td><code>PeriodIndex.weekofyear</code></td>
<td>The week ordinal of the year</td>
</tr>
<tr>
<td><code>PeriodIndex.year</code></td>
<td>The year of the period</td>
</tr>
</tbody>
</table>

### 34.13.2.1 pandas.PeriodIndex.end_time

` PeriodIndex.end_time`

### 34.13.2.2 pandas.PeriodIndex.qyear

` PeriodIndex.qyear`

### 34.13.2.3 pandas.PeriodIndex.start_time

` PeriodIndex.start_time`

### 34.13.3 Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>PeriodIndex.asfreq(freq, how)</code></td>
<td>Convert the PeriodIndex to the specified frequency <code>freq</code>.</td>
</tr>
<tr>
<td><code>PeriodIndex.strftime(date_format)</code></td>
<td>Convert to Index using specified <code>date_format</code>.</td>
</tr>
<tr>
<td><code>PeriodIndex.to_timestamp([freq, how])</code></td>
<td>Cast to DatetimeIndex</td>
</tr>
<tr>
<td><code>PeriodIndex.tz_convert(tz)</code></td>
<td>Convert tz-aware DatetimeIndex from one time zone to another (using pytz/dateutil)</td>
</tr>
<tr>
<td><code>PeriodIndex.tz_localize(tz[, ambiguous])</code></td>
<td>Localize tz-naive DatetimeIndex to given time zone (using pytz/dateutil), or remove timezone from tz-aware DatetimeIndex</td>
</tr>
</tbody>
</table>

### 34.14 Scalars

#### 34.14.1 Period

<table>
<thead>
<tr>
<th>Period</th>
<th>Represents a period of time</th>
</tr>
</thead>
</table>

#### 34.14.1.1 pandas.Period

class `pandas.Period`

Represents a period of time

**Parameters**

- **value**: Period or compat.string_types, default None
  
The time period represented (e.g., ‘4Q2005’)

- **freq**: str, default None
One of pandas period strings or corresponding objects

- **year** [int, default None]
- **month** [int, default 1]
- **quarter** [int, default None]
- **day** [int, default 1]
- **hour** [int, default 0]
- **minute** [int, default 0]
- **second** [int, default 0]

### Attributes

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>day</td>
<td>Get day of the month that a Period falls on.</td>
</tr>
<tr>
<td>dayofweek</td>
<td>Return the day of the week.</td>
</tr>
<tr>
<td>dayofyear</td>
<td>Return the day of the year.</td>
</tr>
<tr>
<td>days_in_month</td>
<td>Get the total number of days in the month that this period falls on.</td>
</tr>
<tr>
<td>daysinmonth</td>
<td>Get the total number of days of the month that the Period falls in.</td>
</tr>
<tr>
<td>hour</td>
<td>Get the hour of the day component of the Period.</td>
</tr>
<tr>
<td>minute</td>
<td>Get minute of the hour component of the Period.</td>
</tr>
<tr>
<td>second</td>
<td>Get the second component of the Period.</td>
</tr>
<tr>
<td>start_time</td>
<td>Get the Timestamp for the start of the period.</td>
</tr>
<tr>
<td>week</td>
<td>Get the week of the year on the given Period.</td>
</tr>
</tbody>
</table>

### pandas.Period.day

- **Period.day**
  - Get day of the month that a Period falls on.

  **Returns**

  - int

  **See also:**

  - `Period.dayofweek` Get the day of the week
  - `Period.dayofyear` Get the day of the year

### Examples

```python
>>> p = pd.Period("2018-03-11", freq='H')
>>> p.day
11
```
**pandas.Period.dayofweek**

Period.dayofweek

Return the day of the week.

This attribute returns the day of the week on which the particular date for the given period occurs depending on the frequency with Monday=0, Sunday=6.

**Returns** Int

Range from 0 to 6 (included).

See also:

Period.dayofyear Return the day of the year.

Period.daysinmonth Return the number of days in that month.

**Examples**

```python
>>> period1 = pd.Period('2012-1-1 19:00', freq='H')
>>> period1
Period('2012-01-01 19:00', 'H')
>>> period1.dayofweek
6
```

```python
>>> period2 = pd.Period('2013-1-9 11:00', freq='H')
>>> period2
Period('2013-01-09 11:00', 'H')
>>> period2.dayofweek
2
```

**pandas.Period.dayofyear**

Period.dayofyear

Return the day of the year.

This attribute returns the day of the year on which the particular date occurs. The return value ranges between 1 to 365 for regular years and 1 to 366 for leap years.

**Returns** int

The day of year.

See also:

Period.day Return the day of the month.

Period.dayofweek Return the day of week.

PeriodIndex.dayofyear Return the day of year of all indexes.

**Examples**
```python
>>> period = pd.Period("2015-10-23", freq='H')
>>> period.dayofyear
296
>>> period = pd.Period("2012-12-31", freq='D')
>>> period.dayofyear
366
>>> period = pd.Period("2013-01-01", freq='D')
>>> period.dayofyear
1
```

**pandas.Period.days_in_month**

`Period.days_in_month`

Get the total number of days in the month that this period falls on.

Returns

int

See also:

`Period.daysinmonth` Gets the number of days in the month.

`DatetimeIndex.daysinmonth` Gets the number of days in the month.

`calendar.monthrange` Returns a tuple containing weekday (0-6 ~ Mon-Sun) and number of days (28-31).

**Examples**

```python
>>> p = pd.Period('2018-2-17')
>>> p.days_in_month
28

>>> pd.Period('2018-03-01').days_in_month
31
```

Handles the leap year case as well:

```python
>>> p = pd.Period('2016-2-17')
>>> p.days_in_month
29
```

**pandas.Period.daysinmonth**

`Period.daysinmonth`

Get the total number of days of the month that the Period falls in.

Returns

int

See also:
Period.days_in_month Return the days of the month

Period.dayofyear Return the day of the year

Examples

```python
>>> p = pd.Period("2018-03-11", freq='H')
>>> p.daysinmonth
31
```

pandas.Period.hour

Period.hour Get the hour of the day component of the Period.

Returns int

The hour as an integer, between 0 and 23.

See also:

Period.second Get the second component of the Period.

Period.minute Get the minute component of the Period.

Examples

```python
>>> p.hour
13
```

Period longer than a day

```python
>>> p = pd.Period("2018-03-11", freq="M")
>>> p.hour
0
```

pandas.Period.minute

Period.minute Get minute of the hour component of the Period.

Returns int

The minute as an integer, between 0 and 59.

See also:

Period.hour Get the hour component of the Period.

Period.second Get the second component of the Period.
Examples

```python
```

```python
>>> p.minute
3
```

`pandas.Period.second`

**Period.second**

Get the second component of the Period.

**Returns** *int*

The second of the Period (ranges from 0 to 59).

**See also:**

`Period.hour` Get the hour component of the Period.

`Period.minute` Get the minute component of the Period.

Examples

```python
```

```python
>>> p.second
12
```

`pandas.Period.start_time`

**Period.start_time**

Get the Timestamp for the start of the period.

**Returns**

Timestamp

**See also:**

`Period.end_time` Return the end Timestamp.

`Period.dayofyear` Return the day of year.

`Period.daysinmonth` Return the days in that month.

`Period.dayofweek` Return the day of the week.

Examples

```python
>>> period = pd.Period('2012-1-1', freq='D')
```

```python
>>> period
Period('2012-01-01', 'D')
```
pandas: powerful Python data analysis toolkit, Release 0.23.2

>>> period.start_time
Timestamp('2012-01-01 00:00:00')

>>> period.end_time
Timestamp('2012-01-01 23:59:59.999999999')

**pandas.Period.week**

**Period.week**

Get the week of the year on the given Period.

**Returns**

int

**See also:**

*Period.dayofweek* Get the day component of the Period.

*Period.weekday* Get the day component of the Period.

**Examples**

```python
>>> p = pd.Period("2018-03-11", "H")
>>> p.week
10

>>> p = pd.Period("2018-02-01", "D")
>>> p.week
5

>>> p = pd.Period("2018-01-06", "D")
>>> p.week
1
```

<table>
<thead>
<tr>
<th>Methods</th>
<th>end_time</th>
<th>freq</th>
<th>freqstr</th>
<th>is_leap_year</th>
<th>month</th>
<th>ordinal</th>
<th>quarter</th>
<th>qyear</th>
<th>weekday</th>
<th>weekofyear</th>
<th>year</th>
</tr>
</thead>
</table>

**Methods**
### pandas.Period.asfreq

**Period.asfreq()**

Convert Period to desired frequency, either at the start or end of the interval

**Parameters**

- **freq** [string]
- **how** : {'E', 'S', 'end', 'start'}, default 'end'
  
Start or end of the timespan

**Returns**

- **resampled** [Period]

### pandas.Period.strftime

**Period.strftime()**

Returns the string representation of the Period, depending on the selected fmt. fmt must be a string containing one or several directives. The method recognizes the same directives as the `time.strftime()` function of the standard Python distribution, as well as the specific additional directives `%f`, `%F`, `%q`. (formatting & docs originally from scikits.timeries)
<table>
<thead>
<tr>
<th>Directive</th>
<th>Meaning</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>%a</td>
<td>Locale’s abbreviated weekday name.</td>
<td></td>
</tr>
<tr>
<td>%A</td>
<td>Locale’s full weekday name.</td>
<td></td>
</tr>
<tr>
<td>%b</td>
<td>Locale’s abbreviated month name.</td>
<td></td>
</tr>
<tr>
<td>%B</td>
<td>Locale’s full month name.</td>
<td></td>
</tr>
<tr>
<td>%c</td>
<td>Locale’s appropriate date and time representation.</td>
<td></td>
</tr>
<tr>
<td>%d</td>
<td>Day of the month as a decimal number [01,31].</td>
<td></td>
</tr>
<tr>
<td>%e</td>
<td>‘Fiscal’ year without a century as a decimal number [00,99]</td>
<td>(1)</td>
</tr>
<tr>
<td>%E</td>
<td>‘Fiscal’ year with a century as a decimal number</td>
<td>(2)</td>
</tr>
<tr>
<td>%H</td>
<td>Hour (24-hour clock) as a decimal number [00,23].</td>
<td></td>
</tr>
<tr>
<td>%I</td>
<td>Hour (12-hour clock) as a decimal number [01,12].</td>
<td></td>
</tr>
<tr>
<td>%j</td>
<td>Day of the year as a decimal number [001,366].</td>
<td></td>
</tr>
<tr>
<td>%m</td>
<td>Month as a decimal number [01,12].</td>
<td></td>
</tr>
<tr>
<td>%M</td>
<td>Minute as a decimal number [00,59].</td>
<td></td>
</tr>
<tr>
<td>%p</td>
<td>Locale’s equivalent of either AM or PM.</td>
<td>(3)</td>
</tr>
<tr>
<td>%q</td>
<td>Quarter as a decimal number [01,04]</td>
<td></td>
</tr>
<tr>
<td>%s</td>
<td>Second as a decimal number [00,61].</td>
<td>(4)</td>
</tr>
<tr>
<td>%u</td>
<td>Week number of the year (Sunday as the first day of the week) as a decimal number [00,53]. All days in a new year preceding the first Sunday are considered to be in week 0.</td>
<td>(5)</td>
</tr>
<tr>
<td>%w</td>
<td>Weekday as a decimal number [0(Sunday),6].</td>
<td></td>
</tr>
<tr>
<td>%w</td>
<td>Week number of the year (Monday as the first day of the week) as a decimal number [00,53]. All days in a new year preceding the first Monday are considered to be in week 0.</td>
<td>(5)</td>
</tr>
<tr>
<td>%x</td>
<td>Locale’s appropriate date representation.</td>
<td></td>
</tr>
<tr>
<td>%X</td>
<td>Locale’s appropriate time representation.</td>
<td></td>
</tr>
<tr>
<td>%y</td>
<td>Year without century as a decimal number [00,99].</td>
<td></td>
</tr>
<tr>
<td>%Y</td>
<td>Year with century as a decimal number.</td>
<td></td>
</tr>
<tr>
<td>%z</td>
<td>Time zone name (no characters if no time zone exists).</td>
<td></td>
</tr>
<tr>
<td>%Z</td>
<td>A literal % character.</td>
<td></td>
</tr>
</tbody>
</table>

**Notes**

1. The %f directive is the same as %y if the frequency is not quarterly. Otherwise, it corresponds to the ‘fiscal’ year, as defined by the qyear attribute.
2. The %F directive is the same as %Y if the frequency is not quarterly. Otherwise, it corresponds to the ‘fiscal’ year, as defined by the qyear attribute.
3. The %p directive only affects the output hour field if the %I directive is used to parse the hour.
4. The range really is 0 to 61; this accounts for leap seconds and the (very rare) double leap seconds.
5. The %U and %W directives are only used in calculations when the day of the week and the year are specified.

**Examples**
>> a = Period(freq='Q-JUL', year=2006, quarter=1)
>> a.strftime('%F-Q%q')
'2006-Q1'
>> # Output the last month in the quarter of this date
>> a.strftime('%b-%Y')
'Oct-2005'
>> a = Period(freq='D', year=2001, month=1, day=1)
>> a.strftime('%d-%b-%Y')
'01-Jan-2006'
>> a.strftime('%b. %d, %Y was a %A')
'Jan. 01, 2001 was a Monday'

pandas.Period.to_timestamp

Period.to_timestamp()
Return the Timestamp representation of the Period at the target frequency at the specified end (how) of the Period

Parameters freq : string or DateOffset
Target frequency. Default is ‘D’ if self.freq is week or longer and ‘S’ otherwise

how: str, default ‘S’ (start)

Returns
Timestamp

34.14.2 Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period.day</td>
<td>Get day of the month that a Period falls on.</td>
</tr>
<tr>
<td>Period.dayofweek</td>
<td>Return the day of the week.</td>
</tr>
<tr>
<td>Period.dayofyear</td>
<td>Return the day of the year.</td>
</tr>
<tr>
<td>Period.days_in_month</td>
<td>Get the total number of days in the month that this period falls on.</td>
</tr>
<tr>
<td>Period.daysinmonth</td>
<td>Get the total number of days of the month that the Period falls in.</td>
</tr>
<tr>
<td>Period.end_time</td>
<td></td>
</tr>
<tr>
<td>Period.freq</td>
<td></td>
</tr>
<tr>
<td>Period.freqstr</td>
<td></td>
</tr>
<tr>
<td>Period.hour</td>
<td>Get the hour of the day component of the Period.</td>
</tr>
<tr>
<td>Period.is_leap_year</td>
<td></td>
</tr>
<tr>
<td>Period.minute</td>
<td>Get minute of the hour component of the Period.</td>
</tr>
<tr>
<td>Period.month</td>
<td></td>
</tr>
<tr>
<td>Period.ordinal</td>
<td></td>
</tr>
<tr>
<td>Period.quarter</td>
<td></td>
</tr>
<tr>
<td>Period.qyear</td>
<td></td>
</tr>
</tbody>
</table>

Continued on next page
## pandas: powerful Python data analysis toolkit, Release 0.23.2

### Table 144 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Period.second</code></td>
<td>Get the second component of the Period.</td>
</tr>
<tr>
<td><code>Period.start_time</code></td>
<td>Get the Timestamp for the start of the period.</td>
</tr>
<tr>
<td><code>Period.week</code></td>
<td>Get the week of the year on the given Period.</td>
</tr>
<tr>
<td><code>Period.weekday</code></td>
<td></td>
</tr>
<tr>
<td><code>Period.weekofyear</code></td>
<td></td>
</tr>
<tr>
<td><code>Period.year</code></td>
<td></td>
</tr>
</tbody>
</table>

**34.14.2.1 pandas.Period.end_time**

```
Period.end_time
```

**34.14.2.2 pandas.Period.freq**

```
Period.freq
```

**34.14.2.3 pandas.Period.freqstr**

```
Period.freqstr
```

**34.14.2.4 pandas.Period.is_leap_year**

```
Period.is_leap_year
```

**34.14.2.5 pandas.Period.month**

```
Period.month
```

**34.14.2.6 pandas.Period.ordinal**

```
Period.ordinal
```

**34.14.2.7 pandas.Period.quarter**

```
Period.quarter
```

**34.14.2.8 pandas.Period.qyear**

```
Period.qyear
```

**34.14.2.9 pandas.Period.weekday**

```
Period.weekday
```

**34.14.2.10 pandas.Period.weekofyear**

```
Period.weekofyear
```
34.14.2.11 pandas.Period.year

Period.year

34.14.3 Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period.asfreq</td>
<td>Convert Period to desired frequency, either at the start or end of the interval</td>
</tr>
<tr>
<td>Period.now</td>
<td></td>
</tr>
<tr>
<td>Period.strftime</td>
<td>Returns the string representation of the Period, depending on the selected fmt.</td>
</tr>
<tr>
<td>Period.to_timestamp</td>
<td>Return the Timestamp representation of the Period at the target frequency at the specified end (how) of the Period</td>
</tr>
</tbody>
</table>

34.14.3.1 pandas.Period.now

Period.now()

34.14.4 Timestamp

Timestamp Pandas replacement for datetime.datetime

34.14.4.1 pandas.Timestamp

class pandas.Timestamp
Pandas replacement for datetime.datetime

Timestamp is the pandas equivalent of python’s Datetime and is interchangeable with it in most cases. It’s the type used for the entries that make up a DatetimeIndex, and other timeseries oriented data structures in pandas.

Parameters

- ts_input : datetime-like, str, int, float
  Value to be converted to Timestamp
- freq : str, DateOffset
  Offset which Timestamp will have
- tz : str, pytz.timezone, dateutil.tz.tzfile or None
  Time zone for time which Timestamp will have.
- unit : str
  Unit used for conversion if ts_input is of type int or float. The valid values are ‘D’, ‘h’, ‘m’, ‘s’, ‘ms’, ‘us’, and ‘ns’. For example, ‘s’ means seconds and ‘ms’ means milliseconds.
- year, month, day : int
  New in version 0.19.0.
- hour, minute, second, microsecond : int, optional, default 0
  New in version 0.19.0.
- nanosecond : int, optional, default 0
New in version 0.23.0.

**tzinfo** : datetime.tzinfo, optional, default None

New in version 0.19.0.

**Notes**

There are essentially three calling conventions for the constructor. The primary form accepts four parameters. They can be passed by position or keyword.

The other two forms mimic the parameters from `datetime.datetime`. They can be passed by either position or keyword, but not both mixed together.

**Examples**

Using the primary calling convention:

This converts a datetime-like string >>> pd.Timestamp('2017-01-01T12') Timestamp('2017-01-01 12:00:00')

This converts a float representing a Unix epoch in units of seconds >>> pd.Timestamp(1513393355.5, unit='s') Timestamp('2017-12-16 03:02:35.500000')

This converts an int representing a Unix-epoch in units of seconds and for a particular timezone >>> pd.Timestamp(1513393355, unit='s', tz='US/Pacific') Timestamp('2017-12-15 19:02:35-0800', tz='US/Pacific')

Using the other two forms that mimic the API for `datetime.datetime`:

```python
>>> pd.Timestamp(2017, 1, 1, 12)
Timestamp('2017-01-01 12:00:00')

>>> pd.Timestamp(year=2017, month=1, day=1, hour=12)
Timestamp('2017-01-01 12:00:00')
```

**Attributes**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>tz</code></td>
<td>Alias for <code>tzinfo</code></td>
</tr>
<tr>
<td><code>weekday_name</code></td>
<td>(DEPRECATED) ..</td>
</tr>
</tbody>
</table>

**pandas.Timestamp.tz**

`Timestamp.tz`

Alias for `tzinfo`

**pandas.Timestamp.weekday_name**

`Timestamp.weekday_name`

Deprecated since version 0.23.0: Use `Timestamp.day_name()` instead
Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>astimezone</code></td>
<td>Convert tz-aware Timestamp to another time zone.</td>
</tr>
<tr>
<td><code>ceil</code></td>
<td>Return a new Timestamp ceiled to this resolution</td>
</tr>
<tr>
<td><code>combine</code></td>
<td>(date, time) -&gt; datetime with same date and time fields</td>
</tr>
<tr>
<td><code>ctime</code></td>
<td>Return ctime() style string.</td>
</tr>
<tr>
<td><code>date</code></td>
<td>Return date object with same year, month and day.</td>
</tr>
<tr>
<td><code>day_name</code></td>
<td>Return the day name of the Timestamp with specified locale.</td>
</tr>
<tr>
<td><code>dst</code></td>
<td>Return self.tzinfo.dst(self).</td>
</tr>
<tr>
<td><code>floor</code></td>
<td>Return a new Timestamp floored to this resolution</td>
</tr>
<tr>
<td><code>fromordinal</code></td>
<td>(ordinal[, freq, tz]) -&gt; translate and convert to a ts note:</td>
</tr>
<tr>
<td></td>
<td>passed an ordinal, translate and convert to a ts note: by definition there</td>
</tr>
<tr>
<td></td>
<td>cannot be any tz info on the ordinal itself</td>
</tr>
<tr>
<td><code>fromtimestamp</code></td>
<td>(ts) -&gt; tz’s local time from POSIX timestamp.</td>
</tr>
<tr>
<td><code>isocalendar</code></td>
<td>Return a 3-tuple containing ISO year, week number, and weekday.</td>
</tr>
<tr>
<td><code>isoweekday</code></td>
<td>Return the day of the week represented by the date.</td>
</tr>
</tbody>
</table>

Continued on next page
### Table 148 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>month_name</code></td>
<td>Return the month name of the Timestamp with specified locale.</td>
</tr>
<tr>
<td><code>normalize</code></td>
<td>Normalize Timestamp to midnight, preserving tz information.</td>
</tr>
<tr>
<td><code>now([tz])</code></td>
<td>Returns new Timestamp object representing current time local to tz.</td>
</tr>
<tr>
<td><code>replace</code></td>
<td>implements datetime.replace, handles nanoseconds</td>
</tr>
<tr>
<td><code>round</code></td>
<td>Round the Timestamp to the specified resolution</td>
</tr>
<tr>
<td><code>strftime</code></td>
<td>format -&gt; strftime() style string.</td>
</tr>
<tr>
<td><code>strptime</code></td>
<td>string, format -&gt; new datetime parsed from a string (like time.strptime()).</td>
</tr>
<tr>
<td><code>time</code></td>
<td>Return time object with same time but with tz-info=None.</td>
</tr>
<tr>
<td><code>timestamp</code></td>
<td>Return POSIX timestamp as float.</td>
</tr>
<tr>
<td><code>timetz</code></td>
<td>Return time object with same time and tzinfo.</td>
</tr>
<tr>
<td><code>to_datetime64</code></td>
<td>Returns a numpy.datetime64 object with &quot;ns&quot; precision</td>
</tr>
<tr>
<td><code>to_julian_date</code></td>
<td>Convert TimeStamp to a Julian Date.</td>
</tr>
<tr>
<td><code>to_period</code></td>
<td>Return an an period of which this timestamp is an observation.</td>
</tr>
<tr>
<td><code>to_pydatetime</code></td>
<td>Convert a Timestamp object to a native Python datetime object.</td>
</tr>
<tr>
<td><code>today(cls[, tz])</code></td>
<td>Return the current time in the local timezone.</td>
</tr>
<tr>
<td><code>toordinal</code></td>
<td>Return proleptic Gregorian ordinal.</td>
</tr>
<tr>
<td><code>tz_convert</code></td>
<td>Convert tz-aware Timestamp to another time zone.</td>
</tr>
<tr>
<td><code>tz_localize</code></td>
<td>Convert naive Timestamp to local time zone, or remove timezone from tz-aware Timestamp.</td>
</tr>
<tr>
<td><code>tzname</code></td>
<td>Return self.tzinfo.tzname(self).</td>
</tr>
<tr>
<td><code>utcfromtimestamp</code></td>
<td>Construct a naive UTC datetime from a POSIX timestamp.</td>
</tr>
<tr>
<td><code>utcnow()</code></td>
<td>Return a new Timestamp representing UTC day and time.</td>
</tr>
<tr>
<td><code>utcoffset</code></td>
<td>Return self.tzinfo.utcoffset(self).</td>
</tr>
<tr>
<td><code>utctimetuple</code></td>
<td>Return UTC time tuple, compatible with time.localtime().</td>
</tr>
<tr>
<td><code>weekday</code></td>
<td>Return the day of the week represented by the date.</td>
</tr>
</tbody>
</table>

---

**pandas.Timestamp.astimezone**

Convert tz-aware Timestamp to another time zone.

**Parameters**

- `tz`: str, pytz.timezone, dateutil.tz.tzfile or None

Time zone for time which Timestamp will be converted to. None will remove timezone holding UTC time.

**Returns**

- `converted` [Timestamp]

**Raises**

- TypeError

If Timestamp is tz-naive.
pandas.Timestamp.ceil

Timestamp.ceil
    return a new Timestamp ceiled to this resolution

Parameters
    freq [a freq string indicating the ceiling resolution]

pandas.Timestamp.combine
classmethod Timestamp.combine(date, time)
    date, time -> datetime with same date and time fields

pandas.Timestamp.ctime

Timestamp.ctime()
    Return ctime() style string.

pandas.Timestamp.date

Timestamp.date()
    Return date object with same year, month and day.

pandas.Timestamp.day_name

Timestamp.day_name
    Return the day name of the Timestamp with specified locale.

Parameters
    locale : string, default None (English locale)

locale determining the language in which to return the day name

Returns
    day_name [string]

.. versionadded:: 0.23.0

pandas.Timestamp.dst

Timestamp.dst()
    Return self.tzinfo.dst(self).

pandas.Timestamp.floor

Timestamp.floor
    return a new Timestamp floored to this resolution

Parameters
    freq [a freq string indicating the flooring resolution]
**pandas.Timestamp.fromordinal**

**classmethod pandas.Timestamp.fromordinal**(ordinal, freq=None, tz=None)

Passed an ordinal, translate and convert to a ts note: by definition there cannot be any tz info on the ordinal itself

**Parameters**

- **ordinal** : int
date corresponding to a proleptic Gregorian ordinal
- **freq** : str, DateOffset
  Offset which Timestamp will have
- **tz** : str, pytz.timezone, dateutil.tz.tzfile or None
  Time zone for time which Timestamp will have.

**pandas.Timestamp.fromtimestamp**

**classmethod pandas.Timestamp.fromtimestamp**(ts)
timestamp[, tz] -> tz’s local time from POSIX timestamp.

**pandas.Timestamp.isocalendar**

**Timestamp.isocalendar**()
Return a 3-tuple containing ISO year, week number, and weekday.

**pandas.Timestamp.isoweekday**

**Timestamp.isoweekday**()
Return the day of the week represented by the date. Monday == 1 ... Sunday == 7

**pandas.Timestamp.month_name**

**Timestamp.month_name**
Return the month name of the Timestamp with specified locale.

**Parameters**

- **locale** : string, default None (English locale)
  locale determining the language in which to return the month name

**Returns**

- **month_name** [string]
  .. versionadded:: 0.23.0

**pandas.Timestamp.normalize**

**Timestamp.normalize**
Normalize Timestamp to midnight, preserving tz information.
**pandas.Timestamp.now**

**classmethod**  
*pandas.Timestamp.now(tz=None)*

Returns new Timestamp object representing current time local to `tz`.

**Parameters**

- `tz`: str or timezone object, default None
  Timezone to localize to

**pandas.Timestamp.replace**

*Timestamp.replace*

Implements datetime.replace, handles nanoseconds

**Parameters**

- `year` [int, optional]
- `month` [int, optional]
- `day` [int, optional]
- `hour` [int, optional]
- `minute` [int, optional]
- `second` [int, optional]
- `microsecond` [int, optional]
- `nanosecond` int, optional
- `tzinfo` [tz-convertible, optional]
- `fold` : int, optional, default is 0
  added in 3.6, NotImplemented

**Returns**

Timestamp with fields replaced

**pandas.Timestamp.round**

*Timestamp.round*

Round the Timestamp to the specified resolution

**Parameters**

- `freq` [a freq string indicating the rounding resolution]

**Returns**

- a new Timestamp rounded to the given resolution of ‘freq’

**Raises**

- ValueError if the freq cannot be converted
pandas.Timestamp.strptime

```
Timestamp.strptime(string, format)
```
string, format -> new datetime parsed from a string (like `time.strptime()`).

pandas.Timestamp.time

```
Timestamp.time()
```
Return time object with same time but with tzinfo=None.

pandas.Timestamp.timestamp

```
Timestamp.timestamp()
```
Return POSIX timestamp as float.

pandas.Timestamp.timetuple

```
Timestamp.timetuple()
```
Return time tuple, compatible with `time.localtime()`.

pandas.Timestamp.timetz

```
Timestamp.timetz()
```
Return time object with same time and tzinfo.

pandas.Timestamp.to_datetime64

```
Timestamp.to_datetime64()
```
Returns a numpy.datetime64 object with ‘ns’ precision.

pandas.Timestamp.to_julian_date

```
Timestamp.to_julian_date()
```
Convert TimeStamp to a Julian Date. 0 Julian date is noon January 1, 4713 BC.

pandas.Timestamp.to_period

```
Timestamp.to_period
```
Return an period of which this timestamp is an observation.
```python
pandas.Timestamp.to_pydatetime

Timestamp.to_pydatetime()
Convert a Timestamp object to a native Python datetime object.
If warn=True, issue a warning if nanoseconds is nonzero.

pandas.Timestamp.today

classmethod Timestamp.today(cls, tz=None)
Return the current time in the local timezone. This differs from datetime.today() in that it can be localized
to a passed timezone.

Parameters tz : str or timezone object, default None
    Timezone to localize to

pandas.Timestamp.toordinal

Timestamp.toordinal()
Return proleptic Gregorian ordinal. January 1 of year 1 is day 1.

pandas.Timestamp.tz_convert

Timestamp.tz_convert
Convert tz-aware Timestamp to another time zone.

Parameters tz : str, pytz.timezone, dateutil.tz.tzfile or None
    Time zone for time which Timestamp will be converted to. None will remove
timezone holding UTC time.

Returns
converted [Timestamp]

Raises TypeError
    If Timestamp is tz-naive.

pandas.Timestamp.tz_localize

Timestamp.tz_localize
Convert naive Timestamp to local time zone, or remove timezone from tz-aware Timestamp.

Parameters tz : str, pytz.timezone, dateutil.tz.tzfile or None
    Time zone for time which Timestamp will be converted to. None will remove
timezone holding local time.

ambiguous : bool, ‘NaT’, default ‘raise’
    • bool contains flags to determine if time is dst or not (note that this flag is only appli-
cable for ambiguous fall dst dates)
    • ‘NaT’ will return NaT for an ambiguous time
```
• ‘raise’ will raise an AmbiguousTimeError for an ambiguous time errors: ‘raise’, ‘coerce’, default ‘raise’
• ‘raise’ will raise a NonExistentTimeError if a timestamp is not valid in the specified timezone (e.g. due to a transition from or to DST time)
• ‘coerce’ will return NaT if the timestamp can not be converted into the specified timezone

New in version 0.19.0.

Returns

localized [Timestamp]

Raises TypeError

If the Timestamp is tz-aware and tz is not None.

pandas.Timestamp.tzname

Timestamp.tzname()
    Return self.tzinfo.tzname(self).

pandas.Timestamp.utcfromtimestamp

classmethod Timestamp.utcfromtimestamp(ts)
    Construct a naive UTC datetime from a POSIX timestamp.

pandas.Timestamp.utcnow

classmethod Timestamp.utcnow()
    Return a new Timestamp representing UTC day and time.

pandas.Timestamp.utcoffset

Timestamp.utcoffset()
    Return self.tzinfo.utcoffset(self).

pandas.Timestamp.utctimetuple

Timestamp.utctimetuple()
    Return UTC time tuple, compatible with time.localtime().

pandas.Timestamp.weekday

Timestamp.weekday()
    Return the day of the week represented by the date. Monday == 0 ... Sunday == 6

isoformat
34.14.5 Properties

```
Timestamp.asm8
Timestamp.day
Timestamp.dayofweek
Timestamp.dayofyear
Timestamp.days_in_month
Timestamp.daysinmonth
Timestamp.fold
Timestamp.hour
Timestamp.is_leap_year
Timestamp.is_month_end
Timestamp.is_month_start
Timestamp.is_quarter_end
Timestamp.is_quarter_start
Timestamp.is_year_end
Timestamp.is_year_start
Timestamp.max
Timestamp.microsecond
Timestamp.min
Timestamp.month
Timestamp.nanosecond
Timestamp.quarter
Timestamp.resolution
Timestamp.second
Timestamp.tz
Timestamp.tzinfo
Timestamp.value
Timestamp.week
Timestamp.weekofyear
Timestamp.year
```

### 34.14.5.1 pandas.Timestamp.asm8

`Timestamp.asm8`

### 34.14.5.2 pandas.Timestamp.day

`Timestamp.day`

### 34.14.5.3 pandas.Timestamp.dayofweek

`Timestamp.dayofweek`

### 34.14.5.4 pandas.Timestamp.dayofyear

`Timestamp.dayofyear`
34.14.5.5 pandas.Timestamp.days_in_month
Timestamp.days_in_month

34.14.5.6 pandas.Timestamp.daysinmonth
Timestamp.daysinmonth

34.14.5.7 pandas.Timestamp.fold
Timestamp.fold

34.14.5.8 pandas.Timestamp.hour
Timestamp.hour

34.14.5.9 pandas.Timestamp.is_leap_year
Timestamp.is_leap_year

34.14.5.10 pandas.Timestamp.is_month_end
Timestamp.is_month_end

34.14.5.11 pandas.Timestamp.is_month_start
Timestamp.is_month_start

34.14.5.12 pandas.Timestamp.is_quarter_end
Timestamp.is_quarter_end

34.14.5.13 pandas.Timestamp.is_quarter_start
Timestamp.is_quarter_start

34.14.5.14 pandas.Timestamp.is_year_end
Timestamp.is_year_end

34.14.5.15 pandas.Timestamp.is_year_start
Timestamp.is_year_start
34.14.5.16 pandas.Timestamp.max

Timestamp.max = Timestamp('2262-04-11 23:47:16.854775807')

34.14.5.17 pandas.Timestamp.microsecond

Timestamp.microsecond

34.14.5.18 pandas.Timestamp.min

Timestamp.min = Timestamp('1677-09-21 00:12:43.145225')

34.14.5.19 pandas.Timestamp.minute

Timestamp.minute

34.14.5.20 pandas.Timestamp.month

Timestamp.month

34.14.5.21 pandas.Timestamp.nanosecond

Timestamp.nanosecond

34.14.5.22 pandas.Timestamp.quarter

Timestamp.quarter

34.14.5.23 pandas.Timestamp.resolution

Timestamp.resolution = datetime.timedelta(0, 0, 1)

34.14.5.24 pandas.Timestamp.second

Timestamp.second

34.14.5.25 pandas.Timestamp.tzinfo

Timestamp.tzinfo

34.14.5.26 pandas.Timestamp.value

Timestamp.value
### pandas: powerful Python data analysis toolkit, Release 0.23.2

#### 34.14.5.27 pandas.Timestamp.week

**Timestamp.week**

#### 34.14.5.28 pandas.Timestamp.weekofyear

**Timestamp.weekofyear**

#### 34.14.5.29 pandas.Timestamp.year

**Timestamp.year**

### 34.14.6 Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Timestamp.astimezone</code></td>
<td>Convert tz-aware Timestamp to another time zone.</td>
</tr>
<tr>
<td><code>Timestamp.ceil</code></td>
<td>Return a new Timestamp ceiled to this resolution</td>
</tr>
<tr>
<td><code>Timestamp.combine</code></td>
<td><code>date, time</code> -&gt; datetime with same date and time fields</td>
</tr>
<tr>
<td><code>Timestamp.ctime</code></td>
<td>Return ctime() style string.</td>
</tr>
<tr>
<td><code>Timestamp.date</code></td>
<td>Return date object with same year, month and day.</td>
</tr>
<tr>
<td><code>Timestamp.day_name</code></td>
<td>Return the day name of the Timestamp with specified locale.</td>
</tr>
<tr>
<td><code>Timestamp.dst</code></td>
<td>Return self.tzinfo.dst(self).</td>
</tr>
<tr>
<td><code>Timestamp.floor</code></td>
<td>Return a new Timestamp floored to this resolution</td>
</tr>
<tr>
<td><code>Timestamp.freq</code></td>
<td></td>
</tr>
<tr>
<td><code>Timestamp.freqstr</code></td>
<td></td>
</tr>
<tr>
<td><code>Timestamp.fromordinal</code></td>
<td>passed an ordinal, translate and convert to a ts note: by definition there cannot be any tz info on the ordinal itself</td>
</tr>
<tr>
<td><code>Timestamp.fromtimestamp</code></td>
<td><code>ts</code> -&gt; tz’s local time from POSIX timestamp.</td>
</tr>
<tr>
<td><code>Timestamp.isocalendar</code></td>
<td>Return a 3-tuple containing ISO year, week number, and weekday.</td>
</tr>
<tr>
<td><code>Timestamp.isoformat</code></td>
<td></td>
</tr>
<tr>
<td><code>Timestamp.isoweekday</code></td>
<td>Return the day of the week represented by the date.</td>
</tr>
<tr>
<td><code>Timestamp.month_name</code></td>
<td>Return the month name of the Timestamp with specified locale.</td>
</tr>
<tr>
<td><code>Timestamp.normalize</code></td>
<td>Normalize Timestamp to midnight, preserving tz information.</td>
</tr>
<tr>
<td><code>Timestamp.now([tz])</code></td>
<td>Returns new Timestamp object representing current time local to tz.</td>
</tr>
<tr>
<td><code>Timestamp.replace</code></td>
<td>implements datetime.replace, handles nanoseconds</td>
</tr>
<tr>
<td><code>Timestamp.round</code></td>
<td>Round the Timestamp to the specified resolution</td>
</tr>
<tr>
<td><code>Timestamp.strptime</code></td>
<td><code>string, format</code> -&gt; new datetime parsed from a string (like time.strptime()).</td>
</tr>
<tr>
<td><code>Timestamp.strftime</code></td>
<td><code>format</code> -&gt; strftime() style string.</td>
</tr>
<tr>
<td><code>Timestamp.time</code></td>
<td>Return time object with same time but with tz-info=None.</td>
</tr>
<tr>
<td><code>Timestamp.timestamp</code></td>
<td>Return POSIX timestamp as float.</td>
</tr>
<tr>
<td><code>Timestamp.timetuple</code></td>
<td>Return time tuple, compatible with time.localtime().</td>
</tr>
<tr>
<td><code>Timestamp.timetz</code></td>
<td>Return time object with same time and tzinfo.</td>
</tr>
</tbody>
</table>

**Continued on next page**
Table 150 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Timestamp.to_datetime64</code></td>
<td>Returns a numpy.datetime64 object with ‘ns’ precision</td>
</tr>
<tr>
<td><code>Timestamp.to_julian_date</code></td>
<td>Convert TimeStamp to a Julian Date.</td>
</tr>
<tr>
<td><code>Timestamp.to_period</code></td>
<td>Return an period of which this timestamp is an observation.</td>
</tr>
<tr>
<td><code>Timestamp.to_pydatetime</code></td>
<td>Convert a Timestamp object to a native Python datetime object.</td>
</tr>
<tr>
<td><code>Timestamp.today(cls[, tz])</code></td>
<td>Return the current time in the local timezone.</td>
</tr>
<tr>
<td><code>Timestamp.toordinal</code></td>
<td>Return proleptic Gregorian ordinal.</td>
</tr>
<tr>
<td><code>Timestamp.tz_convert</code></td>
<td>Convert tz-aware Timestamp to another time zone.</td>
</tr>
<tr>
<td><code>Timestamp.tz_localize</code></td>
<td>Convert naive Timestamp to local time zone, or remove timezone from tz-aware Timestamp.</td>
</tr>
<tr>
<td><code>Timestamp.tzname</code></td>
<td>Return self.tzinfo.tzname(self).</td>
</tr>
<tr>
<td><code>Timestamp.utcfromtimestamp(ts)</code></td>
<td>Construct a naive UTC datetime from a POSIX timestamp.</td>
</tr>
<tr>
<td><code>Timestamp.utcnow()</code></td>
<td>Return a new Timestamp representing UTC day and time.</td>
</tr>
<tr>
<td><code>Timestamp.utcoffset</code></td>
<td>Return self.tzinfo.utcoffset(self).</td>
</tr>
<tr>
<td><code>Timestamp.utctimetuple</code></td>
<td>Return UTC time tuple, compatible with time.localtime().</td>
</tr>
<tr>
<td><code>Timestamp.weekday</code></td>
<td>Return the day of the week represented by the date.</td>
</tr>
</tbody>
</table>

34.14.6.1 pandas.Timestamp.freq

`Timestamp.freq`

34.14.6.2 pandas.Timestamp.freqstr

`Timestamp.freqstr`

34.14.6.3 pandas.Timestamp.isoformat

`Timestamp.isoformat`

34.14.7 Interval

`Interval` Immutable object implementing an Interval, a bounded slice-like interval.

34.14.7.1 pandas.Interval

```
class pandas.Interval
    Immutable object implementing an Interval, a bounded slice-like interval.

    New in version 0.20.0.

    Parameters
    left : orderable scalar
        Left bound for the interval.

    right : orderable scalar
```
Right bound for the interval.

**closed**: \{‘left’, ‘right’, ‘both’, ‘neither’\}, default ‘right’

Whether the interval is closed on the left-side, right-side, both or neither.

**closed**: \{‘right’, ‘left’, ‘both’, ‘neither’\}, default ‘right’

Whether the interval is closed on the left-side, right-side, both or neither. See the Notes for more detailed explanation.

**See also:**

**IntervalIndex** An Index of Interval objects that are all closed on the same side.

**cut** Convert continuous data into discrete bins (Categorical of Interval objects).

**qcut** Convert continuous data into bins (Categorical of Interval objects) based on quantiles.

**Period** Represents a period of time.

**Notes**

The parameters *left* and *right* must be from the same type, you must be able to compare them and they must satisfy \( \text{left} \leq \text{right} \).

A closed interval (in mathematics denoted by square brackets) contains its endpoints, i.e. the closed interval \([0, 5]\) is characterized by the conditions \(0 \leq x \leq 5\). This is what \text{closed='both'} \ stands for. An open interval (in mathematics denoted by parentheses) does not contain its endpoints, i.e. the open interval \((0, 5)\) is characterized by the conditions \(0 < x < 5\). This is what \text{closed='neither'} \ stands for. Intervals can also be half-open or half-closed, i.e. \([0, 5)\) is described by \(0 \leq x < 5\) (\text{closed='left'}) and \((0, 5]\) is described by \(0 < x \leq 5\) (\text{closed='right'}).

**Examples**

It is possible to build Intervals of different types, like numeric ones:

```python
>>> iv = pd.Interval(left=0, right=5)
>>> iv
Interval(0, 5, closed='right')
```

You can check if an element belongs to it

```python
>>> 2.5 in iv
True
```

You can test the bounds (\text{closed='right'}, so \(0 < x \leq 5\)):

```python
>>> 0 in iv
False
>>> 5 in iv
True
>>> 0.0001 in iv
True
```

Calculate its length
>>> iv.length
5

You can operate with + and * over an Interval and the operation is applied to each of its bounds, so the result depends on the type of the bound elements

>>> shifted_iv = iv + 3
>>> shifted_iv
Interval(3, 8, closed='right')
>>> extended_iv = iv * 10.0
>>> extended_iv
Interval(0.0, 50.0, closed='right')

To create a time interval you can use Timestamps as the bounds

>>> year_2017 = pd.Interval(pd.Timestamp('2017-01-01 00:00:00'),
...                          pd.Timestamp('2018-01-01 00:00:00'),
...                          closed='left')
>>> pd.Timestamp('2017-01-01 00:00') in year_2017
True
>>> year_2017.length
Timedelta('365 days 00:00:00')

And also you can create string intervals

>>> volume_1 = pd.Interval('Ant', 'Dog', closed='both')
>>> 'Bee' in volume_1
True

Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>closed</td>
<td>Whether the interval is closed on the left-side, right-side, both or neither</td>
</tr>
<tr>
<td>closed_left</td>
<td>Check if the interval is closed on the left side.</td>
</tr>
<tr>
<td>closed_right</td>
<td>Check if the interval is closed on the right side.</td>
</tr>
<tr>
<td>left</td>
<td>Left bound for the interval</td>
</tr>
<tr>
<td>length</td>
<td>Return the length of the Interval</td>
</tr>
<tr>
<td>mid</td>
<td>Return the midpoint of the Interval</td>
</tr>
<tr>
<td>open_left</td>
<td>Check if the interval is open on the left side.</td>
</tr>
<tr>
<td>open_right</td>
<td>Check if the interval is open on the right side.</td>
</tr>
<tr>
<td>right</td>
<td>Right bound for the interval</td>
</tr>
</tbody>
</table>

pandas.Interval.closed

Interval.closed

Whether the interval is closed on the left-side, right-side, both or neither

pandas.Interval.closed_left

Interval.closed_left

Check if the interval is closed on the left side.
For the meaning of closed and open see Interval.

Returns bool

True if the Interval is closed on the left-side, else False.

**pandas.Interval.closed_right**

Interval.closed_right

Check if the interval is closed on the right side.

For the meaning of closed and open see Interval.

Returns bool

True if the Interval is closed on the left-side, else False.

**pandas.Interval.left**

Interval.left

Left bound for the interval

**pandas.Interval.length**

Interval.length

Return the length of the Interval

**pandas.Interval.mid**

Interval.mid

Return the midpoint of the Interval

**pandas.Interval.open_left**

Interval.open_left

Check if the interval is open on the left side.

For the meaning of closed and open see Interval.

Returns bool

True if the Interval is closed on the left-side, else False.

**pandas.Interval.open_right**

Interval.open_right

Check if the interval is open on the right side.

For the meaning of closed and open see Interval.

Returns bool

True if the Interval is closed on the left-side, else False.
**pandas.Interval.right**

*Interval.*right

Right bound for the interval

### 34.14.8 Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval.closed</td>
<td>Whether the interval is closed on the left-side, right-side, both or neither</td>
</tr>
<tr>
<td>Interval.closed_left</td>
<td>Check if the interval is closed on the left side.</td>
</tr>
<tr>
<td>Interval.closed_right</td>
<td>Check if the interval is closed on the right side.</td>
</tr>
<tr>
<td>Interval.left</td>
<td>Left bound for the interval</td>
</tr>
<tr>
<td>Interval.length</td>
<td>Return the length of the Interval</td>
</tr>
<tr>
<td>Interval.mid</td>
<td>Return the midpoint of the Interval</td>
</tr>
<tr>
<td>Interval.open_left</td>
<td>Check if the interval is open on the left side.</td>
</tr>
<tr>
<td>Interval.open_right</td>
<td>Check if the interval is open on the right side.</td>
</tr>
<tr>
<td>Interval.right</td>
<td>Right bound for the interval</td>
</tr>
</tbody>
</table>

### 34.14.9 Timedelta

**Timedelta**

Represents a duration, the difference between two dates or times.

#### 34.14.9.1 pandas.Timedelta

class pandas.Timedelta

Represents a duration, the difference between two dates or times.

Timedelta is the pandas equivalent of python’s `datetime.timedelta` and is interchangeable with it in most cases.

**Parameters**

- **value** [Timedelta, timedelta, np.timedelta64, string, or integer]
- **unit** : string, {'ns', 'us', 'ms', 's', 'm', 'h', 'D'}, optional
  
  Denote the unit of the input, if input is an integer. Default ‘ns’.

- **days, seconds, microseconds, milliseconds, minutes, hours, weeks** : numeric, optional

  Values for construction in compat with datetime.timedelta. np ints and floats will be coerced to python ints and floats.

**Notes**

The .value attribute is always in ns.
### Attributes

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>asm8</code></td>
<td>Return a numpy timedelta64 array view of myself.</td>
</tr>
<tr>
<td><code>components</code></td>
<td>Return a Components NamedTuple-like.</td>
</tr>
<tr>
<td><code>days</code></td>
<td>Number of days.</td>
</tr>
<tr>
<td><code>delta</code></td>
<td>Return the timedelta in nanoseconds (ns), for internal compatibility.</td>
</tr>
<tr>
<td><code>microseconds</code></td>
<td>Number of microseconds (&gt;= 0 and less than 1 second).</td>
</tr>
<tr>
<td><code>nanoseconds</code></td>
<td>Return the number of nanoseconds (n), where 0 &lt;= n &lt; 1 microsecond.</td>
</tr>
<tr>
<td><code>resolution</code></td>
<td>Return a string representing the lowest resolution that we have.</td>
</tr>
<tr>
<td><code>seconds</code></td>
<td>Number of seconds (&gt;= 0 and less than 1 day).</td>
</tr>
</tbody>
</table>

#### pandas.Timedelta.asm8

Timedelta `asm8`

Return a numpy timedelta64 array view of myself.

#### pandas.Timedelta.components

Timedelta `components`

Return a Components NamedTuple-like.

#### pandas.Timedelta.days

Timedelta `days`

Number of days.

#### pandas.Timedelta.delta

Timedelta `delta`

Return the timedelta in nanoseconds (ns), for internal compatibility.

**Returns int**

Timedelta in nanoseconds.

### Examples

```python
>>> td = pd.Timedelta('1 days 42 ns')
>>> td.delta
86400000000042
```

```python
>>> td = pd.Timedelta('3 s')
>>> td.delta
3000000000
```
>> td = pd.Timedelta('3 ms 5 us')
>>> td.delta
3005000

>> td = pd.Timedelta(42, unit='ns')
>> td.delta
42

**pandas.Timedelta.microseconds**

Timedelta.microseconds
Number of microseconds (>= 0 and less than 1 second).

**pandas.Timedelta.nanoseconds**

Timedelta.nanoseconds
Return the number of nanoseconds (n), where 0 <= n < 1 microsecond.

Returns int
Number of nanoseconds.

See also:

Timedelta.components Return all attributes with assigned values (i.e. days, hours, minutes, seconds, milliseconds, microseconds, nanoseconds).

**Examples**

**Using string input**

```python
>>> td = pd.Timedelta('1 days 2 min 3 us 42 ns')
>>> td.nanoseconds
42
```

**Using integer input**

```python
>>> td = pd.Timedelta(42, unit='ns')
>>> td.nanoseconds
42
```

**pandas.Timedelta.resolution**

Timedelta.resolution
return a string representing the lowest resolution that we have

**pandas.Timedelta.seconds**

Timedelta.seconds
Number of seconds (>= 0 and less than 1 day).
Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ceil</strong></td>
<td>return a new Timedelta ceiled to this resolution</td>
</tr>
<tr>
<td><strong>floor</strong></td>
<td>return a new Timedelta floored to this resolution</td>
</tr>
<tr>
<td><strong>isoformat</strong></td>
<td>Format Timedelta as ISO 8601 Duration like ( P[n]Y[n]M[n]DT[n]H[n]M[n]S, ) where the ([n])s are replaced by the values.</td>
</tr>
<tr>
<td><strong>round</strong></td>
<td>Round the Timedelta to the specified resolution</td>
</tr>
<tr>
<td><strong>to_pytime delta</strong></td>
<td>return an actual datetime.timedelta object note: we lose nanosecond resolution if any</td>
</tr>
<tr>
<td><strong>to_timal delta64</strong></td>
<td>Returns a numpy.timedelta64 object with “ns” precision</td>
</tr>
<tr>
<td><strong>total_seconds</strong></td>
<td>Total duration of timedelta in seconds (to ns precision)</td>
</tr>
<tr>
<td><strong>view</strong></td>
<td>array view compat</td>
</tr>
</tbody>
</table>

**pandas.Timedelta.ceil**

Timedelta.ceil

return a new Timedelta ceiled to this resolution

Parameters

- freq [a freq string indicating the ceiling resolution]

**pandas.Timedelta.floor**

Timedelta.floor

return a new Timedelta floored to this resolution

Parameters

- freq [a freq string indicating the flooring resolution]

**pandas.Timedelta.isoformat**

Timedelta.isoformat()


New in version 0.20.0.

Returns

- formatted [str]

See also:

Timestamp.isoformat
Notes

The longest component is days, whose value may be larger than 365. Every component is always included, even if its value is 0. Pandas uses nanosecond precision, so up to 9 decimal places may be included in the seconds component. Trailing 0’s are removed from the seconds component after the decimal. We do not 0 pad components, so it’s ...T5H..., not ...T05H...

Examples

```python
>>> td = pd.Timedelta(days=6, minutes=50, seconds=3,
...                   milliseconds=10, microseconds=10, nanoseconds=12)
>>> td.isoformat()
'P6DT0H50M3.010010012S'
>>> pd.Timedelta(hours=1, seconds=10).isoformat()
'P0DT0H0M10S'
>>> pd.Timedelta(hours=1, seconds=10).isoformat()
'P0DT0H0M10S'
>>> pd.Timedelta(days=500.5).isoformat()
'P500DT12H0MS'
```

pandas.Timedelta.round

Timedelta.round

Round the Timedelta to the specified resolution

Parameters

- freq [a freq string indicating the rounding resolution]

Returns

- a new Timedelta rounded to the given resolution of ‘freq’

Raises

- ValueError if the freq cannot be converted

pandas.Timedelta.to_pytimedelta

Timedelta.to_pytimedelta()

return an actual datetime.timedelta object note: we lose nanosecond resolution if any

pandas.Timedelta.to_timedelta64

Timedelta.to_timedelta64()

Returns a numpy.timedelta64 object with ‘ns’ precision

pandas.Timedelta.total_seconds

Timedelta.total_seconds()

Total duration of timedelta in seconds (to ns precision)
pandas: powerful Python data analysis toolkit, Release 0.23.2

34.14.10.1 pandas.Timedelta.freq

Timedelta.freq

34.14.10.2 pandas.Timedelta.is_populated

Timedelta.is_populated

34.14.10.3 pandas.Timedelta.max

Timedelta.max = Timedelta('106751 days 23:47:16.854775')

34.14.10.4 pandas.Timedelta.min

Timedelta.min = Timedelta('-106752 days +00:12:43.145224')

34.14.10.5 pandas.Timedelta.value

Timedelta.value

34.14.11 Methods
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Timedelta.ceil</code></td>
<td>Return a new Timedelta ceiled to this resolution</td>
</tr>
<tr>
<td><code>Timedelta.floor</code></td>
<td>Return a new Timedelta floored to this resolution</td>
</tr>
<tr>
<td><code>Timedelta.round</code></td>
<td>Round the Timedelta to the specified resolution</td>
</tr>
<tr>
<td><code>Timedelta.to_pytimedelta</code></td>
<td>Return an actual datetime.timedelta object note: we lose nanosecond resolution if any</td>
</tr>
<tr>
<td><code>Timedelta.to_timedelta64</code></td>
<td>Returns a numpy.timedelta64 object with 'ns' precision</td>
</tr>
<tr>
<td><code>Timedelta.total_seconds</code></td>
<td>Total duration of timedelta in seconds (to ns precision)</td>
</tr>
</tbody>
</table>

### 34.15 Frequencies

#### to_offset(freq)

**Return** DateOffset object from string or tuple representation or datetime.timedelta object

**Parameters**

- **freq** [str, tuple, datetime.timedelta, DateOffset or None]

**Returns** delta : DateOffset

None if freq is None

**Raises** ValueError

If freq is an invalid frequency

**See also:**

pandas.DateOffset

**Examples**

```python
>>> to_offset('5min')
<5 * Minutes>

>>> to_offset('1D1H')
<25 * Hours>

>>> to_offset(('W', 2))
<2 * Weeks: weekday=6>

>>> to_offset((2, 'B'))
<2 * BusinessDays>

>>> to_offset(datetime.timedelta(days=1))
<Day>
```
34.16 Window

Rolling objects are returned by `.rolling` calls: `pandas.DataFrame.rolling()`, `pandas.Series.rolling()`, etc. Expanding objects are returned by `.expanding` calls: `pandas.DataFrame.expanding()`, `pandas.Series.expanding()`, etc. EWM objects are returned by `.ewm` calls: `pandas.DataFrame.ewm()`, `pandas.Series.ewm()`, etc.

34.16.1 Standard moving window functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolling.count()</td>
<td>The rolling count of any non-NaN observations inside the window.</td>
</tr>
<tr>
<td>Rolling.sum(*args, **kwvars)</td>
<td>Calculate rolling sum of given DataFrame or Series.</td>
</tr>
<tr>
<td>Rolling.mean(*args, **kwvars)</td>
<td>Calculate the rolling mean of the values.</td>
</tr>
<tr>
<td>Rolling.median(**kwvars)</td>
<td>Calculate the rolling median.</td>
</tr>
<tr>
<td>Rolling.var(ddof)</td>
<td>Calculate unbiased rolling variance.</td>
</tr>
<tr>
<td>Rolling.std(ddof)</td>
<td>Calculate rolling standard deviation.</td>
</tr>
<tr>
<td>Rolling.min(*args, **kwvars)</td>
<td>Calculate the rolling minimum.</td>
</tr>
<tr>
<td>Rolling.max(*args, **kwvars)</td>
<td>Rolling maximum</td>
</tr>
<tr>
<td>Rolling.corr(other, pairwise)</td>
<td>Rolling sample correlation</td>
</tr>
<tr>
<td>Rolling.cov(other, pairwise, ddof)</td>
<td>Rolling sample covariance</td>
</tr>
<tr>
<td>Rolling.skew(**kwvars)</td>
<td>Unbiased rolling skewness</td>
</tr>
<tr>
<td>Rolling.kurt(**kwvars)</td>
<td>Calculate unbiased rolling kurtosis.</td>
</tr>
<tr>
<td>Rolling.apply(func[, raw, args, kwvars])</td>
<td>Rolling function apply</td>
</tr>
<tr>
<td>Rolling.aggregate(arg, *args, **kwvars)</td>
<td>Aggregate using one or more operations over the specified axis.</td>
</tr>
<tr>
<td>Window.mean(*args, **kwvars)</td>
<td>Calculate the window mean of the values.</td>
</tr>
<tr>
<td>Window.sum(*args, **kwvars)</td>
<td>Calculate window sum of given DataFrame or Series.</td>
</tr>
</tbody>
</table>

34.16.1.1 pandas.core.window.Rolling.count

Rolling.count()

The rolling count of any non-NaN observations inside the window.

Returns Series or DataFrame

Returned object type is determined by the caller of the rolling calculation.

See also:

- `pandas.Series.rolling` Calling object with Series data
- `pandas.DataFrame.rolling` Calling object with DataFrames
- `pandas.DataFrame.count` Count of the full DataFrame
Examples

```python
>>> s = pd.Series([2, 3, np.nan, 10])
>>> s.rolling(2).count()
0   1.0  
1   2.0  
2   1.0  
3   1.0  
dtype: float64
>>> s.rolling(3).count()
0   1.0  
1   2.0  
2   2.0  
3   2.0  
dtype: float64
>>> s.rolling(4).count()
0   1.0  
1   2.0  
2   2.0  
3   3.0  
dtype: float64
```

34.16.1.2 pandas.core.window.Rolling.sum

Rolling.sum(*args, **kwargs)
Calculate rolling sum of given DataFrame or Series.

Parameters

*args, **kwargs
For compatibility with other rolling methods. Has no effect on the computed value.

Returns

Series or DataFrame
Same type as the input, with the same index, containing the rolling sum.

See also:

Series.sum Reducing sum for Series.
DataFrame.sum Reducing sum for DataFrame.

Examples

```python
>>> s = pd.Series([1, 2, 3, 4, 5])
>>> s
0 1
1 2
2 3
3 4
4 5
dtype: int64

```

```python
>>> s.rolling(3).sum()
0 NaN
1 NaN
```
(continues on next page)
2  6.0
3  9.0
4 12.0
dtype: float64

>>> s.expanding(3).sum()
0  NaN
1  NaN
2  6.0
3 10.0
4 15.0
dtype: float64

>>> s.rolling(3, center=True).sum()
0  NaN
1  6.0
2  9.0
3 12.0
4  NaN
dtype: float64

For DataFrame, each rolling sum is computed column-wise.

>>> df = pd.DataFrame({'A': s, 'B': s ** 2})
>>> df
   A  B
0  1  1
1  2  4
2  3  9
3  4 16
4  5 25

>>> df.rolling(3).sum()
   A  B
0  NaN NaN
1  NaN NaN
2  6.0 14.0
3  9.0 29.0
4 12.0 50.0

34.16.1.3 pandas.core.window.Rolling.mean

Rolling.mean(*args, **kwargs)
Calculate the rolling mean of the values.

Parameters *args
Under Review.

**kwargs
Under Review.

Returns Series or DataFrame
Returned object type is determined by the caller of the rolling calculation.
See also:

**Series.rolling** Calling object with Series data

**DataFrame.rolling** Calling object with DataFrames

**Series.mean** Equivalent method for Series

**DataFrame.mean** Equivalent method for DataFrame

### Examples

The below examples will show rolling mean calculations with window sizes of two and three, respectively.

```python
>>> s = pd.Series([1, 2, 3, 4])
>>> s.rolling(2).mean()
0    NaN
1    1.5
2    2.5
3    3.5
dtype: float64

>>> s.rolling(3).mean()
0    NaN
1    NaN
2    2.0
3    3.0
dtype: float64
```

### 34.16.1.4 pandas.core.window.Rolling.median

**Rolling.median(****kwargs**)

Calculate the rolling median.

**Parameters** **kwargs

For compatibility with other rolling methods. Has no effect on the computed median.

**Returns**  **Series or DataFrame**

Returned type is the same as the original object.

See also:

**Series.rolling** Calling object with Series data

**DataFrame.rolling** Calling object with DataFrames

**Series.median** Equivalent method for Series

**DataFrame.median** Equivalent method for DataFrame

### Examples

Compute the rolling median of a series with a window size of 3.

```python
>>> s = pd.Series([1, 2, 3, 4])
>>> s.rolling(3).median()
0    NaN
1    NaN
2    2.0
3    3.0
dtype: float64
```
```python
>>> s = pd.Series([0, 1, 2, 3, 4])
>>> s.rolling(3).median()
0    NaN
1    NaN
2    1.0
3    2.0
4    3.0
dtype: float64
```

### 34.16.1.5 pandas.core.window.Rolling.var

Rolling.var(ddof=1, *args, **kwargs)

Calculate unbiased rolling variance.

Normalized by N-1 by default. This can be changed using the *ddof* argument.

**Parameters**
- **ddof** : int, default 1
  
  Delta Degrees of Freedom. The divisor used in calculations is \( N - ddof \), where \( N \) represents the number of elements.

- **args, **kwargs
  
  For NumPy compatibility. No additional arguments are used.

**Returns**

Series or DataFrame

Returns the same object type as the caller of the rolling calculation.

See also:

- Series.rolling Calling object with Series data
- DataFrame.rolling Calling object with DataFrames
- Series.var Equivalent method for Series
- DataFrame.var Equivalent method for DataFrame
- numpy.var Equivalent method for Numpy array

**Notes**

The default *ddof* of 1 used in Series.var() is different than the default *ddof* of 0 in numpy.var().

A minimum of 1 period is required for the rolling calculation.

**Examples**

```python
>>> s = pd.Series([5, 5, 6, 7, 5, 5, 5])
>>> s.rolling(3).var()
0    NaN
1    NaN
2    0.333333
3    1.000000
4    1.000000
5    1.333333
```

(continues on next page)
>>> s.expanding(3).var()
0    NaN
1    NaN
2    0.333333
3    0.916667
4    0.800000
5    0.700000
6    0.619048
dtype: float64

34.16.1.6 pandas.core.window.Rolling.std

Rolling.std(ddof=1, *args, **kwargs)
Calculate rolling standard deviation.

Normalized by N-1 by default. This can be changed using the ddof argument.

Parameters ddof : int, default 1
Delta Degrees of Freedom. The divisor used in calculations is \( N - ddof \), where \( N \) represents the number of elements.

*args, **kwargs
For NumPy compatibility. No additional arguments are used.

Returns Series or DataFrame
Returns the same object type as the caller of the rolling calculation.

See also:
Series.rolling Calling object with Series data
DataFrame.rolling Calling object with DataFrames
Series.std Equivalent method for Series
DataFrame.std Equivalent method for DataFrames
numpy.std Equivalent method for Numpy array

Notes
The default \( ddof \) of 1 used in Series.std is different than the default \( ddof \) of 0 in numpy.std.
A minimum of one period is required for the rolling calculation.

Examples
>>> s = pd.Series([5, 5, 6, 7, 5, 5, 5])
>>> s.rolling(3).std()
0   NaN
1   NaN
2  0.577350
3  1.000000
4  1.000000
5  1.154701
6   0.000000
   dtype: float64

>>> s.expanding(3).std()
0   NaN
1   NaN
2  0.577350
3  0.957427
4  0.894427
5  0.836660
6  0.786796
   dtype: float64

34.16.1.7 pandas.core.window.Rolling.min

Rolling.min(*args, **kwargs)

Calculate the rolling minimum.

Parameters
**kwargs

Under Review.

Returns Series or DataFrame

Returned object type is determined by the caller of the rolling calculation.

See also:

Series.rolling Calling object with a Series

DataFrame.rolling Calling object with a DataFrame

Series.min Similar method for Series

DataFrame.min Similar method for DataFrame

Examples

Performing a rolling minimum with a window size of 3.

```python
>>> s = pd.Series([4, 3, 5, 2, 6])
>>> s.rolling(3).min()
0   NaN
1   NaN
2   3.0
3   2.0
4   2.0
   dtype: float64
```
34.16.1.8 pandas.core.window.Rolling.max

Rolling.max(*args, **kwargs)

rolling maximum

Returns

same type as input

See also:

pandas.Series.rolling, pandas.DataFrame.rolling

34.16.1.9 pandas.core.window.Rolling.corr

Rolling.corr(other=None, pairwise=None, **kwargs)

rolling sample correlation

Parameters

other : Series, DataFrame, or ndarray, optional

if not supplied then will default to self and produce pairwise output

pairwise : bool, default None

If False then only matching columns between self and other will be used and the output will be a DataFrame. If True then all pairwise combinations will be calculated and the output will be a MultiIndex DataFrame in the case of DataFrame inputs. In the case of missing elements, only complete pairwise observations will be used.

Returns

same type as input

See also:

pandas.Series.rolling, pandas.DataFrame.rolling

34.16.1.10 pandas.core.window.Rolling.cov

Rolling.cov(other=None, pairwise=None, ddof=1, **kwargs)

rolling sample covariance

Parameters

other : Series, DataFrame, or ndarray, optional

if not supplied then will default to self and produce pairwise output

pairwise : bool, default None

If False then only matching columns between self and other will be used and the output will be a DataFrame. If True then all pairwise combinations will be calculated and the output will be a MultiIndexed DataFrame in the case of DataFrame inputs. In the case of missing elements, only complete pairwise observations will be used.

ddof : int, default 1

Delta Degrees of Freedom. The divisor used in calculations is $N - ddof$, where $N$ represents the number of elements.

Returns

same type as input
See also:

`pandas.Series.rolling`, `pandas.DataFrame.rolling`

### 34.16.1.11 pandas.core.window.Rolling.skew

`Rolling.skew(**kwargs)`

Unbiased rolling skewness

**Returns**

same type as input

See also:

`pandas.Series.rolling`, `pandas.DataFrame.rolling`

### 34.16.1.12 pandas.core.window.Rolling.kurt

`Rolling.kurt(**kwargs)`

Calculate unbiased rolling kurtosis.

This function uses Fisher’s definition of kurtosis without bias.

**Parameters** **kwargs

Under Review.

**Returns** Series or DataFrame

Returned object type is determined by the caller of the rolling calculation

See also:

`Series.rolling` Calling object with Series data

`DataFrame.rolling` Calling object with DataFrames

`Series.kurt` Equivalent method for Series

`DataFrame.kurt` Equivalent method for DataFrame

`scipy.stats.skew` Third moment of a probability density

`scipy.stats.kurtosis` Reference SciPy method

**Notes**

A minimum of 4 periods is required for the rolling calculation.

**Examples**

The example below will show a rolling calculation with a window size of four matching the equivalent function call using `scipy.stats`. 
>>> arr = [1, 2, 3, 4, 999]
>>> fmt = "/0:.6f/" # limit the printed precision to 6 digits
>>> import scipy.stats
>>> print(fmt.format(scipy.stats.kurtosis(arr[:-1], bias=False)))
-1.200000
>>> print(fmt.format(scipy.stats.kurtosis(arr[1:], bias=False)))
3.999946
>>> s = pd.Series(arr)
>>> s.rolling(4).kurt()
0   NaN
1   NaN
2   NaN
3   -1.20000
4   3.999946
dtype: float64

34.16.1.13 pandas.core.window.Rolling.apply

Rolling.apply(func, raw=None, args=(), kwags=())

rolling function apply

Parameters

func : function

Must produce a single value from an ndarray input if raw=True or a Series if
raw=False

raw : bool, default None

- False : passes each row or column as a Series to the function.
- True or None : the passed function will receive ndarray objects instead. If
you are just applying a NumPy reduction function this will achieve much better
performance.

The raw parameter is required and will show a FutureWarning if not passed. In the
future raw will default to False.

New in version 0.23.0.

*args and **kwargs are passed to the function

Returns

same type as input

See also:
pandas.Series.rolling, pandas.DataFrame.rolling

34.16.1.14 pandas.core.window.Rolling.aggregate

Rolling.aggregate(arg, *args, **kwargs)

Aggregate using one or more operations over the specified axis.

Parameters

func : function, string, dictionary, or list of string/functions

Function to use for aggregating the data. If a function, must either work when passed
a Series/DataFrame or when passed to Series/DataFrame.apply. For a DataFrame,
can pass a dict, if the keys are DataFrame column names.
Accepted combinations are:

- string function name.
- function.
- list of functions.
- dict of column names -> functions (or list of functions).

*args

Positional arguments to pass to func.

**kwargs

Keyword arguments to pass to func.

Returns

aggregated [Series/DataFrame]

See also:

pandas.Series.rolling, pandas.DataFrame.rolling

Notes

agg is an alias for aggregate. Use the alias.

A passed user-defined-function will be passed a Series for evaluation.

Examples

```python
>>> df = pd.DataFrame(np.random.randn(10, 3), columns=['A', 'B', 'C'])
>>> df
   A        B        C
0 -2.385977 -0.102758  0.438822
1 -1.004295  0.905829 -0.954544
2  0.735167 -0.165272 -1.619346
3 -0.702657 -1.340923 -0.706334
4 -0.246845  0.211596 -0.901819
5  2.463718  3.157577 -1.380906
6  1.142255  2.340594 -0.039875
7  1.396598 -1.647453  1.677227
8 -0.543425  1.761277 -0.220481
9 -0.640505  0.289374 -1.550670

>>> df.rolling(3).sum()
   A        B        C
0   NaN     NaN     NaN
1   NaN     NaN     NaN
2 -2.655105  0.637799 -2.135068
3 -0.971785 -0.600366 -3.280224
4 -0.214334 -1.294599 -3.227500
5  1.514216  2.028250 -2.989060
6  1.074618  5.709767 -2.322600
7  2.718061  3.850718  0.256446
8 -0.289082  2.454418  1.416871
9  0.212668  0.403198 -0.093924
```
>>> df.rolling(3).agg({'A':'sum', 'B':'min'})

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>1</td>
<td>NaN</td>
<td>NaN</td>
</tr>
<tr>
<td>2</td>
<td>-2.655105</td>
<td>-0.165272</td>
</tr>
<tr>
<td>3</td>
<td>-0.971785</td>
<td>-1.340923</td>
</tr>
<tr>
<td>4</td>
<td>-0.214334</td>
<td>-1.340923</td>
</tr>
<tr>
<td>5</td>
<td>1.514216</td>
<td>-1.340923</td>
</tr>
<tr>
<td>6</td>
<td>1.074618</td>
<td>0.211596</td>
</tr>
<tr>
<td>7</td>
<td>2.718061</td>
<td>-1.647453</td>
</tr>
<tr>
<td>8</td>
<td>-0.289082</td>
<td>-1.647453</td>
</tr>
<tr>
<td>9</td>
<td>0.212668</td>
<td>-1.647453</td>
</tr>
</tbody>
</table>

### 34.16.15 pandas.core.window.Rolling.quantile

Rolling.quantile(quantile, interpolation='linear', **kwargs)

rolling quantile.

**Parameters**
- **quantile** : float
  
  Quantile to compute. 0 <= quantile <= 1.

- **interpolation** : {'linear', 'lower', 'higher', 'midpoint', 'nearest'}
  
  New in version 0.23.0.

  This optional parameter specifies the interpolation method to use, when the desired
  quantile lies between two data points i and j:

  - linear: \( i + (j - i) \times \text{fraction} \), where \( \text{fraction} \) is the fractional part of the index
    surrounded by \( i \) and \( j \).
  - lower: \( i \).
  - higher: \( j \).
  - nearest: \( i \) or \( j \) whichever is nearest.
  - midpoint: \((i + j) / 2\).

**kwargs:

For compatibility with other rolling methods. Has no effect on the result.

**Returns**
- **Series or DataFrame**
  
  Returned object type is determined by the caller of the rolling calculation.

See also:

- **pandas.Series.quantile** Computes value at the given quantile over all data in Series.
- **pandas.DataFrame.quantile** Computes values at the given quantile over requested axis in DataFrame.

**Examples**

```python
>>> s = pd.Series([1, 2, 3, 4])
>>> s.rolling(2).quantile(.4, interpolation='lower')
0  NaN
```

(continues on next page)
1 1.0
2 2.0
3 3.0
dtype: float64

```python
>>> s.rolling(2).quantile(.4, interpolation='midpoint')
0   NaN
1   1.5
2   2.5
3   3.5
dtype: float64
```

34.16.16 pandas.core.window.Window.mean

Window.mean(*args, **kwargs)
Calculate the window mean of the values.

Parameters

*args
Under Review.

**kwargs
Under Review.

Returns

Series or DataFrame
Returned object type is determined by the caller of the window calculation.

See also:

Series.window Calling object with Series data
DataFrame.window Calling object with DataFrames
Series.mean Equivalent method for Series
DataFrame.mean Equivalent method for DataFrame

Examples

The below examples will show rolling mean calculations with window sizes of two and three, respectively.

```python
>>> s = pd.Series([1, 2, 3, 4])
>>> s.rolling(2).mean()
0   NaN
1   1.5
2   2.5
3   3.5
dtype: float64
```

```python
>>> s.rolling(3).mean()
0   NaN
1   NaN
2   2.0
3   3.0
dtype: float64
```
34.16.17 pandas.core.window.Window.sum

Window.sum(*args, **kwargs)
Calculate window sum of given DataFrame or Series.

Parameters

*args, **kwargs
For compatibility with other window methods. Has no effect on the computed value.

Returns

Series or DataFrame
Same type as the input, with the same index, containing the window sum.

See also:

Series.sum Reducing sum for Series.
DataFrame.sum Reducing sum for DataFrame.

Examples

```python
def main():
    s = pd.Series([1, 2, 3, 4, 5])
    print(s)
    print(s.rolling(3).sum())
    print(s.expanding(3).sum())
    print(s.rolling(3, center=True).sum())

if __name__ == '__main__':
    main()
```
```bash
>>> s = pd.Series([1, 2, 3, 4, 5])
>>> s
0  1
1  2
2  3
3  4
4  5
dtype: int64

>>> s.rolling(3).sum()
0   NaN
1   NaN
2    6.0
3    9.0
4   12.0
dtype: float64

>>> s.expanding(3).sum()
0   NaN
1   NaN
2    6.0
3    9.0
4    15.0
dtype: float64

>>> s.rolling(3, center=True).sum()
0   NaN
1    6.0
2    9.0
3   12.0
4   NaN
dtype: float64
```

For DataFrame, each window sum is computed column-wise.
```python
>>> df = pd.DataFrame({"A": s, "B": s ** 2})
>>> df
   A  B
0  1  1
1  2  4
2  3  9
3  4 16
4  5 25

>>> df.rolling(3).sum()
    A   B
0  NaN  NaN
1  NaN  NaN
2  6.0 14.0
3  9.0 29.0
4 12.0 50.0
```

### 34.16.2 Standard expanding window functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Expanding.count(**kwargs)</code></td>
<td>The expanding count of any non-NaN observations inside the window.</td>
</tr>
<tr>
<td><code>Expanding.sum(*args, **kwargs)</code></td>
<td>Calculate expanding sum of given DataFrame or Series.</td>
</tr>
<tr>
<td><code>Expanding.mean(*args, **kwargs)</code></td>
<td>Calculate the expanding mean of the values.</td>
</tr>
<tr>
<td><code>Expanding.median(**kwargs)</code></td>
<td>Calculate the expanding median.</td>
</tr>
<tr>
<td><code>Expanding.var([ddof])</code></td>
<td>Calculate unbiased expanding variance.</td>
</tr>
<tr>
<td><code>Expanding.std([ddof])</code></td>
<td>Calculate expanding standard deviation.</td>
</tr>
<tr>
<td><code>Expanding.min(*args, **kwargs)</code></td>
<td>Calculate the expanding minimum.</td>
</tr>
<tr>
<td><code>Expanding.max(*args, **kwargs)</code></td>
<td>Expanding maximum</td>
</tr>
<tr>
<td><code>Expanding.corr([other, pairwise])</code></td>
<td>Expanding sample correlation</td>
</tr>
<tr>
<td><code>Expanding.cov([other, pairwise, ddof])</code></td>
<td>Expanding sample covariance</td>
</tr>
<tr>
<td><code>Expanding.skew(**kwargs)</code></td>
<td>Unbiased expanding skewness</td>
</tr>
<tr>
<td><code>Expanding.kurt(**kwargs)</code></td>
<td>Calculate unbiased expanding kurtosis.</td>
</tr>
<tr>
<td><code>Expanding.aggregate(func[, raw, args, kwargs])</code></td>
<td>Expanding function apply</td>
</tr>
<tr>
<td><code>Expanding.aggregate</code></td>
<td>Aggregate using one or more operations over the specified axis.</td>
</tr>
<tr>
<td><code>Expanding.quantile</code></td>
<td>Expanding quantile.</td>
</tr>
</tbody>
</table>

#### 34.16.2.1 pandas.core.window.Expanding.count

Expanding.count(**kwargs)

The expanding count of any non-NaN observations inside the window.

**Returns** Series or DataFrame

Returned object type is determined by the caller of the expanding calculation.

**See also:**

- `pandas.Series.expanding` Calling object with Series data
- `pandas.DataFrame.expanding` Calling object with DataFrames
- `pandas.DataFrame.count` Count of the full DataFrame
Examples

```python
>>> s = pd.Series([2, 3, np.nan, 10])
>>> s.rolling(2).count()
0    1.0
1    2.0
2    1.0
3    1.0
dtype: float64
>>> s.rolling(3).count()
0    1.0
1    2.0
2    2.0
3    2.0
dtype: float64
>>> s.rolling(4).count()
0    1.0
1    2.0
2    2.0
3    3.0
dtype: float64
```

34.16.2.2 pandas.core.window.Expanding.sum

Expanding. `sum`(*args, **kwargs)
Calculate expanding sum of given DataFrame or Series.

**Parameters** *args, **kwargs

For compatibility with other expanding methods. Has no effect on the computed value.

**Returns** Series or DataFrame

Same type as the input, with the same index, containing the expanding sum.

See also:

Series. `sum` Reducing sum for Series.

DataFrame. `sum` Reducing sum for DataFrame.

Examples

```python
>>> s = pd.Series([1, 2, 3, 4, 5])
>>> s
0    1
1    2
2    3
3    4
4    5
dtype: int64

>>> s.rolling(3).sum()
0   NaN
   NaN
   NaN
   NaN
   NaN
5    8
6    11
7    14
8    17
9    20
dtype: int64
```
pandas: powerful Python data analysis toolkit, Release 0.23.2

1 NaN
2 6.0
3 9.0
4 12.0
dtype: float64

```python
>>> s.expanding(3).sum()
0   NaN
1   NaN
2    6.0
3    10.0
4    15.0
dtype: float64
```

```python
>>> s.rolling(3, center=True).sum()
0   NaN
1    6.0
2    9.0
3    12.0
4   NaN
dtype: float64
```

For DataFrame, each expanding sum is computed column-wise.

```python
>>> df = pd.DataFrame({"A": s, "B": s ** 2})
>>> df
   A  B
0  1  1
1  2  4
2  3  9
3  4 16
4  5 25

>>> df.rolling(3).sum()
   A  B
0   NaN NaN
1   NaN NaN
2   6.0 14.0
3   9.0 29.0
4  12.0 50.0
```

34.16.2.3 pandas.core.window.Expanding.mean

`Expanding.mean(*args, **kwargs)`

Calculate the expanding mean of the values.

**Parameters**

*args

Under Review.

**kwargs

Under Review.

**Returns**

Series or DataFrame

Returned object type is determined by the caller of the expanding calculation.
See also:

Series.expanding Calling object with Series data
Dataframe.expanding Calling object with DataFrames
Series.mean Equivalent method for Series
Dataframe.mean Equivalent method for Dataframe

Examples

The below examples will show rolling mean calculations with window sizes of two and three, respectively.

```python
>>> s = pd.Series([1, 2, 3, 4])
>>> s.rolling(2).mean()
0    NaN
1    1.5
2    2.5
3    3.5
dtype: float64

>>> s.rolling(3).mean()
0    NaN
1    NaN
2    2.0
3    3.0
dtype: float64
```

34.16.2.4 pandas.core.window.Expanding.median

Expanding.median(**kwargs)
Calculate the expanding median.

Parameters **kwargs
For compatibility with other expanding methods. Has no effect on the computed median.

Returns Series or DataFrame
Returned type is the same as the original object.

See also:

Series.expanding Calling object with Series data
Dataframe.expanding Calling object with DataFrames
Series.median Equivalent method for Series
Dataframe.median Equivalent method for DataFrame

Examples

Compute the rolling median of a series with a window size of 3.
```python
>>> s = pd.Series([0, 1, 2, 3, 4])
>>> s.rolling(3).median()
0    NaN
1    NaN
2    1.0
3    2.0
4    3.0
dtype: float64
```

34.16.2.5 pandas.core.window.Expanding.var

Expanding.var(ddof=1, *args, **kwargs)

Calculate unbiased expanding variance.

Normalized by N-1 by default. This can be changed using the ddof argument.

**Parameters**

- **ddof**: int, default 1
  
  Delta Degrees of Freedom. The divisor used in calculations is N - ddof, where N represents the number of elements.

- **args**, **kwargs**
  
  For NumPy compatibility. No additional arguments are used.

**Returns**

Series or DataFrame

Returns the same object type as the caller of the expanding calculation.

**See also:**

- Series.expanding Calling object with Series data
- DataFrame.expanding Calling object with DataFrames
- Series.var Equivalent method for Series
- DataFrame.var Equivalent method for DataFrame
- numpy.var Equivalent method for Numpy array

**Notes**

The default ddof of 1 used in Series.var() is different than the default ddof of 0 in numpy.var().

A minimum of 1 period is required for the rolling calculation.

**Examples**

```python
>>> s = pd.Series([5, 5, 6, 7, 5, 5, 5])
>>> s.rolling(3).var()
0    NaN
1    NaN
2  0.333333
3  1.000000
4  1.000000
5  1.333333
```
6    0.000000
dtype: float64

```python
>>> s.expanding(3).var()
0   NaN
1   NaN
2   0.333333
3   0.916667
4   0.800000
5   0.700000
6   0.619048
dtype: float64
```

### 34.16.2.6 pandas.core.window.Expanding.std

`Expanding.std(ddof=1, *args, **kwargs)`

Calculate expanding standard deviation.

Normalized by N-1 by default. This can be changed using the `ddof` argument.

**Parameters**

- **ddof**: int, default 1
  
  Delta Degrees of Freedom. The divisor used in calculations is \( N - \text{ddof} \), where \( N \) represents the number of elements.

- **args, **kwargs
  
  For NumPy compatibility. No additional arguments are used.

**Returns**

- **Series or DataFrame**

  Returns the same object type as the caller of the expanding calculation.

**See also:**

- **Series.expanding** Calling object with Series data
- **DataFrame.expanding** Calling object with DataFrames
- **Series.std** Equivalent method for Series
- **DataFrame.std** Equivalent method for DataFrame
- **numpy.std** Equivalent method for Numpy array

**Notes**

The default `ddof` of 1 used in Series.std is different than the default `ddof` of 0 in numpy.std.

A minimum of one period is required for the rolling calculation.

**Examples**
>>> s = pd.Series([5, 5, 6, 7, 5, 5, 5])
>>> s.rolling(3).std()
0    NaN
1    NaN
2  0.577350
3  1.000000
4  1.000000
5  1.154701
6    0.000000
dtype: float64

>>> s.expanding(3).std()
0    NaN
1    NaN
2  0.577350
3  0.957427
4  0.894427
5  0.836660
6  0.786796
dtype: float64

34.16.2.7 pandas.core.window.Expanding.min

Expanding.min(*args, **kwargs)

Calculate the expanding minimum.

Parameters
**kwargs

Under Review.

Returns Series or DataFrame

Returned object type is determined by the caller of the expanding calculation.

See also:

Series.expanding Calling object with a Series
Dataframe.expanding Calling object with a DataFrame
Series.min Similar method for Series
Dataframe.min Similar method for DataFrame

Examples

Performing a rolling minimum with a window size of 3.

>>> s = pd.Series([4, 3, 5, 2, 6])
>>> s.rolling(3).min()
0    NaN
1    NaN
2   3.0
3   2.0
4   2.0
dtype: float64
34.16.2.8 pandas.core.window.Expanding.max

Expanding.max(*args, **kwargs)
expanding maximum

Returns
same type as input

See also:
pandas.Series.expanding, pandas.DataFrame.expanding

34.16.2.9 pandas.core.window.Expanding.corr

Expanding.corr(other=None, pairwise=None, **kwargs)
expanding sample correlation

Parameters other : Series, DataFrame, or ndarray, optional
if not supplied then will default to self and produce pairwise output

pairwise : bool, default None
If False then only matching columns between self and other will be used and the output will be a DataFrame. If True then all pairwise combinations will be calculated and the output will be a MultiIndex DataFrame in the case of DataFrame inputs. In the case of missing elements, only complete pairwise observations will be used.

Returns
same type as input

See also:
pandas.Series.expanding, pandas.DataFrame.expanding

34.16.2.10 pandas.core.window.Expanding.cov

Expanding.cov(other=None, pairwise=None, ddof=1, **kwargs)
expanding sample covariance

Parameters other : Series, DataFrame, or ndarray, optional
if not supplied then will default to self and produce pairwise output

pairwise : bool, default None
If False then only matching columns between self and other will be used and the output will be a DataFrame. If True then all pairwise combinations will be calculated and the output will be a MultiIndex DataFrame in the case of DataFrame inputs. In the case of missing elements, only complete pairwise observations will be used.

ddof : int, default 1
Delta Degrees of Freedom. The divisor used in calculations is \( N - \text{ddof} \), where \( N \) represents the number of elements.

Returns
same type as input
See also:

\[ \texttt{pandas.Series.expanding, pandas.DataFrame.expanding} \]

34.16.2.11 pandas.core.window.Expanding.skew

Expanding.skew(**kwargs)

Unbiased expanding skewness

Returns

same type as input

See also:

\[ \texttt{pandas.Series.expanding, pandas.DataFrame.expanding} \]

34.16.2.12 pandas.core.window.Expanding.kurt

Expanding.kurt(**kwargs)

Calculate unbiased expanding kurtosis.

This function uses Fisher’s definition of kurtosis without bias.

Parameters **kwargs

Under Review.

Returns Series or DataFrame

Returned object type is determined by the caller of the expanding calculation

See also:

\[ \texttt{Series.expanding} \text{ Calling object with Series data} \]
\[ \texttt{DataFrame.expanding} \text{ Calling object with DataFrames} \]
\[ \texttt{Series.kurt} \text{ Equivalent method for Series} \]
\[ \texttt{DataFrame.kurt} \text{ Equivalent method for DataFrame} \]
\[ \texttt{scipy.stats.skew} \text{ Third moment of a probability density} \]
\[ \texttt{scipy.stats.kurtosis} \text{ Reference SciPy method} \]

Notes

A minimum of 4 periods is required for the expanding calculation.

Examples

The example below will show an expanding calculation with a window size of four matching the equivalent function call using scipy.stats.
```python
>>> arr = [1, 2, 3, 4, 999]
>>> import scipy.stats
>>> fmt = "{0:.6f}"  # limit the printed precision to 6 digits
>>> print(fmt.format(scipy.stats.kurtosis(arr[:-1], bias=False)))
-1.200000
>>> print(fmt.format(scipy.stats.kurtosis(arr, bias=False)))
4.999874
>>> s = pd.Series(arr)
>>> s.expanding(4).kurt()
0    NaN
1    NaN
2    NaN
3   -1.200000
4    4.999874
dtype: float64
```

### 34.16.2.13 pandas.core.window.Expanding.apply

Expanding.apply(func, raw=None, args=(), kwargs={})

Expanding function apply

**Parameters**

- **func**: function
  - Must produce a single value from an ndarray input if raw=True or a Series if raw=False
- **raw**: bool, default None
  - False: passes each row or column as a Series to the function.
  - True or None: the passed function will receive ndarray objects instead. If you are just applying a NumPy reduction function this will achieve much better performance.

The raw parameter is required and will show a FutureWarning if not passed. In the future raw will default to False.

New in version 0.23.0.

*args and **kwargs are passed to the function

**Returns**

same type as input

**See also:**

pandas.Series.expanding, pandas.DataFrame.expanding

### 34.16.2.14 pandas.core.window.Expanding.aggregate

Expanding.aggregate(arg, *args, **kwargs)

Aggregate using one or more operations over the specified axis.

**Parameters**

- **func**: function, string, dictionary, or list of string/functions
  - Function to use for aggregating the data. If a function, must either work when passed a Series/DataFrame or when passed to Series/DataFrame.apply. For a DataFrame, can pass a dict, if the keys are DataFrame column names.
Accepted combinations are:
  • string function name.
  • function.
  • list of functions.
  • dict of column names -> functions (or list of functions).

  *args
  Positional arguments to pass to func.

  **kwargs
  Keyword arguments to pass to func.

Returns
  aggregated [Series/DataFrame]

See also:
  pandas.DataFrame.expanding.aggregate, pandas.DataFrame.rolling.aggregate,
pandas.DataFrame.aggregate

Notes
  agg is an alias for aggregate. Use the alias.
  A passed user-defined-function will be passed a Series for evaluation.

Examples

```python
>>> df = pd.DataFrame(np.random.randn(10, 3), columns=['A', 'B', 'C'])
>>> df
   A        B        C
0 -2.385977 -0.102758  0.438822
1  1.004295  0.905829 -0.954544
2  0.735167 -0.165272 -1.619346
3 -0.702657 -1.340923 -0.706334
4  0.246845  0.211596 -0.901819
5  2.463718  3.157577 -1.380906
6 -1.142255  2.340594 -0.039875
7  1.396598 -1.647453  1.677227
8  0.543425  1.761277 -0.220481
9  0.640505  0.289374 -1.550670

>>> df.ewm(alpha=0.5).mean()
   A         B         C
0 -2.385977 -0.102758  0.438822
1 -1.464856  0.569633 -0.954544
2 -0.702657 -1.340923 -0.706334
3 -0.471677 -0.645305 -0.901819
4 -0.355635 -0.203033 -0.904111
5  1.076417  1.503943 -1.146293
6  0.041654  1.925562 -0.588728
7  0.680292  0.132049  0.548693

(continues on next page)
### pandas.core.window.Expanding.quantile

Expanding .quantile (quantile, interpolation='linear', **kwargs)

**Parameters**
- **quantile**: float
  - Quantile to compute. 0 <= quantile <= 1.
- **interpolation**: {'linear', 'lower', 'higher', 'midpoint', 'nearest'}
  - New in version 0.23.0.
  - This optional parameter specifies the interpolation method to use, when the desired quantile lies between two data points i and j:
    - linear: \( i + (j - i) \times fraction \), where fraction is the fractional part of the index surrounded by i and j.
    - lower: i.
    - higher: j.
    - nearest: i or j whichever is nearest.
    - midpoint: \((i + j) / 2\).

**kwargs:
- For compatibility with other expanding methods. Has no effect on the result.

**Returns**
- Series or DataFrame
  - Returned object type is determined by the caller of the expanding calculation.

**See also:**
- pandas.Series.quantile
  - Computes value at the given quantile over all data in Series.
- pandas.DataFrame.quantile
  - Computes values at the given quantile over requested axis in DataFrame.

**Examples**

```python
>>> s = pd.Series([1, 2, 3, 4])
>>> s.rolling(2).quantile(.4, interpolation='lower')
0    NaN
1    1.0
2    2.0
3    3.0
dtype: float64

>>> s.rolling(2).quantile(.4, interpolation='midpoint')
0    NaN
1    1.5
2    2.5
```
34.16.3 Exponentially-weighted moving window functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWM.mean(*args, **kwargs)</td>
<td>exponential weighted moving average</td>
</tr>
<tr>
<td>EWM.std((bias))</td>
<td>exponential weighted moving stddev</td>
</tr>
<tr>
<td>EWM.var((bias))</td>
<td>exponential weighted moving variance</td>
</tr>
<tr>
<td>EWM.corr([other, pairwise])</td>
<td>exponential weighted sample correlation</td>
</tr>
<tr>
<td>EWM.cov([other, pairwise, bias])</td>
<td>exponential weighted sample covariance</td>
</tr>
</tbody>
</table>

34.16.3.1 pandas.core.window.EWM.mean

EWM.mean(*args, **kwargs)

exponential weighted moving average

Returns

same type as input

See also:
pandas.Series.ewm, pandas.DataFrame.ewm

34.16.3.2 pandas.core.window.EWM.std

EWM.std(bias=False, *args, **kwargs)

exponential weighted moving stddev

Parameters bias : boolean, default False

Use a standard estimation bias correction

Returns

same type as input

See also:
pandas.Series.ewm, pandas.DataFrame.ewm

34.16.3.3 pandas.core.window.EWM.var

EWM.var(bias=False, *args, **kwargs)

exponential weighted moving variance

Parameters bias : boolean, default False

Use a standard estimation bias correction

Returns

same type as input

See also:
pandas.Series.ewm, pandas.DataFrame.ewm
34.16.3.4 pandas.core.window.EWM.corr

EWM.corr(other=None, pairwise=None, **kwargs)

Exponential weighted sample correlation

**Parameters**
- **other**: Series, DataFrame, or ndarray, optional
  - If not supplied then will default to self and produce pairwise output
- **pairwise**: bool, default None
  - If False then only matching columns between self and other will be used and the output will be a DataFrame. If True then all pairwise combinations will be calculated and the output will be a MultiIndex DataFrame in the case of DataFrame inputs. In the case of missing elements, only complete pairwise observations will be used.
- **bias**: boolean, default False
  - Use a standard estimation bias correction

**Returns**
- same type as input

**See also:**
- pandas.Series.ewm, pandas.DataFrame.ewm

34.16.3.5 pandas.core.window.EWM.cov

EWM.cov(other=None, pairwise=None, bias=False, **kwargs)

Exponential weighted sample covariance

**Parameters**
- **other**: Series, DataFrame, or ndarray, optional
  - If not supplied then will default to self and produce pairwise output
- **pairwise**: bool, default None
  - If False then only matching columns between self and other will be used and the output will be a DataFrame. If True then all pairwise combinations will be calculated and the output will be a MultiIndex DataFrame in the case of DataFrame inputs. In the case of missing elements, only complete pairwise observations will be used.
- **bias**: boolean, default False
  - Use a standard estimation bias correction

**Returns**
- same type as input

**See also:**
- pandas.Series.ewm, pandas.DataFrame.ewm

34.17 GroupBy

GroupBy objects are returned by groupby calls: pandas.DataFrame.groupby(), pandas.Series.groupby(), etc.
34.17.1 Indexing, iteration

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GroupBy.<strong>iter</strong>()</td>
<td>Groupby iterator</td>
</tr>
<tr>
<td>GroupBy.groups</td>
<td>dict {group name -&gt; group labels}</td>
</tr>
<tr>
<td>GroupBy.indices</td>
<td>dict {group name -&gt; group indices}</td>
</tr>
<tr>
<td>GroupBy.get_group(name[, obj])</td>
<td>Constructs NDFrame from group with provided name</td>
</tr>
</tbody>
</table>

34.17.1.1 pandas.core.groupby.GroupBy.__iter__

GroupBy.__iter__()

Returns

Generator yielding sequence of (name, subsetted object)
for each group

34.17.1.2 pandas.core.groupby.GroupBy.groups

GroupBy.groups
dict {group name -> group labels}

34.17.1.3 pandas.core.groupby.GroupBy.indices

GroupBy.indices
dict {group name -> group indices}

34.17.1.4 pandas.core.groupby.GroupBy.get_group

GroupBy.get_group(name, obj=None)
Constructs NDFrame from group with provided name

Parameters

name : object
    the name of the group to get as a DataFrame

obj : NDFrame, default None
    the NDFrame to take the DataFrame out of. If it is None, the object groupby was called on will be used

Returns

group [type of obj]

Grouper([key, level, freq, axis, sort])
A Grouper allows the user to specify a groupby instruction for a target object

34.17.1.5 pandas.Grouper

class pandas.Grouper(key=None, level=None, freq=None, axis=0, sort=False)
A Grouper allows the user to specify a groupby instruction for a target object
This specification will select a column via the key parameter, or if the level and/or axis parameters are given, a level of the index of the target object.

These are local specifications and will override ‘global’ settings, that is the parameters axis and level which are passed to the groupby itself.

**Parameters**

- **key** : string, defaults to None
  - groupby key, which selects the grouping column of the target
- **level** : name/number, defaults to None
  - the level for the target index
- **freq** : string / frequency object, defaults to None
  - This will groupby the specified frequency if the target selection (via key or level) is a datetime-like object. For full specification of available frequencies, please see here.
- **axis** [number/name of the axis, defaults to 0]
- **sort** : boolean, default to False
  - whether to sort the resulting labels

**Additional kwargs to control time-like groupers (when “freq” is passed)**

- **closed** [closed end of interval; ‘left’ or ‘right’]
- **label** [interval boundary to use for labeling; ‘left’ or ‘right’]
- **convention** : {'start', ‘end’, ‘e’, ‘s’}
  - If grouper is PeriodIndex

**base, loffset**

**Returns**

A specification for a groupby instruction

**Examples**

Syntactic sugar for `df.groupby('A')`

```python
>>> df.groupby(Grouper(key='A'))
```

Specify a resample operation on the column ‘date’

```python
>>> df.groupby(Grouper(key='date', freq='60s'))
```

Specify a resample operation on the level ‘date’ on the columns axis with a frequency of 60s

```python
>>> df.groupby(Grouper(level='date', freq='60s', axis=1))
```
34.17.2 Function application

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>GroupBy.apply</code></td>
<td>Apply function <code>func</code> group-wise and combine the results together.</td>
</tr>
<tr>
<td><code>GroupBy.aggregate</code></td>
<td>Apply a function <code>func</code> with arguments to the GroupBy object and return the function’s result.</td>
</tr>
<tr>
<td><code>GroupBy.transform</code></td>
<td>Apply a function <code>func</code> with arguments to this GroupBy object and return the function’s result.</td>
</tr>
<tr>
<td><code>GroupBy.pipe</code></td>
<td>Apply function <code>func</code> to each group.</td>
</tr>
</tbody>
</table>

34.17.2.1 pandas.core.groupby.GroupBy.apply

GroupBy. **apply** *(func, *args, **kwargs)*

Apply function `func` group-wise and combine the results together.

The function passed to `apply` must take a dataframe as its first argument and return a dataframe, a series or a scalar. `apply` will then take care of combining the results back together into a single dataframe or series. `apply` is therefore a highly flexible grouping method.

While `apply` is a very flexible method, its downside is that using it can be quite a bit slower than using more specific methods. Pandas offers a wide range of methods that will be much faster than using `apply` for their specific purposes, so try to use them before reaching for `apply`.

**Parameters**

- **func**: function
  - A callable that takes a dataframe as its first argument, and returns a dataframe, a series or a scalar. In addition the callable may take positional and keyword arguments
  - **args, kwargs**: tuple and dict
    - Optional positional and keyword arguments to pass to `func`

**Returns**

- **applied**: [Series or DataFrame]

**See also**

- **pipe**: Apply function to the full GroupBy object instead of to each group.
  - `aggregate, transform`

**Notes**

In the current implementation `apply` calls `func` twice on the first group to decide whether it can take a fast or slow code path. This can lead to unexpected behavior if `func` has side-effects, as they will take effect twice for the first group.
Examples

```python
>>> df = pd.DataFrame({'A': 'a a b'.split(), 'B': [1, 2, 3], 'C': [4, 6, 5]})
>>> g = df.groupby('A')
```

From `df` above we can see that `g` has two groups, `a`, `b`. Calling `apply` in various ways, we can get different grouping results:

**Example 1:** below the function passed to `apply` takes a dataframe as its argument and returns a dataframe. `apply` combines the result for each group together into a new dataframe:

```python
>>> g.apply(lambda x: x / x.sum())
   B    C
0 0.333333 0.4
1 0.666667 0.6
2 1.000000 1.0
```

**Example 2:** The function passed to `apply` takes a dataframe as its argument and returns a series. `apply` combines the result for each group together into a new dataframe:

```python
>>> g.apply(lambda x: x.max() - x.min())
   B    C
A
a 1 2
b 0 0
```

**Example 3:** The function passed to `apply` takes a dataframe as its argument and returns a scalar. `apply` combines the result for each group together into a series, including setting the index as appropriate:

```python
>>> g.apply(lambda x: x.C.max() - x.B.min())
A
a 5
b 2
dtype: int64
```

34.17.2.2 pandas.core.groupby.GroupBy.aggregate

GroupBy.aggregate(func, *args, **kwargs)

34.17.2.3 pandas.core.groupby.GroupBy.transform

GroupBy.transform(func, *args, **kwargs)

34.17.2.4 pandas.core.groupby.GroupBy.pipe

GroupBy.pipe(func, *args, **kwargs)

Apply a function `func` with arguments to this GroupBy object and return the function’s result.

New in version 0.21.0.

Use .pipe when you want to improve readability by chaining together functions that expect Series, DataFrame, GroupBy or Resampler objects. Instead of writing
You can write

```python
(df.groupby('group')
... .pipe(f)
... .pipe(g, arg1=a)
... .pipe(h, arg2=b, arg3=c))
```

which is much more readable.

**Parameters**

- **func**: callable or tuple of (callable, string)
  
  Function to apply to this GroupBy object or, alternatively, a (callable, data_keyword) tuple where data_keyword is a string indicating the keyword of callable that expects the GroupBy object.

- **args**: iterable, optional
  
  positional arguments passed into func.

- **kwargs**: dict, optional
  
  a dictionary of keyword arguments passed into func.

**Returns**

- **object**: [the return type of func.]

**See also**

- **pandas.Series.pipe**  Apply a function with arguments to a series
- **pandas.DataFrame.pipe**  Apply a function with arguments to a dataframe
- **apply**  Apply function to each group instead of to the full GroupBy object.

**Notes**

See more [here](#)

**Examples**

```python
>>> df = pd.DataFrame({'A': 'a b a b'.split(), 'B': [1, 2, 3, 4]})
```

```python
>>> df
    A  B
0  a  1
1  b  2
2  a  3
3  b  4
```

To get the difference between each groups maximum and minimum value in one pass, you can do

```python
>>> df.groupby('A').pipe(lambda x: x.max() - x.min())
```

```
    B
A
a  2
b  2
```
34.17.3 Computations / Descriptive Stats

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GroupBy.all</td>
<td>Returns True if all values in the group are truthful, else False</td>
</tr>
<tr>
<td>GroupBy.any</td>
<td>Returns True if any value in the group is truthful, else False</td>
</tr>
<tr>
<td>GroupBy.bfill</td>
<td>Backward fill the values</td>
</tr>
<tr>
<td>GroupBy.count</td>
<td>Compute count of group, excluding missing values</td>
</tr>
<tr>
<td>GroupBy.cumcount</td>
<td>Number each item in each group from 0 to the length of that group - 1.</td>
</tr>
<tr>
<td>GroupBy.ffill</td>
<td>Forward fill the values</td>
</tr>
<tr>
<td>GroupBy.first</td>
<td>Compute first of group values</td>
</tr>
<tr>
<td>GroupBy.last</td>
<td>Compute last of group values</td>
</tr>
<tr>
<td>GroupBy.max</td>
<td>Compute max of group values</td>
</tr>
<tr>
<td>GroupBy.mean</td>
<td>Compute mean of groups, excluding missing values</td>
</tr>
<tr>
<td>GroupBy.median</td>
<td>Compute median of groups, excluding missing values</td>
</tr>
<tr>
<td>GroupBy.min</td>
<td>Compute min of group values</td>
</tr>
<tr>
<td>GroupBy.ngroup</td>
<td>Number each group from 0 to the number of groups - 1.</td>
</tr>
<tr>
<td>GroupBy.nth</td>
<td>Take the nth row from each group if n is an int, or a subset of rows if n is a list of ints.</td>
</tr>
<tr>
<td>GroupBy.ohlc</td>
<td>Compute sum of values, excluding missing values For multiple groupings, the result index will be a MultiIndex</td>
</tr>
<tr>
<td>GroupBy.prod</td>
<td>Compute prod of group values</td>
</tr>
<tr>
<td>GroupBy.rank</td>
<td>Provides the rank of values within each group.</td>
</tr>
<tr>
<td>GroupBy.pct_change</td>
<td>Calculate pct_change of each value to previous entry in group</td>
</tr>
<tr>
<td>GroupBy.size</td>
<td>Compute group sizes</td>
</tr>
<tr>
<td>GroupBy.sem</td>
<td>Compute standard error of the mean of groups, excluding missing values</td>
</tr>
<tr>
<td>GroupBy.std</td>
<td>Compute standard deviation of groups, excluding missing values</td>
</tr>
<tr>
<td>GroupBy.sum</td>
<td>Compute sum of group values</td>
</tr>
<tr>
<td>GroupBy.var</td>
<td>Compute variance of groups, excluding missing values</td>
</tr>
<tr>
<td>GroupBy.tail</td>
<td>Returns last n rows of each group</td>
</tr>
</tbody>
</table>

34.17.3.1 pandas.core.groupby.GroupBy.all

**GroupBy.all** *(skipna=True)*

Returns True if all values in the group are truthful, else False

**Parameters** skipna : bool, default True

Flag to ignore nan values during truth testing

**See also:**

pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.17.3.2 pandas.core.groupby.GroupBy.any

**GroupBy.any** *(skipna=True)*

Returns True if any value in the group is truthful, else False
Parameters skipna: bool, default True
Flag to ignore nan values during truth testing

See also:
pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

### 34.17.3.3 pandas.core.groupby.GroupBy.bfill

GroupBy.bfill(limit=None)
Backward fill the values

Parameters limit: integer, optional
limit of how many values to fill

See also:
Series.backfill, DataFrame.backfill, Series.fillna, DataFrame.fillna

### 34.17.3.4 pandas.core.groupby.GroupBy.count

GroupBy.count()
Compute count of group, excluding missing values

See also:
pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

### 34.17.3.5 pandas.core.groupby.GroupBy.cumcount

GroupBy.cumcount(ascending=True)
Number each item in each group from 0 to the length of that group - 1.

Essentially this is equivalent to

```python
>>> self.apply(lambda x: Series(np.arange(len(x)), x.index))
```

Parameters ascending: bool, default True
If False, number in reverse, from length of group - 1 to 0.

See also:

ngroup Number the groups themselves.

Examples

```python
>>> df = pd.DataFrame([["a"], ["a"], ["a"], ["b"], ["b"], ["a"],
                    ...                            columns=['A'])
>>> df
   A
0  a
1  a
2  a
(continues on next page)```
3 b
4 b
5 a

```python
>>> df.groupby('A').cumcount()
0   0
1   1
2   2
3   0
4   1
5   3
dtype: int64

>>> df.groupby('A').cumcount(ascending=False)
0   3
1   2
2   1
3   1
4   0
5   0
dtype: int64
```

### 34.17.3.6 pandas.core.groupby.GroupBy.ffill

**GroupBy.ffill(limit=None)**

Forward fill the values

**Parameters**
- `limit`: integer, optional
  - limit of how many values to fill

**See also:**
- `Series.pad`, `DataFrame.pad`, `Seriesfillna`, `DataFramefillna`

### 34.17.3.7 pandas.core.groupby.GroupBy.first

**GroupBy.first(**kwargs)**

Compute first of group values

**See also:**

### 34.17.3.8 pandas.core.groupby.GroupBy.head

**GroupBy.head(n=5)**

Returns first n rows of each group.

Essentially equivalent to `.apply(lambda x: x.head(n))`, except ignores as_index flag.

**See also:**
Examples

```python
>>> df = DataFrame([[1, 2], [1, 4], [5, 6]],
                  columns=['A', 'B'])
>>> df.groupby('A', as_index=False).head(1)
   A  B
0  1  2
2  5  6
>>> df.groupby('A').head(1)
   A  B
0  1  2
2  5  6
```

34.17.3.9 pandas.core.groupby.GroupBy.last

GroupBy.*last**(kwargs)**

Compute last of group values

See also:

pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.17.3.10 pandas.core.groupby.GroupBy.max

GroupBy.*max**(kwargs)**

Compute max of group values

See also:

pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.17.3.11 pandas.core.groupby.GroupBy.mean

GroupBy.*mean*(args, **kwargs)**

Compute mean of groups, excluding missing values
For multiple groupings, the result index will be a MultiIndex

See also:

pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.17.3.12 pandas.core.groupby.GroupBy.median

GroupBy.*median**(kwargs)**

Compute median of groups, excluding missing values
For multiple groupings, the result index will be a MultiIndex

See also:

pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby
34.17.3.13 pandas.core.groupby.GroupBy.min

GroupBy.min(**kwargs)
Compute min of group values

See also:

pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.17.3.14 pandas.core.groupby.GroupBy.ngroup

GroupBy.ngroup(ascending=True)
Number each group from 0 to the number of groups - 1.

This is the enumerative complement of cumcount. Note that the numbers given to the groups match the order in which the groups would be seen when iterating over the groupby object, not the order they are first observed.

New in version 0.20.2.

Parameters ascending : bool, default True
If False, number in reverse, from number of group - 1 to 0.

See also:

cumcount  Number the rows in each group.

Examples

```python
>>> df = pd.DataFrame({"A": list("aaabba")})
>>> df
   A
0  a
1  a
2  a
3  b
4  b
5  a

>>> df.groupby('A').ngroup()
0    0
1    0
2    0
3    1
4    1
5    0
dtype: int64

>>> df.groupby('A').ngroup(ascending=False)
0    1
1    1
2    1
3    0
4    0
5    1
dtype: int64

>>> df.groupby(["A", [1,1,2,3,2,1]]).ngroup()
0    0
1    0
(continues on next page)```
34.17.3.15 pandas.core.groupby.GroupBy.nth

GroupBy.nth(n, dropna=None)

Take the nth row from each group if n is an int, or a subset of rows if n is a list of ints.

If dropna, will take the nth non-null row, dropna is either Truthy (if a Series) or ‘all’, ‘any’ (if a DataFrame); this is equivalent to calling dropna(how=dropna) before the groupby.

Parameters:
- **n**: int or list of ints
  - a single nth value for the row or a list of nth values
- **dropna**: None or str, optional
  - apply the specified dropna operation before counting which row is the nth row. Needs to be None, ‘any’ or ‘all’

See also:

Examples

```python
>>> df = pd.DataFrame({'A': [1, 1, 2, 1, 2],
                      'B': [np.nan, 2, 3, 4, 5]}, columns=['A', 'B'])

>>> g = df.groupby('A')

>>> g.nth(0)
B
A
1  NaN
2  3.0

>>> g.nth(1)
B
A
1  2.0
2  5.0

>>> g.nth(-1)
B
A
1  4.0
2  5.0

>>> g.nth([0, 1])
B
A
1  NaN
1  2.0
2  3.0
2  5.0
```

Specifying dropna allows count ignoring NaN
```python
>>> g.nth(0, dropna='any')
B
A   
1 2.0
2 3.0

NaNs denote group exhausted when using dropna

>>> g.nth(3, dropna='any')
B
A   
1 NaN
2 NaN

Specifying `as_index=False` in `groupby` keeps the original index.

```python
>>> df.groupby('A', as_index=False).nth(1)
A   B
1 1 2.0
4 2 5.0

34.17.3.16 pandas.core.groupby.GroupBy.ohlc

GroupBy.ohlc()  
Compute sum of values, excluding missing values For multiple groupings, the result index will be a MultiIndex

See also:  
pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.17.3.17 pandas.core.groupby.GroupBy.prod

GroupBy.prod(**kwargs)  
Compute prod of group values

See also:  
pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.17.3.18 pandas.core.groupby.GroupBy.rank

GroupBy.rank (method='average', ascending=True, na_option='keep', pct=False, axis=0)  
Provides the rank of values within each group.

Parameters method : {'average', 'min', 'max', 'first', 'dense'}, default 'average'

- average: average rank of group
- min: lowest rank in group
- max: highest rank in group
- first: ranks assigned in order they appear in the array
- dense: like 'min', but rank always increases by 1 between groups

ascending : boolean, default True
False for ranks by high (1) to low (N)

**na_option**: {'keep', 'top', 'bottom'}, default 'keep'
- keep: leave NA values where they are
- top: smallest rank if ascending
- bottom: smallest rank if descending

**pct**: boolean, default False
Compute percentage rank of data within each group

**axis**: int, default 0
The axis of the object over which to compute the rank.

**Returns**

DataFrame with ranking of values within each group

See also:
pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

### 34.17.3.19 pandas.core.groupby.GroupBy.pct_change

**GroupBy.pct_change**(periods=1, fill_method='pad', limit=None, freq=None, axis=0)
Calculates pct_change of each value to previous entry in group

See also:
pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

### 34.17.3.20 pandas.core.groupby.GroupBy.size

**GroupBy.size()
**
Compute group sizes

See also:
pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

### 34.17.3.21 pandas.core.groupby.GroupBy.sem

**GroupBy.sem**(ddof=1)
Compute standard error of the mean of groups, excluding missing values
For multiple groupings, the result index will be a MultiIndex

**Parameters**

- **ddof**: integer, default 1
degrees of freedom

See also:
pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby
34.17.3.22 pandas.core.groupby.GroupBy.std

GroupBy `.std(ddof=1, *args, **kwargs)`
Compute standard deviation of groups, excluding missing values
For multiple groupings, the result index will be a MultiIndex

**Parameters**
- `ddof`: integer, default 1
degrees of freedom

**See also:**

34.17.3.23 pandas.core.groupby.GroupBy.sum

GroupBy `.sum(**kwargs)`
Compute sum of group values

**See also:**

34.17.3.24 pandas.core.groupby.GroupBy.var

GroupBy `.var(ddof=1, *args, **kwargs)`
Compute variance of groups, excluding missing values
For multiple groupings, the result index will be a MultiIndex

**Parameters**
- `ddof`: integer, default 1
degrees of freedom

**See also:**

34.17.3.25 pandas.core.groupby.GroupBy.tail

GroupBy `.tail(n=5)`
Returns last n rows of each group
Essentially equivalent to `.apply(lambda x: x.tail(n))`, except ignores `as_index` flag.

**See also:**

**Examples**

```python
>>> df = DataFrame([[['a', 1], ['a', 2], ['b', 1], ['b', 2]],
                   columns=['A', 'B'])
>>> df.groupby('A').tail(1)
   A  B
0  a  2
1  b  2
(continues on next page)
```
The following methods are available in both SeriesGroupBy and DataFrameGroupBy objects, but may differ slightly, usually in that the DataFrameGroupBy version usually permits the specification of an axis argument, and often an argument indicating whether to restrict application to columns of a specific data type.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrameGroupBy.agg(arg, *args, **kwargs)</td>
<td>Aggregate using one or more operations over the specified axis.</td>
</tr>
<tr>
<td>DataFrameGroupBy.all([skipna])</td>
<td>Returns True if all values in the group are truthful, else False.</td>
</tr>
<tr>
<td>DataFrameGroupBy.any([skipna])</td>
<td>Returns True if any value in the group is truthful, else False.</td>
</tr>
<tr>
<td>DataFrameGroupBy.bfill([limit])</td>
<td>Backward fill the values.</td>
</tr>
<tr>
<td>DataFrameGroupBy.corr</td>
<td>Compute pairwise correlation of columns, excluding NA/null values.</td>
</tr>
<tr>
<td>DataFrameGroupBy.count()</td>
<td>Compute count of group, excluding missing values.</td>
</tr>
<tr>
<td>DataFrameGroupBy.cov</td>
<td>Compute pairwise covariance of columns, excluding NA/null values.</td>
</tr>
<tr>
<td>DataFrameGroupBy.cummax([axis])</td>
<td>Cumulative max for each group.</td>
</tr>
<tr>
<td>DataFrameGroupBy.cummin([axis])</td>
<td>Cumulative min for each group.</td>
</tr>
<tr>
<td>DataFrameGroupBy.cumprod([axis])</td>
<td>Cumulative product for each group.</td>
</tr>
<tr>
<td>DataFrameGroupBy.cumsum([axis])</td>
<td>Cumulative sum for each group.</td>
</tr>
<tr>
<td>DataFrameGroupBy.describe(**kwargs)</td>
<td>Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset’s distribution, excluding NaN values.</td>
</tr>
<tr>
<td>DataFrameGroupBy.diff</td>
<td>First discrete difference of element.</td>
</tr>
<tr>
<td>DataFrameGroupBy.ffill([limit])</td>
<td>Forward fill the values.</td>
</tr>
<tr>
<td>DataFrameGroupBy.fillna</td>
<td>Fill NA/NaN values using the specified method.</td>
</tr>
<tr>
<td>DataFrameGroupBy.filter(func[, dropna])</td>
<td>Return a copy of a DataFrame excluding elements from groups that do not satisfy the boolean criterion specified by func.</td>
</tr>
<tr>
<td>DataFrameGroupBy.hist</td>
<td>Make a histogram of the DataFrame’s.</td>
</tr>
<tr>
<td>DataFrameGroupBy.idxmax</td>
<td>Return index of first occurrence of maximum over requested axis.</td>
</tr>
<tr>
<td>DataFrameGroupBy.idxmin</td>
<td>Return index of first occurrence of minimum over requested axis.</td>
</tr>
<tr>
<td>DataFrameGroupBy.mad</td>
<td>Return the mean absolute deviation of the values for the requested axis.</td>
</tr>
<tr>
<td>DataFrameGroupBy.pct_change([periods, ...])</td>
<td>Calculate pct_change of each value to previous entry in group.</td>
</tr>
<tr>
<td>DataFrameGroupBy.plot</td>
<td>Class implementing the .plot attribute for groupby objects.</td>
</tr>
<tr>
<td>DataFrameGroupBy.quantile</td>
<td>Return values at the given quantile over requested axis, a la numpy.percentile.</td>
</tr>
<tr>
<td>DataFrameGroupBy.rank([method, ascending, ...])</td>
<td>Provides the rank of values within each group.</td>
</tr>
<tr>
<td>DataFrameGroupBy.resample(rule, *args, **kwargs)</td>
<td>Provide resampling when using a TimeGrouper Return a new grouper with our resampler appended.</td>
</tr>
</tbody>
</table>
Table 167 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataFrameGroupBy.shift([periods, freq, axis])</td>
<td>Shift each group by periods observations</td>
</tr>
<tr>
<td>DataFrameGroupBy.size()</td>
<td>Compute group sizes</td>
</tr>
<tr>
<td>DataFrameGroupBy.skew</td>
<td>Return unbiased skew over requested axis Normalized by N-1</td>
</tr>
<tr>
<td>DataFrameGroupBy.take</td>
<td>Return the elements in the given positional indices along an axis.</td>
</tr>
<tr>
<td>DataFrameGroupBy.tshift</td>
<td>Shift the time index, using the index’s frequency if available.</td>
</tr>
</tbody>
</table>

34.17.3.26 pandas.core.groupby.DataFrameGroupBy.agg

DataFrameGroupBy.**agg**(arg, *args, **kwargs)

Aggregate using one or more operations over the specified axis.

**Parameters**

- **func** : function, string, dictionary, or list of string/functions

  Function to use for aggregating the data. If a function, must either work when passed a DataFrame or when passed to DataFrame.apply. For a DataFrame, can pass a dict, if the keys are DataFrame column names.

  Accepted combinations are:

  - string function name.
  - function.
  - list of functions.
  - dict of column names -> functions (or list of functions).

- **args**

  Positional arguments to pass to **func**.

- **kwargs**

  Keyword arguments to pass to **func**.

**Returns**

- aggregated [DataFrame]

**See also:**

pandas.DataFrame.groupby.apply, pandas.DataFrame.groupby.transform, pandas.DataFrame.aggregate

**Notes**

- **agg** is an alias for **aggregate**. Use the alias.

  A passed user-defined-function will be passed a Series for evaluation.

**Examples**
>>> df = pd.DataFrame({'A': [1, 1, 2, 2],
...                   'B': [1, 2, 3, 4],
...                   'C': np.random.randn(4)})

>>> df
   A  B          C
0  1  1   0.362838
1  1  2   0.227877
2  2  3   1.267767
3  2  4  -0.562860

The aggregation is for each column.

>>> df.groupby('A').agg('min')
   B  C
A
1  1  0.227877
2  3 -0.562860

Multiple aggregations

>>> df.groupby('A').agg(['min', 'max'])
   B  C
  min max  min  max
A
1  1  2 0.227877 0.362838
2  3  4 -0.562860 1.267767

Select a column for aggregation

>>> df.groupby('A').B.agg(['min', 'max'])
   min  max
A
1  1  2
2  3  4

Different aggregations per column

>>> df.groupby('A').agg({'B': ['min', 'max'], 'C': 'sum'})
   B  C
  min max    sum
A
1  1  2 0.590716
2  3  4 0.704907

34.17.3.27 pandas.core.groupby.DataFrameGroupBy.all

DataFrameGroupBy.all(skipna=True)
Returns True if all values in the group are truthful, else False

Parameters skipna : bool, default True
Flag to ignore nan values during truth testing

See also:
pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby
34.17.3.28 pandas.core.groupby.DataFrameGroupBy.any

DataFrameGroupBy\texttt{.any}(\texttt{skipna=True})

Returns True if any value in the group is truthful, else False

\textbf{Parameters} \texttt{skipna}: bool, default True

Flag to ignore nan values during truth testing

\textbf{See also:}
pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.17.3.29 pandas.core.groupby.DataFrameGroupBy.bfill

DataFrameGroupBy\texttt{.bfill}(\texttt{limit=None})

Backward fill the values

\textbf{Parameters} \texttt{limit}: integer, optional

limit of how many values to fill

\textbf{See also:}
Series.backfill, DataFrame.backfill, Series.fillna, DataFrame.fillna

34.17.3.30 pandas.core.groupby.DataFrameGroupBy.corr

DataFrameGroupBy\texttt{.corr}

Compute pairwise correlation of columns, excluding NA/null values

\textbf{Parameters} \texttt{method}: \{'pearson’, ‘kendall’, ‘spearman’\}

- pearson: standard correlation coefficient
- kendall: Kendall Tau correlation coefficient
- spearman: Spearman rank correlation

\textbf{min_periods}: int, optional

Minimum number of observations required per pair of columns to have a valid result. Currently only available for pearson and spearman correlation

\textbf{Returns}

\texttt{y} [DataFrame]

34.17.3.31 pandas.core.groupby.DataFrameGroupBy.count

DataFrameGroupBy\texttt{.count}()

Compute count of group, excluding missing values

34.17.3.32 pandas.core.groupby.DataFrameGroupBy.cov

DataFrameGroupBy\texttt{.cov}

Compute pairwise covariance of columns, excluding NA/null values.

Compute the pairwise covariance among the series of a DataFrame. The returned data frame is the covariance matrix of the columns of the DataFrame.
Both NA and null values are automatically excluded from the calculation. (See the note below about bias from missing values.) A threshold can be set for the minimum number of observations for each value created. Comparisons with observations below this threshold will be returned as NaN.

This method is generally used for the analysis of time series data to understand the relationship between different measures across time.

Parameters

min_periods : int, optional
Minimum number of observations required per pair of columns to have a valid result.

Returns

DataFrame

The covariance matrix of the series of the DataFrame.

See also:

pandas.Series.cov compute covariance with another Series
pandas.core.window.EWM.cov exponential weighted sample covariance
pandas.core.window.Expanding.cov expanding sample covariance
pandas.core.window.Rolling.cov rolling sample covariance

Notes

Returns the covariance matrix of the DataFrame’s time series. The covariance is normalized by N-1.

For DataFrames that have Series that are missing data (assuming that data is missing at random) the returned covariance matrix will be an unbiased estimate of the variance and covariance between the member Series.

However, for many applications this estimate may not be acceptable because the estimate covariance matrix is not guaranteed to be positive semi-definite. This could lead to estimate correlations having absolute values which are greater than one, and/or a non-invertible covariance matrix. See Estimation of covariance matrices for more details.

Examples

```python
>>> df = pd.DataFrame([(1, 2), (0, 3), (2, 0), (1, 1)],
... columns=['dogs', 'cats'])
>>> df.cov()
   dogs    cats
dogs 0.666667 -1.000000
cats -1.000000  1.666667
```

```python
>>> np.random.seed(42)
>>> df = pd.DataFrame(np.random.randn(1000, 5),
... columns=['a', 'b', 'c', 'd', 'e'])
>>> df.cov()
      a         b         c         d         e
a  0.998438 -0.020161  0.059277 -0.008943  0.014144
b -0.020161  1.059352 -0.008543 -0.024738  0.009826
c  0.059277 -0.008543  1.010670 -0.001486 -0.000271
d -0.008943 -0.024738 -0.001486  0.921297 -0.013692
e  0.014144  0.009826 -0.000271 -0.013692  0.977795
```
Minimum number of periods

This method also supports an optional `min_periods` keyword that specifies the required minimum number of non-NA observations for each column pair in order to have a valid result:

```python
c>> np.random.seed(42)
c>> df = pd.DataFrame(np.random.randn(20, 3),
c                  columns=['a', 'b', 'c'])
c>> df.loc[df.index[:5], 'a'] = np.nan
>> df.loc[df.index[5:10], 'b'] = np.nan
>> df.cov(min_periods=12)
```

```
   a   b   c
a 0.316741 NaN -0.150812
b  NaN 1.248003 0.191417
c -0.150812 0.191417 0.895202
```

34.17.33 `pandas.core.groupby.DataFrameGroupBy.cummax`

`DataFrameGroupBy.cummax(axis=0, **kwargs)`
Cumulative max for each group

See also:

34.17.34 `pandas.core.groupby.DataFrameGroupBy.cummin`

`DataFrameGroupBy.cummin(axis=0, **kwargs)`
Cumulative min for each group

See also:

34.17.35 `pandas.core.groupby.DataFrameGroupBy.cumprod`

`DataFrameGroupBy.cumprod(axis=0, *args, **kwargs)`
Cumulative product for each group

See also:

34.17.36 `pandas.core.groupby.DataFrameGroupBy.cumsum`

`DataFrameGroupBy.cumsum(axis=0, *args, **kwargs)`
Cumulative sum for each group

See also:
DataFrameGroupBy.describe(**kwargs)

Generates descriptive statistics that summarize the central tendency, dispersion and shape of a dataset’s distribution, excluding NaN values.

Analyzes both numeric and object series, as well as DataFrame column sets of mixed data types. The output will vary depending on what is provided. Refer to the notes below for more detail.

**Parameters**

percentiles : list-like of numbers, optional

The percentiles to include in the output. All should fall between 0 and 1. The default is [.25, .5, .75], which returns the 25th, 50th, and 75th percentiles.

include : ‘all’, list-like of dtypes or None (default), optional

A white list of data types to include in the result. Ignored for Series. Here are the options:

- ‘all’ : All columns of the input will be included in the output.
- A list-like of dtypes : Limits the results to the provided data types. To limit the result to numeric types submit numpy.number. To limit it instead to object columns submit the numpy.object data type. Strings can also be used in the style of select_dtypes (e.g. df.describe(include=['O'])). To select pandas categorical columns, use 'category'
- None (default) : The result will include all numeric columns.

exclude : list-like of dtypes or None (default), optional,

A black list of data types to omit from the result. Ignored for Series. Here are the options:

- A list-like of dtypes : Excludes the provided data types from the result. To exclude numeric types submit numpy.number. To exclude object columns submit the data type numpy.object. Strings can also be used in the style of select_dtypes (e.g. df.describe(include=['O'])). To exclude pandas categorical columns, use 'category'
- None (default) : The result will exclude nothing.

**Returns**

summary: Series/DataFrame of summary statistics

See also:

DataFrame.count, DataFrame.max, DataFrame.min, DataFrame.mean, DataFrame.std, DataFrame.select_dtypes

**Notes**

For numeric data, the result’s index will include count, mean, std, min, max as well as lower, 50 and upper percentiles. By default the lower percentile is 25 and the upper percentile is 75. The 50 percentile is the same as the median.

For object data (e.g. strings or timestamps), the result’s index will include count, unique, top, and freq. The top is the most common value. The freq is the most common value’s frequency. Timestamps also include the first and last items.
If multiple object values have the highest count, then the count and top results will be arbitrarily chosen from among those with the highest count.

For mixed data types provided via a DataFrame, the default is to return only an analysis of numeric columns. If the dataframe consists only of object and categorical data without any numeric columns, the default is to return an analysis of both the object and categorical columns. If include='all' is provided as an option, the result will include a union of attributes of each type.

The include and exclude parameters can be used to limit which columns in a DataFrame are analyzed for the output. The parameters are ignored when analyzing a Series.

Examples

Describing a numeric Series.

```python
>>> s = pd.Series([1, 2, 3])
>>> s.describe()
count 3.0
mean 2.0
std 1.0
min 1.0
25% 1.5
50% 2.0
75% 2.5
max 3.0
```

Describing a categorical Series.

```python
>>> s = pd.Series(['a', 'a', 'b', 'c'])
>>> s.describe()
count 4
unique 3
top a
freq 2
dtype: object
```

Describing a timestamp Series.

```python
>>> s = pd.Series([... np.datetime64("2000-01-01"),
... np.datetime64("2010-01-01"),
... np.datetime64("2010-01-01")
... ])
>>> s.describe()
count 3
unique 2
top 2010-01-01 00:00:00
freq 2
first 2000-01-01 00:00:00
last 2010-01-01 00:00:00
dtype: object
```

Describing a DataFrame. By default only numeric fields are returned.

```python
>>> df = pd.DataFrame({'object': ['a', 'b', 'c'],
...                     'numeric': [1, 2, 3],
...                     'categorical': pd.Categorical(['d', 'e', 'f'])})
```

(continues on next page)
... })
>>> df.describe()
   numeric
   count 3.0
   mean 2.0
   std  1.0
   min  1.0
  25%  1.5
  50%  2.0
  75%  2.5
   max 3.0

Describing all columns of a DataFrame regardless of data type.

>>> df.describe(include='all')
   categorical  numeric  object
   count        3      3.0       3
   unique       3      NaN       3
   top          f      NaN       c
   freq         1      NaN       1
   mean         NaN    2.0       NaN
   std          NaN    1.0       NaN
   min          NaN    1.0       NaN
  25%           NaN    1.5       NaN
  50%           NaN    2.0       NaN
  75%           NaN    2.5       NaN
   max          NaN    3.0       NaN

Describing a column from a DataFrame by accessing it as an attribute.

>>> df.numeric.describe()
   numeric
   count 3.0
   mean 2.0
   std  1.0
   min  1.0
  25%  1.5
  50%  2.0
  75%  2.5
   max 3.0
Name: numeric, dtype: float64

Including only numeric columns in a DataFrame description.

>>> df.describe(include=[np.number])
   numeric
   count 3.0
   mean 2.0
   std  1.0
   min  1.0
  25%  1.5
  50%  2.0
  75%  2.5
   max 3.0

Including only string columns in a DataFrame description.
Including only categorical columns from a DataFrame description.

```python
>>> df.describe(include=[np.object])

<table>
<thead>
<tr>
<th></th>
<th>object</th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>3</td>
</tr>
<tr>
<td>unique</td>
<td>3</td>
</tr>
<tr>
<td>top</td>
<td>c</td>
</tr>
<tr>
<td>freq</td>
<td>1</td>
</tr>
</tbody>
</table>
```

Excluding numeric columns from a DataFrame description.

```python
>>> df.describe(include=['category'])

<table>
<thead>
<tr>
<th></th>
<th>categorical</th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>3</td>
</tr>
<tr>
<td>unique</td>
<td>3</td>
</tr>
<tr>
<td>top</td>
<td>f</td>
</tr>
<tr>
<td>freq</td>
<td>1</td>
</tr>
</tbody>
</table>
```

Excluding object columns from a DataFrame description.

```python
>>> df.describe(exclude=[np.object])

<table>
<thead>
<tr>
<th></th>
<th>categorical</th>
<th>numeric</th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>3 3</td>
<td></td>
</tr>
<tr>
<td>unique</td>
<td>3 3</td>
<td></td>
</tr>
<tr>
<td>top</td>
<td>f c</td>
<td></td>
</tr>
<tr>
<td>freq</td>
<td>1 1</td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>NaN 2.0</td>
<td></td>
</tr>
<tr>
<td>std</td>
<td>NaN 1.0</td>
<td></td>
</tr>
<tr>
<td>min</td>
<td>NaN 1.0</td>
<td></td>
</tr>
<tr>
<td>25%</td>
<td>NaN 1.5</td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td>NaN 2.0</td>
<td></td>
</tr>
<tr>
<td>75%</td>
<td>NaN 2.5</td>
<td></td>
</tr>
<tr>
<td>max</td>
<td>NaN 3.0</td>
<td></td>
</tr>
</tbody>
</table>
```

### 34.17.3.38 pandas.core.groupby.DataFrameGroupBy.diff

**DataFrameGroupBy.diff**

First discrete difference of element.

Calculates the difference of a DataFrame element compared with another element in the DataFrame (default is the element in the same column of the previous row).

- **Parameters**
  - `periods`: int, default 1
    - Periods to shift for calculating difference, accepts negative values.
  - `axis`: {0 or ‘index’, 1 or ‘columns’}, default 0
    - Take difference over rows (0) or columns (1).

New in version 0.16.1..
Returns

diffed [DataFrame]

See also:

Series.diff First discrete difference for a Series.
DataFrame.pct_change Percent change over given number of periods.
DataFrame.shift Shift index by desired number of periods with an optional time freq.

Examples

Difference with previous row

```python
def = pd.DataFrame({'a': [1, 2, 3, 4, 5, 6],
                    'b': [1, 2, 3, 5, 8],
                    'c': [1, 4, 9, 16, 25, 36]})
def
a  b  c
0  1  1  1
1  2  1  4
2  3  2  9
3  4  3 16
4  5  5 25
5  6  8 36
```

```python
def.diff()
da  b  c
0  NaN NaN NaN
1  1.0 0.0 3.0
2  1.0 1.0 5.0
3  1.0 1.0 7.0
4  1.0 2.0 9.0
5  1.0 3.0 11.0
```

Difference with previous column

```python
def.diff(axis=1)
da  b  c
0  NaN 0.0 0.0
1  NaN -1.0 3.0
2  NaN -1.0 7.0
3  NaN -1.0 13.0
4  NaN 0.0 20.0
5  NaN 2.0 28.0
```

Difference with 3rd previous row

```python
def.diff(periods=3)
da  b  c
0  NaN NaN NaN
1  NaN NaN NaN
2  NaN NaN NaN
3  3.0 2.0 15.0
4  3.0 4.0 21.0
5  3.0 6.0 27.0
```
Difference with following row

```python
>>> df.diff(periods=-1)
   a   b   c
0 -1.0 0.0 -3.0
1 -1.0 -1.0 -5.0
2 -1.0 -1.0 -7.0
3 -1.0 -2.0 -9.0
4 -1.0 -3.0 -11.0
5   NaN NaN  NaN
```

34.17.3.39 pandas.core.groupby.DataFrameGroupBy.ffill

DataFrameGroupBy.ffill(\texttt{limit=None})

Forward fill the values

**Parameters**

- \texttt{limit : integer, optional}

  Limit of how many values to fill

**See also:**

- Series.pad, DataFrame.pad, Series.fillna, DataFrame.fillna

34.17.3.40 pandas.core.groupby.DataFrameGroupBy.fillna

DataFrameGroupBy.fillna

Fill NA/Nan values using the specified method

**Parameters**

- \texttt{value : scalar, dict, Series, or DataFrame}

  Value to use to fill holes (e.g. 0), alternately a dict/Series/DataFrame of values specifying which value to use for each index (for a Series) or column (for a DataFrame). (values not in the dict/Series/DataFrame will not be filled). This value cannot be a list.

- \texttt{method : \{‘backfill’, ‘bfill’, ‘pad’, ‘ffill’, None\}, default None}

  Method to use for filling holes in reindexed Series pad / ffill: propagate last valid observation forward to next valid backfill / bfill: use NEXT valid observation to fill gap

- \texttt{axis \{\{0 or ‘index’, 1 or ‘columns’\}\}}

- \texttt{inplace : boolean, default False}

  If True, fill in place. Note: this will modify any other views on this object, (e.g. a no-copy slice for a column in a DataFrame).

- \texttt{limit : int, default None}

  If method is specified, this is the maximum number of consecutive NaN values to forward/backward fill. In other words, if there is a gap with more than this number of consecutive NaNs, it will only be partially filled. If method is not specified, this is the maximum number of entries along the entire axis where NaNs will be filled. Must be greater than 0 if not None.

- \texttt{downcast : dict, default is None}
a dict of item->dtype of what to downcast if possible, or the string ‘infer’ which will try to downcast to an appropriate equal type (e.g. float64 to int64 if possible)

Returns

filled [DataFrame]

See also:

interpolate Fill NaN values using interpolation.

reindex, asfreq

Examples

```python
def = pd.DataFrame([[np.nan, 2, np.nan, 0],
                    [3, 4, np.nan, 1],
                    [np.nan, np.nan, np.nan, 5],
                    [np.nan, 3, np.nan, 4]],
                   columns=list('ABCD'))
def
A   B   C   D
0   NaN 2.0  NaN 0
1   3.0  4.0  NaN 1
2   NaN  NaN  NaN 5
3   NaN  3.0  NaN 4
```

Replace all NaN elements with 0s.

```python
def.fillna(0)
A   B   C   D
0   0.0  2.0  0.0  0
1   3.0  4.0  0.0  1
2   0.0  0.0  0.0  5
3   0.0  3.0  0.0  4
```

We can also propagate non-null values forward or backward.

```python
def.fillna(method='ffill')
A   B   C   D
0   NaN 2.0  NaN 0
1   3.0  4.0  NaN 1
2   3.0  4.0  NaN 5
3   3.0  3.0  NaN 4
```

Replace all NaN elements in column ‘A’, ‘B’, ‘C’, and ‘D’, with 0, 1, 2, and 3 respectively.

```python
values = {'A': 0, 'B': 1, 'C': 2, 'D': 3}
def.fillna(value=values)
A   B   C   D
0   0.0  2.0  2.0  0
1   3.0  4.0  2.0  1
2   0.0  1.0  2.0  5
3   0.0  3.0  2.0  4
```

Only replace the first NaN element.
>>> df.fillna(value=values, limit=1)

A  B  C  D
0  0  2.0 2.0  0
1  3.0 4.0  NaN  1
2  NaN 1.0  NaN  5
3  NaN 3.0  NaN  4

34.17.3.41 pandas.core.groupby.DataFrameGroupBy.filter

DataFrameGroupBy.filter(func, dropna=True, *args, **kwargs)

Return a copy of a DataFrame excluding elements from groups that do not satisfy the boolean criterion specified by func.

Parameters

- **f**: function
  - Function to apply to each subframe. Should return True or False.
- **dropna**: Drop groups that do not pass the filter. True by default; if False, groups that evaluate False are filled with NaNs.

Returns

filtered [DataFrame]

Notes

Each subframe is endowed the attribute ‘name’ in case you need to know which group you are working on.

Examples

```python
>>> import pandas as pd
>>> df = pd.DataFrame({'A' : ['foo', 'bar', 'foo', 'bar',
... 'foo', 'bar'],
... 'B' : [1, 2, 3, 4, 5, 6],
... 'C' : [2.0, 5., 8., 1., 2., 9.]})
>>> grouped = df.groupby('A')
>>> grouped.filter(lambda x: x['B'].mean() > 3.)
A  B  C
1  bar 2.5
3  bar 4.0
5  bar 6.0
```

34.17.3.42 pandas.core.groupby.DataFrameGroupBy.hist

DataFrameGroupBy.hist

Make a histogram of the DataFrame’s.

A histogram is a representation of the distribution of data. This function calls matplotlib.pyplot.hist(), on each series in the DataFrame, resulting in one histogram per column.

Parameters

- **data**: DataFrame
  - The pandas object holding the data.
column : string or sequence
    If passed, will be used to limit data to a subset of columns.
by : object, optional
    If passed, then used to form histograms for separate groups.
grid : boolean, default True
    Whether to show axis grid lines.
xlabelsize : int, default None
    If specified changes the x-axis label size.
xrot : float, default None
    Rotation of x axis labels. For example, a value of 90 displays the x labels rotated 90
degrees clockwise.
ylabelsize : int, default None
    If specified changes the y-axis label size.
yrot : float, default None
    Rotation of y axis labels. For example, a value of 90 displays the y labels rotated 90
degrees clockwise.
ax : Matplotlib axes object, default None
    The axes to plot the histogram on.
sharex : boolean, default True if ax is None else False
    In case subplots=True, share x axis and set some x axis labels to invisible; defaults
to True if ax is None otherwise False if an ax is passed in. Note that passing in both
an ax and sharex=True will alter all x axis labels for all subplots in a figure.
sharey : boolean, default False
    In case subplots=True, share y axis and set some y axis labels to invisible.
figsize : tuple
    The size in inches of the figure to create. Uses the value in matplotlib.rcParams by
default.
layout : tuple, optional
    Tuple of (rows, columns) for the layout of the histograms.
bins : integer or sequence, default 10
    Number of histogram bins to be used. If an integer is given, bins + 1 bin edges are
calculated and returned. If bins is a sequence, gives bin edges, including left edge of
first bin and right edge of last bin. In this case, bins is returned unmodified.
**kwds
    All other plotting keyword arguments to be passed to matplotlib.pyplot.
    hist().

Returns

    axes  [matplotlib.AxesSubplot or numpy.ndarray of them]

See also:
**matplotlib.pyplot.hist** Plot a histogram using matplotlib.

**Examples**

This example draws a histogram based on the length and width of some animals, displayed in three bins.

```python
>>> df = pd.DataFrame(
...     'length': [1.5, 0.5, 1.2, 0.9, 3],
...     'width': [0.7, 0.2, 0.15, 0.2, 1.1],
...     index= ['pig', 'rabbit', 'duck', 'chicken', 'horse'])

>>> hist = df.hist(bins=3)
```

**34.17.3.43 pandas.core.groupby.DataFrameGroupBy.idxmax**

DataFrameGroupBy.idxmax

Return index of first occurrence of maximum over requested axis. NA/null values are excluded.

**Parameters**

axis : {0 or ‘index’, 1 or ‘columns’}, default 0

0 or ‘index’ for row-wise, 1 or ‘columns’ for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA.

**Returns**

idxmax [Series]

**Raises** ValueError

- If the row/column is empty

**See also:**

Series.idxmax

**Notes**

This method is the DataFrame version of ndarray.argmax.

**34.17.3.44 pandas.core.groupby.DataFrameGroupBy.idxmin**

DataFrameGroupBy.idxmin

Return index of first occurrence of minimum over requested axis. NA/null values are excluded.

**Parameters**

axis : {0 or ‘index’, 1 or ‘columns’}, default 0

0 or ‘index’ for row-wise, 1 or ‘columns’ for column-wise

skipna : boolean, default True

Exclude NA/null values. If an entire row/column is NA, the result will be NA.

**Returns**

idxmin [Series]

**Raises** ValueError

- If the row/column is empty
• If the row/column is empty

See also:
Series.idxmin

Notes

This method is the DataFrame version of ndarray.argmin.

34.17.3.45 pandas.core.groupby.DataFrameGroupBy.mad

DataFrameGroupBy.mad
Return the mean absolute deviation of the values for the requested axis

Parameters

axis [index (0), columns (1)]
skipna : boolean, default True
Exclude NA/null values when computing the result.
level : int or level name, default None
If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series
numeric_only : boolean, default None
Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns

mad [Series or DataFrame (if level specified)]

34.17.3.46 pandas.core.groupby.DataFrameGroupBy.pct_change

DataFrameGroupBy.pct_change (periods=1, fill_method='pad', limit=None, freq=None, axis=0)
Calculate pct_change of each value to previous entry in group

See also:
pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.17.3.47 pandas.core.groupby.DataFrameGroupBy.plot

DataFrameGroupBy.plot
Class implementing the .plot attribute for groupby objects

34.17.3.48 pandas.core.groupby.DataFrameGroupBy.quantile

DataFrameGroupBy.quantile
Return values at the given quantile over requested axis, a la numpy.percentile.

Parameters  q : float or array-like, default 0.5 (50% quantile)
0 <= q <= 1, the quantile(s) to compute

axis : {0, 1, ‘index’, ‘columns’} (default 0)

0 or ‘index’ for row-wise, 1 or ‘columns’ for column-wise

numeric_only : boolean, default True

If False, the quantile of datetime and timedelta data will be computed as well

interpolation : {'linear', 'lower', 'higher', 'midpoint', 'nearest'}

New in version 0.18.0.

This optional parameter specifies the interpolation method to use, when the desired
quantile lies between two data points \( i \) and \( j \):

- linear: \( i + (j - i) \times fraction \), where \( fraction \) is the fractional part of the index
  surrounded by \( i \) and \( j \).
- lower: \( i \).
- higher: \( j \).
- nearest: \( i \) or \( j \) whichever is nearest.
- midpoint: \( (i + j) / 2 \).

Returns quantiles : Series or DataFrame

- If \( q \) is an array, a DataFrame will be returned where the index is \( q \), the columns are the
  columns of self, and the values are the quantiles.
- If \( q \) is a float, a Series will be returned where the index is the columns of self and the
  values are the quantiles.

See also:

pandas.core.window.Rolling.quantile

Examples

```python
>>> df = pd.DataFrame(np.array([[1, 1], [2, 10], [3, 100], [4, 100]]),
                     columns=['a', 'b'])
>>> df.quantile(.1)
   a    b
0  1.3  3.7
dtype: float64
>>> df.quantile([.1, .5])
     a    b
0.1  1.3  3.7
0.5  2.5 55.0
```

Specifying numeric_only=False will also compute the quantile of datetime and timedelta data.

```python
>>> df = pd.DataFrame({'A': [1, 2],
                     'B': [pd.Timestamp('2010'), pd.Timestamp('2011')],
                     'C': [pd.Timedelta('1 days'), pd.Timedelta('2 days')]})
>>> df.quantile(0.5, numeric_only=False)
   A
0  1.5
```

(continues on next page)
34.17.3.49 pandas.core.groupby.DataFrameGroupBy.rank

DataFrameGroupBy.rank(method='average', ascending=True, na_option='keep', pct=False, axis=0)

Provides the rank of values within each group.

Parameters

method : {'average', 'min', 'max', 'first', 'dense'}, default 'average'

- average: average rank of group
- min: lowest rank in group
- max: highest rank in group
- first: ranks assigned in order they appear in the array
- dense: like ‘min’, but rank always increases by 1 between groups

ascending : boolean, default True

- False for ranks by high (1) to low (N)

na_option : {'keep', 'top', 'bottom'}, default 'keep'

- keep: leave NA values where they are
- top: smallest rank if ascending
- bottom: smallest rank if descending

pct : boolean, default False

- Compute percentage rank of data within each group

axis : int, default 0

- The axis of the object over which to compute the rank.

Returns

DataFrame with ranking of values within each group

See also:

class pandas.Series, pandas.DataFrame, pandas.Panel

34.17.3.50 pandas.core.groupby.DataFrameGroupBy.resample

DataFrameGroupBy.resample(rule, *args, **kwargs)

Provide resampling when using a TimeGrouper. Return a new grouper with our resampler appended

See also:

class pandas.Series, pandas.DataFrame, pandas.Panel
34.17.3.51 pandas.core.groupby.DataFrameGroupBy.shift

DataFrameGroupBy.shift(periods=1, freq=None, axis=0)
Shift each group by periods observations

Parameters

- periods : integer, default 1
data number of periods to shift

- freq : [frequency string]

- axis : [axis to shift, default 0]

See also:
pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.17.3.52 pandas.core.groupby.DataFrameGroupBy.size

DataFrameGroupBy.size()
Compute group sizes

See also:
pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.17.3.53 pandas.core.groupby.DataFrameGroupBy.skew

DataFrameGroupBy.skew
Return unbiased skew over requested axis Normalized by N-1

Parameters

- axis : [[index (0), columns (1)]]

- skipna : boolean, default True
Exclude NA/null values when computing the result.

- level : int or level name, default None
If the axis is a MultiIndex (hierarchical), count along a particular level, collapsing into a Series

- numeric_only : boolean, default None
Include only float, int, boolean columns. If None, will attempt to use everything, then use only numeric data. Not implemented for Series.

Returns

- skew [Series or DataFrame (if level specified)]

34.17.3.54 pandas.core.groupby.DataFrameGroupBy.take

DataFrameGroupBy.take
Return the elements in the given positional indices along an axis.

This means that we are not indexing according to actual values in the index attribute of the object. We are indexing according to the actual position of the element in the object.
Parameters indices : array-like

An array of ints indicating which positions to take.

axis : {0 or ‘index’, 1 or ‘columns’, None}, default 0

The axis on which to select elements. 0 means that we are selecting rows, 1 means that we are selecting columns.

convert : bool, default True

Whether to convert negative indices into positive ones. For example, -1 would map to the len(axis) – 1. The conversions are similar to the behavior of indexing a regular Python list.

Deprecated since version 0.21.0: In the future, negative indices will always be converted.

is_copy : bool, default True

Whether to return a copy of the original object or not.

**kwargs

For compatibility with numpy.take(). Has no effect on the output.

Returns taken : type of caller

An array-like containing the elements taken from the object.

See also:

Dataframe.loc  Select a subset of a DataFrame by labels.

Dataframe.iloc  Select a subset of a DataFrame by positions.

numpy.take  Take elements from an array along an axis.

Examples

```python
>>> df = pd.DataFrame([('falcon', 'bird', 389.0),
                      ('parrot', 'bird', 24.0),
                      ('lion', 'mammal', 80.5),
                      ('monkey', 'mammal', np.nan)],
                      columns=['name', 'class', 'max_speed'],
                      index=[0, 2, 3, 1])
>>> df
          name class max_speed
0    falcon   bird     389.0
2   parrot   bird      24.0
3     lion  mammal     80.5
1  monkey  mammal        NaN

Take elements at positions 0 and 3 along the axis 0 (default).

Note how the actual indices selected (0 and 1) do not correspond to our selected indices 0 and 3. That’s because we are selecting the 0th and 3rd rows, not rows whose indices equal 0 and 3.

>>> df.take([0, 3])
          name class max_speed
0    falcon   bird     389.0
1  monkey  mammal        NaN
```
Take elements at indices 1 and 2 along the axis 1 (column selection).

```python
>>> df.take([1, 2], axis=1)
   class  max_speed
0   bird      389.0
2   bird       24.0
3  mammal       80.5
1  mammal        NaN
```

We may take elements using negative integers for positive indices, starting from the end of the object, just like with Python lists.

```python
>>> df.take([-1, -2])
   name  class  max_speed
1  monkey  mammal        NaN
3    lion  mammal       80.5
```

### 34.17.3.55 pandas.core.groupby.DataFrameGroupBy.tshift

**DataFrameGroupBy.tshift**

Shift the time index, using the index’s frequency if available.

**Parameters**

- `periods`: int
  
  Number of periods to move, can be positive or negative

- `freq`: DateOffset, timedelta, or time rule string, default None
  
  Increment to use from the tseries module or time rule (e.g. ‘EOM’)

- `axis`: int or basestring
  
  Corresponds to the axis that contains the Index

**Returns**

- `shifted` [NDFrame]

**Notes**

If freq is not specified then tries to use the freq or inferred_freq attributes of the index. If neither of those attributes exist, a ValueError is thrown.

The following methods are available only for `SeriesGroupBy` objects.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>SeriesGroupBy.nlargest</code></td>
<td>Return the largest $n$ elements.</td>
</tr>
<tr>
<td><code>SeriesGroupBy.nsmallest</code></td>
<td>Return the smallest $n$ elements.</td>
</tr>
<tr>
<td><code>SeriesGroupBy.nunique([dropna])</code></td>
<td>Returns number of unique elements in the group</td>
</tr>
<tr>
<td><code>SeriesGroupBy.unique</code></td>
<td>Return unique values of Series object.</td>
</tr>
<tr>
<td><code>SeriesGroupBy.value_counts([normalize, ...])</code></td>
<td>Return count of unique values.</td>
</tr>
<tr>
<td><code>SeriesGroupBy.is_monotonic_increasing</code></td>
<td>Return boolean if values in the object are monotonic_increasing</td>
</tr>
<tr>
<td><code>SeriesGroupBy.is_monotonic_decreasing</code></td>
<td>Return boolean if values in the object are monotonic_decreasing</td>
</tr>
</tbody>
</table>
34.17.3.56 pandas.core.groupby.SeriesGroupBy.nlargest

SeriesGroupBy.nlargest
Return the largest \( n \) elements.

Parameters n : int
Return this many descending sorted values

keep : {'first', 'last'}, default 'first'
Where there are duplicate values: - first : take the first occurrence. - last : take the last occurrence.

Returns top_n : Series
The \( n \) largest values in the Series, in sorted order

See also: Series.nsmallest

Notes
Faster than .sort_values(ascending=False).head(n) for small \( n \) relative to the size of the Series object.

Examples

```python
gb = gpd.DataFrame(df, index=g) 
gb.groupby('G').nlargest(10)
```

34.17.3.57 pandas.core.groupby.SeriesGroupBy.nsmallest

SeriesGroupBy.nsmallest
Return the smallest \( n \) elements.

Parameters n : int
Return this many ascending sorted values

keep : {'first', 'last'}, default 'first'
Where there are duplicate values: - first : take the first occurrence. - last : take the last occurrence.
**Returns**  
bottom_n : Series  
The n smallest values in the Series, in sorted order

**See also:**  
Series.nlargest

**Notes**  
Faster than .sort_values().head(n) for small n relative to the size of the Series object.

**Examples**

```python  
>>> import pandas as pd  
>>> import numpy as np  
>>> s = pd.Series(np.random.randn(10**6))  
>>> s.nsmallest(10)  
# only sorts up to the N requested
288532 -4.954580
732345 -4.835960
64803 -4.812550
446457 -4.609998
501225 -4.483945
669476 -4.472935
973615 -4.401699
621279 -4.355126
773916 -4.347355
359919 -4.331927
```

### 34.17.3.58 pandas.core.groupby.SeriesGroupBy.nunique

SeriesGroupBy.nunique(dropna=True)  
Returns number of unique elements in the group

### 34.17.3.59 pandas.core.groupby.SeriesGroupBy.unique

SeriesGroupBy.unique  
Return unique values of Series object.  
Uniques are returned in order of appearance. Hash table-based unique, therefore does NOT sort.

**Returns**  
ndarray or Categorical  
The unique values returned as a NumPy array. In case of categorical data type, returned as a Categorical.

**See also:**  
pandas.unique top-level unique method for any 1-d array-like object.  
Index.unique return Index with unique values from an Index object.
Examples

```python
>>> pd.Series([2, 1, 3, 3], name='A').unique()
array([2, 1, 3])

>>> pd.Series([pd.Timestamp('2016-01-01') for _ in range(3)]).unique()
array(['2016-01-01T00:00:00.000000000'], dtype='datetime64[ns]')

>>> pd.Series([pd.Timestamp('2016-01-01', tz='US/Eastern') for _ in range(3)]).unique()
array([Timestamp('2016-01-01 00:00:00-0500', tz='US/Eastern')],
dtype=object)
```

An unordered Categorical will return categories in the order of appearance.

```python
>>> pd.Series(pd.Categorical(list('baabc'))).unique()
[b, a, c]
```

An ordered Categorical preserves the category ordering.

```python
>>> pd.Series(pd.Categorical(list('baabc'), categories=list('abc'), ordered=True)).unique()
[b, a, c]
```

---

**34.17.3.60 pandas.core.groupby.SeriesGroupBy.value_counts**

`SeriesGroupBy.value_counts(normalize=False, sort=True, ascending=False, bins=None, dropna=True)`

**34.17.3.61 pandas.core.groupby.SeriesGroupBy.is_monotonic_increasing**

`SeriesGroupBy.is_monotonic_increasing`  
Return boolean if values in the object are monotonic_increasing  
New in version 0.19.0.  

Returns  
`is_monotonic` [boolean]

**34.17.3.62 pandas.core.groupby.SeriesGroupBy.is_monotonic_decreasing**

`SeriesGroupBy.is_monotonic_decreasing`  
Return boolean if values in the object are monotonic_decreasing  
New in version 0.19.0.  

Returns  
`is_monotonic_decreasing` [boolean]

The following methods are available only for `DataFrameGroupBy` objects.
DataFrameGroupBy.corrwith

Compute pairwise correlation between rows or columns of two DataFrame objects.

Parameters

other [DataFrame, Series]
axis : {0 or ‘index’, 1 or ‘columns’}, default 0
  0 or ‘index’ to compute column-wise, 1 or ‘columns’ for row-wise
drop : boolean, default False
  Drop missing indices from result, default returns union of all

Returns
correls [Series]

DataFrameGroupBy.boxplot([subplots, column, …])

Make box plots from DataFrameGroupBy data.

Parameters

grouped [Grouped DataFrame]
subplots :
  • False - no subplots will be used
  • True - create a subplot for each group
column : column name or list of names, or vector
  Can be any valid input to groupby
fontsize [int or string]
rot [label rotation angle]
grid [Setting this to True will show the grid]
ax [Matplotlib axis object, default None]
figsize [A tuple (width, height) in inches]
layout : tuple (optional)
  (rows, columns) for the layout of the plot
**kwds : Keyword Arguments

34.17.3.63 pandas.core.groupby.DataFrameGroupBy.corrwith

DataFrameGroupBy.corrwith

Compute pairwise correlation between rows or columns of two DataFrame objects.

Parameters

other [DataFrame, Series]
axis : {0 or ‘index’, 1 or ‘columns’}, default 0
  0 or ‘index’ to compute column-wise, 1 or ‘columns’ for row-wise
drop : boolean, default False
  Drop missing indices from result, default returns union of all

Returns
correls [Series]

34.17.3.64 pandas.core.groupby.DataFrameGroupBy.boxplot

DataFrameGroupBy.boxplot(subplots=True, column=None, fontsize=None, rot=0, grid=True, ax=None, figsize=None, layout=None, **kwds)

Make box plots from DataFrameGroupBy data.

Parameters

grouped [Grouped DataFrame]
subplots :
  • False - no subplots will be used
  • True - create a subplot for each group
column : column name or list of names, or vector
  Can be any valid input to groupby
fontsize [int or string]
rot [label rotation angle]
grid [Setting this to True will show the grid]
ax [Matplotlib axis object, default None]
figsize [A tuple (width, height) in inches]
layout : tuple (optional)
  (rows, columns) for the layout of the plot
**kwds : Keyword Arguments
All other plotting keyword arguments to be passed to matplotlib’s boxplot function

**Returns**

- dict of key/value = group key/DataFrame.boxplot return value
- or DataFrame.boxplot return value in case subplots=figures=False

**Examples**

```python
>>> import pandas
>>> import numpy as np
>>> import itertools

>>> tuples = [t for t in itertools.product(range(1000), range(4))]
>>> index = pandas.MultiIndex.from_tuples(tuples, names=['lvl0', 'lvl1'])
>>> data = np.random.randn(len(index), 4)
>>> df = pandas.DataFrame(data, columns=list('ABCD'), index=index)

>>> grouped = df.groupby(level='lvl1')
>>> boxplot_frame_groupby(grouped)

>>> grouped = df.unstack(level='lvl1').groupby(level=0, axis=1)
>>> boxplot_frame_groupby(grouped, subplots=False)
```

### 34.18 Resampling

Resampler objects are returned by resample calls: `pandas.DataFrame.resample()`, `pandas.Series.resample()`.

#### 34.18.1 Indexing, iteration

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Resampler.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>iter</strong></td>
<td>Groupby iterator</td>
</tr>
<tr>
<td>groups</td>
<td>dict {group name -&gt; group labels}</td>
</tr>
<tr>
<td>indices</td>
<td>dict {group name -&gt; group indices}</td>
</tr>
<tr>
<td>get_group(name[, obj])</td>
<td>Constructs NDFrame from group with provided name</td>
</tr>
</tbody>
</table>

#### 34.18.1.1 pandas.core.resample.Resampler.__iter__

- **Resampler.**
- __iter__()
- Groupby iterator

**Returns**

- Generator yielding sequence of (name, subsetted object)
  for each group

#### 34.18.1.2 pandas.core.resample.Resampler.groups

- **Resampler.**
- groups
- dict {group name -> group labels}
34.18.1.3 pandas.core.resample.Resampler.indices

Resampler.indices
dict {group name -> group indices}

34.18.1.4 pandas.core.resample.Resampler.get_group

Resampler.get_group(name, obj=None)
Constructs NDFrame from group with provided name

Parameters
name : object
    the name of the group to get as a DataFrame

obj : NDFrame, default None
    the NDFrame to take the DataFrame out of. If it is None, the object groupby was
called on will be used

Returns

group [type of obj]

34.18.2 Function application

<table>
<thead>
<tr>
<th>Resampler.apply(arg, *args, **kwargs)</th>
<th>Aggregate using one or more operations over the specified axis.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resampler.aggregate(arg, *args, **kwargs)</td>
<td>Aggregate using one or more operations over the specified axis.</td>
</tr>
</tbody>
</table>
| Resampler.transform(arg, *args, **kwargs) | Call function producing a like-indexed Series on each
group and return a Series with the transformed values |
| Resampler.pipe(func, *args, **kwargs) | Apply a function func with arguments to this Resampler
object and return the function’s result. |

34.18.2.1 pandas.core.resample.Resampler.apply

Resampler.apply(arg, *args, **kwargs)
Aggregate using one or more operations over the specified axis.

Parameters
func : function, string, dictionary, or list of string/functions
    Function to use for aggregating the data. If a function, must either work when passed
    a DataFrame or when passed to DataFrame.apply. For a DataFrame, can pass a dict,
    if the keys are DataFrame column names.

Accepted combinations are:
    • string function name.
    • function.
    • list of functions.
    • dict of column names -> functions (or list of functions).

*args
    Positional arguments to pass to func.
**kwargs

Keyword arguments to pass to `func`.

**Returns**

- **aggregated** ([DataFrame]

**See also:**

- pandas.DataFrame.groupby.aggregate,
- pandas.DataFrame.resample.transform,
- pandas.DataFrame.aggregate

**Notes**

`agg` is an alias for `aggregate`. Use the alias.

A passed user-defined-function will be passed a Series for evaluation.

**Examples**

```python
>>> s = Series([1,2,3,4,5],
             index=pd.date_range('20130101',
                                 periods=5,freq='s'))
  2013-01-01 00:00:00    1
  2013-01-01 00:00:01    2
  2013-01-01 00:00:02    3
  2013-01-01 00:00:03    4
  2013-01-01 00:00:04    5
Freq: S, dtype: int64
```

```python
>>> r = s.resample('2s')
DatetimeIndexResampler [freq=<2 * Seconds>, axis=0, closed=left,
                        label=left, convention=start, base=0]
```

```python
>>> r.agg(np.sum)
  2013-01-01 00:00:00    3
  2013-01-01 00:00:02    7
  2013-01-01 00:00:04    5
Freq: 2S, dtype: int64
```

```python
>>> r.agg(['sum','mean','max'])
   sum  mean  max
  2013-01-01 00:00:00  3  1.5  2
  2013-01-01 00:00:02  7  3.5  4
  2013-01-01 00:00:04  5  5.0  5
```

```python
>>> r.agg({'result' : lambda x: x.mean() / x.std(),
         'total' : np.sum})
     total      result
  2013-01-01 00:00:00    3   2.121320
  2013-01-01 00:00:02    7   4.949747
  2013-01-01 00:00:04    5   NaN
```
34.18.2.2 pandas.core.resample.Resampler.aggregate

Resampler.aggregate(arg, *args, **kwargs)

Aggregate using one or more operations over the specified axis.

Parameters func : function, string, dictionary, or list of string/functions

Function to use for aggregating the data. If a function, must either work when passed a DataFrame or when passed to DataFrame.apply. For a DataFrame, can pass a dict, if the keys are DataFrame column names.

Accepted combinations are:
- string function name.
- function.
- list of functions.
- dict of column names -> functions (or list of functions).

*args

Positional arguments to pass to func.

**kwargs

Keyword arguments to pass to func.

Returns

aggregated [DataFrame]

See also:
pandas.DataFrame.groupby.aggregate, pandas.DataFrame.resample.transform, pandas.DataFrame.aggregate

Notes

agg is an alias for aggregate. Use the alias.

A passed user-defined-function will be passed a Series for evaluation.

Examples

```python
gs = Series([1, 2, 3, 4, 5],
             index=pd.date_range('20130101',
                                 periods=5, freq='s'))
print(gs)
2013-01-01 00:00:00    1
2013-01-01 00:00:01    2
2013-01-01 00:00:02    3
2013-01-01 00:00:03    4
2013-01-01 00:00:04    5
Freq: s, dtype: int64

rs = s.resample('2s')
print(rs)
```

DatetimeIndexResampler [freq=<2 * Seconds>, axis=0, closed=left, label=left, convention=start, base=0]
```python
>>> r.agg(np.sum)
2013-01-01 00:00:00    3
2013-01-01 00:00:02    7
2013-01-01 00:00:04    5
Freq: 2S, dtype: int64

>>> r.agg(['sum','mean','max'])
      sum  mean  max
2013-01-01 00:00:00  3    1.5    2
2013-01-01 00:00:02  7    3.5    4
2013-01-01 00:00:04  5    5.0    5

>>> r.agg(
    {'result': lambda x: x.mean() / x.std(),
     'total': np.sum})
      total  result
2013-01-01 00:00:00  3  2.121320
2013-01-01 00:00:02  7  4.949747
2013-01-01 00:00:04  5  NaN
```

34.18.2.3 `pandas.core.resample.Resampler.transform`

```python
resampled.transform(lambda x: (x - x.mean()) / x.std())
```

34.18.2.4 `pandas.core.resample.Resampler.pipe`

```python
(df.groupby('group')
...  .pipe(f)
...  .pipe(g, arg1=a)
...  .pipe(h, arg2=b, arg3=c))
```
which is much more readable.

**Parameters**

**func**: callable or tuple of (callable, string)

Function to apply to this Resampler object or, alternatively, a (callable, data_keyword) tuple where data_keyword is a string indicating the keyword of callable that expects the Resampler object.

**args**: iterable, optional

Positional arguments passed into func.

**kwargs**: dict, optional

A dictionary of keyword arguments passed into func.

**Returns**

**object**: [the return type of func.]

**See also**:

- *pandas.Series.pipe*  Apply a function with arguments to a series
- *pandas.DataFrame.pipe*  Apply a function with arguments to a dataframe
- *apply*  Apply function to each group instead of to the full Resampler object.

**Notes**

See more here

**Examples**

```python
>>> df = pd.DataFrame({'A': [1, 2, 3, 4]},
...                   index=pd.date_range('2012-08-02', periods=4))
>>> df
              A
2012-08-02   1
2012-08-03   2
2012-08-04   3
2012-08-05   4
```

To get the difference between each 2-day period’s maximum and minimum value in one pass, you can do

```python
>>> df.resample('2D').pipe(lambda x: x.max() - x.min())
              A
2012-08-02   1
2012-08-04   1
```

**34.18.3 Upsampling**

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Resampler.fffill([limit])</code></td>
<td>Forward fill the values</td>
</tr>
<tr>
<td><code>Resampler.backfill([limit])</code></td>
<td>Backward fill the new missing values in the resampled data.</td>
</tr>
</tbody>
</table>

Continued on next page
Table 172 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resampler.bfill([limit])</td>
<td>Backward fill the new missing values in the resampled data.</td>
</tr>
<tr>
<td>Resampler.pad([limit])</td>
<td>Forward fill the values</td>
</tr>
<tr>
<td>Resampler.nearest([limit])</td>
<td>Fill values with nearest neighbor starting from center</td>
</tr>
<tr>
<td>Resampler.fillna(method[, limit])</td>
<td>Fill missing values introduced by upsampling.</td>
</tr>
<tr>
<td>Resampler.asfreq([fill_value])</td>
<td>return the values at the new freq, essentially a reindex</td>
</tr>
<tr>
<td>Resampler.interpolate(...)</td>
<td>Interpolate values according to different methods.</td>
</tr>
</tbody>
</table>

### 34.18.3.1 pandas.core.resample.Resampler.ffill

Resampler.ffill(limit=None)

Forward fill the values

**Parameters**

- limit : integer, optional
  - limit of how many values to fill

**Returns**

an upsampled Series

**See also:**

Series.fillna, DataFrame.fillna

### 34.18.3.2 pandas.core.resample.Resampler.backfill

Resampler.backfill(limit=None)

Backward fill the new missing values in the resampled data.

In statistics, imputation is the process of replacing missing data with substituted values [R30]. When resampling data, missing values may appear (e.g., when the resampling frequency is higher than the original frequency). The backward fill will replace NaN values that appeared in the resampled data with the next value in the original sequence. Missing values that existed in the original data will not be modified.

**Parameters**

- limit : integer, optional
  - Limit of how many values to fill.

**Returns**

Series, DataFrame

- An upsampled Series or DataFrame with backward filled NaN values.

**See also:**

- bfill Alias of backfill.
- fillna Fill NaN values using the specified method, which can be ‘backfill’.
- nearest Fill NaN values with nearest neighbor starting from center.
- pad Forward fill NaN values.
- pandas.Series.fillna Fill NaN values in the Series using the specified method, which can be ‘backfill’.
- pandas.DataFrame.fillna Fill NaN values in the DataFrame using the specified method, which can be ‘backfill’.
## References

[R30]

## Examples

### Resampling a Series:

```python
>>> s = pd.Series([1, 2, 3],
                index=pd.date_range('20180101', periods=3, freq='h'))
>>> s
2018-01-01 00:00:00    1
2018-01-01 01:00:00    2
2018-01-01 02:00:00    3
Freq: H, dtype: int64
```

```python
>>> s.resample('30min').backfill()
2018-01-01 00:00:00    1
2018-01-01 00:30:00    2
2018-01-01 01:00:00    2
2018-01-01 01:30:00    3
2018-01-01 02:00:00    3
Freq: 30T, dtype: int64
```

```python
>>> s.resample('15min').backfill(limit=2)
2018-01-01 00:00:00    1.0
2018-01-01 00:15:00    NaN
2018-01-01 00:30:00    2.0
2018-01-01 00:45:00    2.0
2018-01-01 01:00:00    2.0
2018-01-01 01:15:00    NaN
2018-01-01 01:30:00    3.0
2018-01-01 01:45:00    3.0
2018-01-01 02:00:00    3.0
Freq: 15T, dtype: float64
```

### Resampling a DataFrame that has missing values:

```python
df = pd.DataFrame({'a': [2, np.nan, 6], 'b': [1, 3, 5]},
                  index=pd.date_range('20180101', periods=3,
                                      freq='h'))
```

```python
df
```
```
a b
2018-01-01 00:00:00 2.0 1
2018-01-01 01:00:00 NaN 3
2018-01-01 02:00:00 6.0 5
```

```python
df.resample('30min').backfill()
```
```
a b
2018-01-01 00:00:00 2.0 1
2018-01-01 00:30:00 NaN 3
2018-01-01 01:00:00 NaN 3
2018-01-01 01:30:00 6.0 5
2018-01-01 02:00:00 6.0 5
```
```python
>>> df.resample('15min').backfill(limit=2)
   a    b
2018-01-01 00:00:00  2.0  1.0
2018-01-01 00:15:00  NaN  NaN
2018-01-01 00:30:00  NaN  3.0
2018-01-01 00:45:00  NaN  3.0
2018-01-01 01:00:00  NaN  3.0
2018-01-01 01:15:00  NaN  NaN
2018-01-01 01:30:00  6.0  5.0
2018-01-01 01:45:00  6.0  5.0
2018-01-01 02:00:00  6.0  5.0
```

34.18.3.3 pandas.core.resample.Resampler.bfill

Resampler.<code>bfill</code>(<code>limit=None</code>)

Backward fill the new missing values in the resampled data.

In statistics, imputation is the process of replacing missing data with substituted values [R31]. When resampling data, missing values may appear (e.g., when the resampling frequency is higher than the original frequency). The backward fill will replace NaN values that appeared in the resampled data with the next value in the original sequence. Missing values that existed in the original data will not be modified.

**Parameters**

- **limit**: integer, optional
  - Limit of how many values to fill.

**Returns**

- **Series, DataFrame**
  - An upsampled Series or DataFrame with backward filled NaN values.

**See also**

- <code>bfill</code> Alias of backfill.
- <code>fillna</code> Fill NaN values using the specified method, which can be ‘backfill’.
- <code>nearest</code> Fill NaN values with nearest neighbor starting from center.
- <code>pad</code> Forward fill NaN values.
- <code>pandas.Series.fillna</code> Fill NaN values in the Series using the specified method, which can be ‘backfill’.
- <code>pandas.DataFrame.fillna</code> Fill NaN values in the DataFrame using the specified method, which can be ‘backfill’.

**References**

[R31]

**Examples**

Resampling a Series:

```python
>>> s = pd.Series([1, 2, 3],
                 index=pd.date_range('20180101', periods=3, freq='h'))
>>> s
```

(continues on next page)
2018-01-01 00:00:00 1
2018-01-01 01:00:00 2
2018-01-01 02:00:00 3
Freq: H, dtype: int64
>>>
\[
\begin{align*}
\text{s.resample('30min').backfill()} \\
2018-01-01 00:00:00 & 1 \\
2018-01-01 00:30:00 & 2 \\
2018-01-01 01:00:00 & 2 \\
2018-01-01 01:30:00 & 3 \\
2018-01-01 02:00:00 & 3 \\
\end{align*}
\]
Freq: 30T, dtype: int64
>>>
\[
\begin{align*}
\text{s.resample('15min').backfill(limit=2)} \\
2018-01-01 00:00:00 & 1.0 \\
2018-01-01 00:15:00 & NaN \\
2018-01-01 00:30:00 & 2.0 \\
2018-01-01 00:45:00 & 2.0 \\
2018-01-01 01:00:00 & 2.0 \\
2018-01-01 01:15:00 & NaN \\
2018-01-01 01:30:00 & 3.0 \\
2018-01-01 01:45:00 & 3.0 \\
2018-01-01 02:00:00 & 3.0 \\
\end{align*}
\]
Freq: 15T, dtype: float64

Resampling a DataFrame that has missing values:

```python
>>> df = pd.DataFrame({'a': [2, np.nan, 6], 'b': [1, 3, 5],
...                    index=pd.date_range('20180101', periods=3,
...                                          freq='h'))
...```  

```python
>>> df
  a   b
2018-01-01 00:00:00  2.0  1
2018-01-01 01:00:00 NaN  3
2018-01-01 02:00:00  6.0  5
```  

```python
>>> df.resample('30min').backfill()
  a   b
2018-01-01 00:00:00  2.0  1
2018-01-01 00:30:00 NaN  3
2018-01-01 01:00:00 NaN  3
2018-01-01 01:30:00  6.0  5
2018-01-01 02:00:00  6.0  5
```  

```python
>>> df.resample('15min').backfill(limit=2)
  a   b
2018-01-01 00:00:00  2.0  1.0
2018-01-01 00:15:00 NaN  NaN
2018-01-01 00:30:00 NaN  3.0
2018-01-01 00:45:00 NaN  3.0
2018-01-01 01:00:00 NaN  3.0
2018-01-01 01:15:00 NaN  NaN
2018-01-01 01:30:00  6.0  5.0
2018-01-01 01:45:00  6.0  5.0
2018-01-01 02:00:00  6.0  5.0
```
34.18.3.4 pandas.core.resample.Resampler.pad

Resampler.pad(limit=None)
Forward fill the values

Parameters limit : integer, optional
limit of how many values to fill

Returns
an upsampled Series

See also:
Series.fillna, DataFrame.fillna

34.18.3.5 pandas.core.resample.Resampler.nearest

Resampler.nearest(limit=None)
Fill values with nearest neighbor starting from center

Parameters limit : integer, optional
limit of how many values to fill
New in version 0.21.0.

Returns
an upsampled Series

See also:
Series.fillna, DataFrame.fillna

34.18.3.6 pandas.core.resample.Resampler.fillna

Resampler.fillna(method, limit=None)
Fill missing values introduced by upsampling.

In statistics, imputation is the process of replacing missing data with substituted values [R32]. When resampling data, missing values may appear (e.g., when the resampling frequency is higher than the original frequency).

Missing values that existed in the original data will not be modified.

Parameters method : {'pad', 'backfill', 'ffill', 'bfill', 'nearest'}
Method to use for filling holes in resampled data
• ‘pad’ or ‘ffill’: use previous valid observation to fill gap (forward fill).
• ‘backfill’ or ‘bfill’: use next valid observation to fill gap.
• ‘nearest’: use nearest valid observation to fill gap.

limit : integer, optional
Limit of how many consecutive missing values to fill.

Returns Series or DataFrame
An upsampled Series or DataFrame with missing values filled.

See also:
backfill Backward fill NaN values in the resampled data.

pad Forward fill NaN values in the resampled data.

nearest Fill NaN values in the resampled data with nearest neighbor starting from center.

interpolate Fill NaN values using interpolation.

default

pandas.Series.fillna Fill NaN values in the Series using the specified method, which can be ‘bfill’ and ‘ffill’.

default

pandas.DataFrame.fillna Fill NaN values in the DataFrame using the specified method, which can be ‘bfill’ and ‘ffill’.

References

[R32]

Examples

Resampling a Series:

```python
>>> s = pd.Series([1, 2, 3],
...                   index=pd.date_range('20180101', periods=3, freq='h'))
>>> s
2018-01-01 00:00:00    1
2018-01-01 01:00:00    2
2018-01-01 02:00:00    3
Freq: H, dtype: int64
```

Without filling the missing values you get:

```python
>>> s.resample("30min").asfreq()
2018-01-01 00:00:00    1
2018-01-01 00:30:00    NaN
2018-01-01 01:00:00    2
2018-01-01 01:30:00    NaN
2018-01-01 02:00:00    3
Freq: 30T, dtype: float64
```

```python
>>> s.resample('30min').fillna("backfill")
2018-01-01 00:00:00    1
2018-01-01 00:30:00    2
2018-01-01 01:00:00    2
2018-01-01 01:30:00    3
2018-01-01 02:00:00    3
Freq: 30T, dtype: int64
```

```python
>>> s.resample('15min').fillna("backfill", limit=2)
2018-01-01 00:00:00    1
2018-01-01 00:15:00    NaN
2018-01-01 00:30:00    2
2018-01-01 00:45:00    2
2018-01-01 01:00:00    2
2018-01-01 01:15:00    NaN
2018-01-01 01:30:00    3
```
(continues on next page)
>>> s.resample('30min').fillna("pad")
2018-01-01 00:00:00  1
2018-01-01 00:30:00  1
2018-01-01 01:00:00  2
2018-01-01 01:30:00  2
2018-01-01 02:00:00  3
Freq: 30T, dtype: int64

Missing values present before the upsampling are not affected.

>>> sm = pd.Series([1, None, 3],
... index=pd.date_range('20180101', periods=3, freq='h'))

>>> sm
2018-01-01 00:00:00  1.0
2018-01-01 01:00:00  NaN
2018-01-01 02:00:00  3.0
Freq: H, dtype: float64

>>> sm.resample('30min').fillna('backfill')
2018-01-01 00:00:00  1.0
2018-01-01 00:30:00  NaN
2018-01-01 01:00:00  NaN
2018-01-01 01:30:00  3.0
2018-01-01 02:00:00  3.0
Freq: 30T, dtype: float64

>>> sm.resample('30min').fillna('pad')
2018-01-01 00:00:00  1.0
2018-01-01 00:30:00  1.0
2018-01-01 01:00:00  NaN
2018-01-01 01:30:00  NaN
2018-01-01 02:00:00  3.0
Freq: 30T, dtype: float64

>>> sm.resample('30min').fillna('nearest')
2018-01-01 00:00:00  1.0
2018-01-01 00:30:00  NaN
2018-01-01 01:00:00  NaN
2018-01-01 01:30:00  3.0
2018-01-01 02:00:00  3.0
Freq: 30T, dtype: float64

Dataframe resampling is done column-wise. All the same options are available.
```python
>>> df = pd.DataFrame({'a': [2, np.nan, 6], 'b': [1, 3, 5]},
                   index=pd.date_range('20180101', periods=3, freq='h'))
>>> df
      a   b
2018-01-01 00:00:00  2.0
2018-01-01 01:00:00  NaN
2018-01-01 02:00:00  6.0

>>> df.resample('30min').fillna('bfill')
      a   b
2018-01-01 00:00:00  2.0
2018-01-01 00:30:00  NaN
2018-01-01 01:00:00  NaN
2018-01-01 01:30:00  6.0
2018-01-01 02:00:00  6.0
```

34.18.3.7 pandas.core.resample.Resampler.asfreq

Resampler.asfreq(fill_value=None)

return the values at the new freq, essentially a reindex

Parameters fill_value: scalar, optional

Value to use for missing values, applied during upsampling (note this does not fill NaNs that already were present).

New in version 0.20.0.

See also:
Series.asfreq, DataFrame.asfreq

34.18.3.8 pandas.core.resample.Resampler.interpolate

Resampler.interpolate(method='linear', axis=0, limit=None, inplace=False, limit_direction='forward', limit_area=None, downcast=None, **kwargs)

Interpolate values according to different methods.

New in version 0.18.1.

Please note that only method='linear' is supported for DataFrames/Series with a MultiIndex.

Parameters method : {'linear', 'time', 'index', 'values', 'nearest', 'zero',
'slinear', 'quadratic', 'cubic', 'barycentric', 'krogh', 'polynomial', 'spline',
'piecewise_polynomial', 'from_derivatives', 'pchip', 'akima'}

• ‘linear’: ignore the index and treat the values as equally spaced. This is the only method supported on MultiIndexes. default
• ‘time’: interpolation works on daily and higher resolution data to interpolate given length of interval
• ‘index’, ‘values’: use the actual numerical values of the index
• ‘nearest’, ‘zero’, ‘slinear’, ‘quadratic’, ‘cubic’, ‘barycentric’, ‘polynomial’ is passed to scipy.interpolate.interp1d. Both ‘polynomial’ and ‘spline’ require that you also specify an order (int), e.g.
df.interpolate(method='polynomial', order=4). These use the actual numerical values of the index.

- ‘krogh’, ‘piecewise_polynomial’, ‘spline’, ‘pchip’ and ‘akima’ are all wrappers around the scipy interpolation methods of similar names. These use the actual numerical values of the index. For more information on their behavior, see the scipy documentation and tutorial documentation

- ‘from_derivatives’ refers to BPoly.from_derivatives which replaces ‘piecewise_polynomial’ interpolation method in scipy 0.18

New in version 0.18.1: Added support for the ‘akima’ method Added interpolate method ‘from_derivatives’ which replaces ‘piecewise_polynomial’ in scipy 0.18; backwards-compatible with scipy < 0.18

axis : {0, 1}, default 0

- 0: fill column-by-column
- 1: fill row-by-row

limit : int, default None.

Maximum number of consecutive NaNs to fill. Must be greater than 0.

limit_direction : [{‘forward’, ‘backward’, ‘both’}, default ‘forward’]

limit_area : {‘inside’, ‘outside’}, default None

- None: (default) no fill restriction
- ‘inside’ Only fill NaNs surrounded by valid values (interpolate).
- ‘outside’ Only fill NaNs outside valid values (extrapolate).

If limit is specified, consecutive NaNs will be filled in this direction.

New in version 0.21.0.

inplace : bool, default False

Update the NDFrame in place if possible.

downcast : optional, ‘infer’ or None, defaults to None

Downcast dtypes if possible.

kwargs [keyword arguments to pass on to the interpolating function.]

Returns

Series or DataFrame of same shape interpolated at the NaNs

See also:

reindex, replace, fillna

Examples

Filling in NaNs
>>> s = pd.Series([0, 1, np.nan, 3])
>>> s.interpolate()

0    0
1    1
2    2
3    3
dtype: float64

### 34.18.4 Computations / Descriptive Stats

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Resampler.count(_method)</code></td>
<td>Compute count of group, excluding missing values</td>
</tr>
<tr>
<td><code>Resampler.nunique(_method)</code></td>
<td>Returns number of unique elements in the group</td>
</tr>
<tr>
<td><code>Resampler.first(_method)</code></td>
<td>Compute first of group values</td>
</tr>
<tr>
<td><code>Resampler.last(_method)</code></td>
<td>Compute last of group values</td>
</tr>
<tr>
<td><code>Resampler.max(_method)</code></td>
<td>Compute max of group values</td>
</tr>
<tr>
<td><code>Resampler.mean(_method)</code></td>
<td>Compute mean of groups, excluding missing values</td>
</tr>
<tr>
<td><code>Resampler.median(_method)</code></td>
<td>Compute median of groups, excluding missing values</td>
</tr>
<tr>
<td><code>Resampler.min(_method)</code></td>
<td>Compute min of group values</td>
</tr>
<tr>
<td><code>Resampler.ohlc(_method)</code></td>
<td>Compute sum of values, excluding missing values For multiple groupings, the result index will be a MultiIndex</td>
</tr>
<tr>
<td><code>Resampler.prod(_method, min_count)</code></td>
<td>Compute prod of group values</td>
</tr>
<tr>
<td><code>Resampler.size()</code></td>
<td>Compute group sizes</td>
</tr>
<tr>
<td><code>Resampler.sem(_method)</code></td>
<td>Compute standard error of the mean of groups, excluding missing values</td>
</tr>
<tr>
<td><code>Resampler.std(ddof)</code></td>
<td>Compute standard deviation of groups, excluding missing values</td>
</tr>
<tr>
<td><code>Resampler.sum(_method, min_count)</code></td>
<td>Compute sum of group values</td>
</tr>
<tr>
<td><code>Resampler.var(ddof)</code></td>
<td>Compute variance of groups, excluding missing values</td>
</tr>
</tbody>
</table>

#### 34.18.4.1 pandas.core.resample.Resampler.count

`Resampler.count(_method='count')`
Compute count of group, excluding missing values

See also:
`pandas.Series.groupby`, `pandas.DataFrame.groupby`, `pandas.Panel.groupby`

#### 34.18.4.2 pandas.core.resample.Resampler.nunique

`Resampler.nunique(_method='nunique')`
Returns number of unique elements in the group

#### 34.18.4.3 pandas.core.resample.Resampler.first

`Resampler.first(_method='first', *args, **kwargs)`
Compute first of group values

See also:
`pandas.Series.groupby`, `pandas.DataFrame.groupby`, `pandas.Panel.groupby`
34.18.4.4 pandas.core.resample.Resampler.last

Resampler.last(_method='last', *args, **kwargs)
Compute last of group values

See also:

pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.18.4.5 pandas.core.resample.Resampler.max

Resampler.max(_method='max', *args, **kwargs)
Compute max of group values

See also:

pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.18.4.6 pandas.core.resample.Resampler.mean

Resampler.mean(_method='mean', *args, **kwargs)
Compute mean of groups, excluding missing values
For multiple groupings, the result index will be a MultiIndex

See also:

pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.18.4.7 pandas.core.resample.Resampler.median

Resampler.median(_method='median', *args, **kwargs)
Compute median of groups, excluding missing values
For multiple groupings, the result index will be a MultiIndex

See also:

pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.18.4.8 pandas.core.resample.Resampler.min

Resampler.min(_method='min', *args, **kwargs)
Compute min of group values

See also:

pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby

34.18.4.9 pandas.core.resample.Resampler.ohlc

Resampler.ohlc(_method='ohlc', *args, **kwargs)
Compute sum of values, excluding missing values For multiple groupings, the result index will be a MultiIndex

See also:

pandas.Series.groupby, pandas.DataFrame.groupby, pandas.Panel.groupby
34.18.4.10 pandas.core.resample.Resampler.prod

`Resampler.prod(_method='prod', min_count=0, *args, **kwargs)`
Compute prod of group values

See also:

34.18.4.11 pandas.core.resample.Resampler.size

`Resampler.size()`
Compute group sizes

See also:

34.18.4.12 pandas.core.resample.Resampler.sem

`Resampler.sem(_method='sem', *args, **kwargs)`
Compute standard error of the mean of groups, excluding missing values
For multiple groupings, the result index will be a MultiIndex

Parameters
- `ddof`: integer, default 1
  degrees of freedom

See also:

34.18.4.13 pandas.core.resample.Resampler.std

`Resampler.std(ddof=1, *args, **kwargs)`
Compute standard deviation of groups, excluding missing values

Parameters
- `ddof`: integer, default 1
  degrees of freedom

34.18.4.14 pandas.core.resample.Resampler.sum

`Resampler.sum(_method='sum', min_count=0, *args, **kwargs)`
Compute sum of group values

See also:
34.18.4.15 pandas.core.resample.Resampler.var

Resampler.var(ddof=1, *args, **kwargs)
Compute variance of groups, excluding missing values

Parameters

d dof  [integer, default 1]
degrees of freedom

34.19 Style

Styler objects are returned by pandas.DataFrame.style.

34.19.1 Styler Constructor

```
Styler(data[, precision, table_styles, ...])  Helps style a DataFrame or Series according to the data with HTML and CSS.

Styler.from_custom_template(searchpath, name)  Factory function for creating a subclass of Styler with a custom template and Jinja environment.
```

34.19.1.1 pandas.io.formats.style.Styler

class pandas.io.formats.style.Styler(data, precision=None, table_styles=None, uuid=None, caption=None, table_attributes=None)
Helps style a DataFrame or Series according to the data with HTML and CSS.

Parameters

data: Series or DataFrame
precision: int
  precision to round floats to, defaults to pd.options.display.precision
table_styles: list-like, default None
  list of {selector: (attr, value)} dicts; see Notes
uuid: str, default None
  a unique identifier to avoid CSS collisions; generated automatically
caption: str, default None
  caption to attach to the table

See also:
pandas.DataFrame.style

Notes

Most styling will be done by passing style functions into Styler.apply or Styler.applymap. Style functions should return values with strings containing CSS 'attr: value' that will be applied to the indicated cells.
If using in the Jupyter notebook, Styler has defined a `__repr_html__` to automatically render itself. Otherwise call `Styler.render` to get the generated HTML.

CSS classes are attached to the generated HTML:

- Index and Column names include `index_name` and `level<k>` where `k` is its level in a MultiIndex
- Index label cells include
  - `row_heading`
  - `row<n>` where `n` is the numeric position of the row
  - `level<k>` where `k` is the level in a MultiIndex
- Column label cells include `*col_heading*` `*col<n>` where `n` is the numeric position of the column
  * `*evel<k>` where `k` is the level in a MultiIndex
- Blank cells include `blank`
- Data cells include `data`

Attributes

<table>
<thead>
<tr>
<th>env</th>
<th>(Jinja2 Environment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>template</td>
<td>(Jinja2 Template)</td>
</tr>
<tr>
<td>loader</td>
<td>(Jinja2 Loader)</td>
</tr>
</tbody>
</table>

Methods

- `apply(func[, axis, subset])` Apply a function column-wise, row-wise, or table-wise, updating the HTML representation with the result.
- `applymap(func[, subset])` Apply a function elementwise, updating the HTML representation with the result.
- `background_gradient([cmap, low, high, axis, ...])` Color the background in a gradient according to the data in each column (optionally row).
- `bar([subset, axis, color, width, align])` Color the background `color` proportional to the values in each column.
- `clear()` “Reset” the styler, removing any previously applied styles.
- `export()` Export the styles to applied to the current Styler.
- `format(formatter[, subset])` Format the text display value of cells.
- `from_custom_template(searchpath, name)` Factory function for creating a subclass of Styler with a custom template and Jinja environment.
- `hide_columns(subset)` Hide columns from rendering.
- `hide_index()` Hide any indices from rendering.
- `highlight_max([subset, color, axis])` Highlight the maximum by shading the background
- `highlight_min([subset, color, axis])` Highlight the minimum by shading the background
- `highlight_null([null_color])` Shade the background `null_color` for missing values.
- `render(**kwargs)` Render the built up styles to HTML
- `set_caption(caption)` Set the caption on a Styler

Continued on next page
Table 175 – continued from previous page

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>set_precision(precision)</code></td>
<td>Set the precision used to render.</td>
</tr>
<tr>
<td><code>set_properties(subset)</code></td>
<td>Convenience method for setting one or more non-data dependent properties or each cell.</td>
</tr>
<tr>
<td><code>set_table_attributes(attributes)</code></td>
<td>Set the table attributes.</td>
</tr>
<tr>
<td><code>set_table_styles(table_styles)</code></td>
<td>Set the table styles on a Styler.</td>
</tr>
<tr>
<td><code>set_uuid(uuid)</code></td>
<td>Set the uuid for a Styler.</td>
</tr>
<tr>
<td><code>to_excel(excel_writer[, sheet_name, na_rep, ...])</code></td>
<td>Write Styler to an excel sheet</td>
</tr>
<tr>
<td><code>use(styles)</code></td>
<td>Set the styles on the current Styler, possibly using styles from Styler.export.</td>
</tr>
<tr>
<td><code>where(cond, value[, other, subset])</code></td>
<td>Apply a function elementwise, updating the HTML representation with a style which is selected in accordance with the return value of a function.</td>
</tr>
</tbody>
</table>

**pandas.io.formats.style.Styler.apply**

Styler.apply(func, axis=0, subset=None, **kwargs)

Apply a function column-wise, row-wise, or table-wise, updating the HTML representation with the result.

Parameters

- **func** : function
  - `func` should take a Series or DataFrame (depending on `axis`), and return an object with the same shape. Must return a DataFrame with identical index and column labels when `axis=None`
  - `axis` : int, str or None
    - apply to each column (`axis=0` or 'index') or to each row (`axis=1` or 'columns') or to the entire DataFrame at once with `axis=None`
  - `subset` : IndexSlice
    - a valid indexer to limit data to before applying the function. Consider using a pandas.IndexSlice
  - `kwargs` : dict
    - pass along to `func`

Returns

self [Styler]

Notes

The output shape of `func` should match the input, i.e. if `x` is the input row, column, or table (depending on `axis`), then `func(x.shape) == x.shape` should be true.

This is similar to DataFrame.apply, except that `axis=None` applies the function to the entire DataFrame at once, rather than column-wise or row-wise.
pandas: powerful Python data analysis toolkit, Release 0.23.2

Examples

```python
>>> def highlight_max(x):
...     return ['background-color: yellow' if v == x.max() else ''
...             for v in x]
...     
... >>> df = pd.DataFrame(np.random.randn(5, 2))
... >>> df.style.apply(highlight_max)
```

**pandas.io.formats.style.Styler.applymap**

`Styler.applymap(func, subset=None, **kwargs)`  
Apply a function elementwise, updating the HTML representation with the result.

- **Parameters**
  - *func*: function
    - `func` should take a scalar and return a scalar
  - *subset*: `IndexSlice`
    - a valid indexer to limit `data` to `before` applying the function. Consider using a `pandas.IndexSlice`
  - *kwargs*: dict  
    - pass along to `func`

- **Returns**
  - *self* `[Styler]`

- **See also:**
  - `Styler.where`

**pandas.io.formats.style.Styler.background_gradient**

`Styler.background_gradient(cmap='PuBu', low=0, high=0, axis=0, subset=None)`  
Color the background in a gradient according to the data in each column (optionally row). Requires `matplotlib`.

- **Parameters**
  - *cmap*: str or colormap
    - `matplotlib` colormap
  - *low, high*: float
    - compress the range by these values.
  - *axis*: int or str
    - 1 or ‘columns’ for columnwise, 0 or ‘index’ for rowwise
  - *subset*: `IndexSlice`
    - a valid slice for `data` to limit the style application to

- **Returns**
  - *self* `[Styler]`
Notes

Tune low and high to keep the text legible by not using the entire range of the color map. These extend the range of the data by low \( \times (x.\text{max}() - x.\text{min}()) \) and high \( \times (x.\text{max}() - x.\text{min}()) \) before normalizing.

`pandas.io.formats.style.Styler.bar`

Styler.bar(subset=None, axis=0, color='#d65f5f', width=100, align='left')

Color the background color proportional to the values in each column. Excludes non-numeric data by default.

Parameters

subset: IndexSlice, default None

A valid slice for data to limit the style application to

axis: int

color: str or 2-tuple/list

If a str is passed, the color is the same for both negative and positive numbers. If 2-tuple/list is used, the first element is the color_negative and the second is the color_positive (eg: ['#d65f5f', '#5fba7d'])

width: float

A number between 0 or 100. The largest value will cover width percent of the cell’s width

align : {'left', 'zero', 'mid'}, default ‘left’

• ‘left’: the min value starts at the left of the cell
• ‘zero’: a value of zero is located at the center of the cell
• ‘mid’: the center of the cell is at (max-min)/2, or if values are all negative (positive) the zero is aligned at the right (left) of the cell

New in version 0.20.0.

Returns

self [Styler]

`pandas.io.formats.style.Styler.clear`

Styler.clear()

“Reset” the styler, removing any previously applied styles. Returns None.

`pandas.io.formats.style.Styler.export`

Styler.export()

Export the styles to applied to the current Styler. Can be applied to a second style with Styler.use.

Returns

styles: list
See also:

Styler.use

pandas.io.formats.style.Styler.format

Styler.format (formatter, subset=None)
Format the text display value of cells.
New in version 0.18.0.

Parameters

formatter: str, callable, or dict
subset: IndexSlice

An argument to DataFrame.loc that restricts which elements formatter is applied to.

Returns

self [Styler]

Notes

formatter is either an a or a dict {column name: a} where a is one of
- str: this will be wrapped in: a.format(x)
- callable: called with the value of an individual cell

The default display value for numeric values is the “general” (g) format with pd.options.display.precision.

Examples

```python
>>> df = pd.DataFrame(np.random.randn(4, 2), columns=['a', 'b'])
>>> df.style.format("{:.2%}")
>>> df['c'] = ['a', 'b', 'c', 'd']
>>> df.style.format({'c': str.upper})
```

pandas.io.formats.style.Styler.from_custom_template

classmethod Styler.from_custom_template (searchpath, name)
Factory function for creating a subclass of Styler with a custom template and Jinja environment.

Parameters

searchpath: str or list
Path or paths of directories containing the templates
name: str
Name of your custom template to use for rendering

Returns

MyStyler: subclass of Styler
has the correct env and template class attributes set.
pandas: powerful Python data analysis toolkit, Release 0.23.2

pandas.io.formats.style.Styler.hide_columns

Styler.hide_columns(subset)
Hide columns from rendering.
New in version 0.23.0.

Parameters subset: IndexSlice
An argument to DataFrame.loc that identifies which columns are hidden.

Returns
self [Styler]

pandas.io.formats.style.Styler.hide_index

Styler.hide_index()
Hide any indices from rendering.
New in version 0.23.0.

Returns
self [Styler]

pandas.io.formats.style.Styler.highlight_max

Styler.highlight_max(subset=None, color='yellow', axis=0)
Highlight the maximum by shading the background

Parameters subset: IndexSlice, default None
a valid slice for data to limit the style application to

color: str, default ‘yellow’

axis: int, str, or None; default 0
0 or ‘index’ for columnwise (default), 1 or ‘columns’ for rowwise, or None for tablewise

Returns
self [Styler]

pandas.io.formats.style.Styler.highlight_min

Styler.highlight_min(subset=None, color='yellow', axis=0)
Highlight the minimum by shading the background

Parameters subset: IndexSlice, default None
a valid slice for data to limit the style application to

color: str, default ‘yellow’

axis: int, str, or None; default 0
0 or ‘index’ for columnwise (default), 1 or ‘columns’ for rowwise, or None for tablewise

Returns
self [Styler]

pandas.io.formats.style.Styler.highlight_null

Styler.highlight_null (null_color='red')
Shade the background null_color for missing values.

Parameters
null_color: str

Returns
self [Styler]

pandas.io.formats.style.Styler.render

Styler.render (**kwargs)
Render the built up styles to HTML

Parameters **kwargs:
Any additional keyword arguments are passed through to self.template.render. This is useful when you need to provide additional variables for a custom template.
New in version 0.20.

Returns rendered: str
the rendered HTML

Notes

Styler objects have defined the _repr_html_ method which automatically calls self.render() when it’s the last item in a Notebook cell. When calling Styler.render() directly, wrap the result in IPython.display.HTML to view the rendered HTML in the notebook.

Pandas uses the following keys in render. Arguments passed in **kwargs take precedence, so think carefully if you want to override them:

- head
- cellstyle
- body
- uuid
- precision
- table_styles
- caption
- table_attributes
pandas: powerful Python data analysis toolkit, Release 0.23.2

pandas.io.formats.style.Styler.set_caption

Styler.set_caption(caption)
Set the caption on a Styler

Parameters

caption: str

Returns

self [Styler]

pandas.io.formats.style.Styler.set_precision

Styler.set_precision(precision)
Set the precision used to render.

Parameters

precision: int

Returns

self [Styler]

pandas.io.formats.style.Styler.set_properties

Styler.set_properties(subset=None, **kwargs)
Convenience method for setting one or more non-data dependent properties or each cell.

Parameters

subset: IndexSlice
    a valid slice for data to limit the style application to

kwargs: dict
    property: value pairs to be set for each cell

Returns

self [Styler]

Examples

```python
>>> df = pd.DataFrame(np.random.randn(10, 4))
>>> df.style.set_properties(color="white", align="right")
>>> df.style.set_properties(**{"background-color": 'yellow'})
```
attributes [string]

Returns
self [Styler]

Examples

```python
gf = pd.DataFrame(np.random.randn(10, 4))
gf.style.set_table_attributes('class="pure-table"')  
# ... <table class="pure-table"> ...
```

pandas.io.formats.style.Styler.set_table_styles

Styler.set_table_styles(table_styles)
Set the table styles on a Styler. These are placed in a <style> tag before the generated HTML table.

Parameters

- **table_styles**: list
  Each individual table_style should be a dictionary with selector and props keys. selector should be a CSS selector that the style will be applied to (automatically prefixed by the table’s UUID) and props should be a list of tuples with (attribute, value).

Returns
self [Styler]

Examples

```python
gf = pd.DataFrame(np.random.randn(10, 4))
gf.style.set_table_styles(
  ... [["selector": 'tr:hover',  
  ...  "props": [{"background-color": 'yellow'}]]
  ...
)
```

pandas.io.formats.style.Styler.set_uuid

Styler.set_uuid(uuid)
Set the uuid for a Styler.

Parameters
- **uuid**: str

Returns
self [Styler]
Write Styler to an excel sheet

New in version 0.20.

**Parameters**

- **excel_writer**: string or ExcelWriter object
  - File path or existing ExcelWriter
- **sheet_name**: string, default ‘Sheet1’
  - Name of sheet which will contain DataFrame
- **na_rep**: string, default ‘’
  - Missing data representation
- **float_format**: string, default None
  - Format string for floating point numbers
- **columns**: sequence, optional
  - Columns to write
- **header**: boolean or list of string, default True
  - Write out the column names. If a list of strings is given it is assumed to be aliases for the column names
- **index**: boolean, default True
  - Write row names (index)
- **index_label**: string or sequence, default None
  - Column label for index column(s) if desired. If None is given, and header and index are True, then the index names are used. A sequence should be given if the DataFrame uses MultiIndex.
- **startrow**: upper left cell row to dump data frame
- **startcol**: upper left cell column to dump data frame
- **engine**: string, default None
  - write engine to use - you can also set this via the options io.excel.xlsx.writer, io.excel.xls.writer, and io.excel.xlsm.writer.
- **merge_cells**: boolean, default True
  - Write MultiIndex and Hierarchical Rows as merged cells.
- **encoding**: string, default None
  - encoding of the resulting excel file. Only necessary for xlwt, other writers support unicode natively.
- **inf_rep**: string, default ‘inf’
Representation for infinity (there is no native representation for infinity in Excel)

freeze_panes : tuple of integer (length 2), default None

Specifies the one-based bottommost row and rightmost column that is to be frozen

New in version 0.20.0.

Notes

If passing an existing ExcelWriter object, then the sheet will be added to the existing workbook. This can be used to save different DataFrames to one workbook:

```python
>>> writer = pd.ExcelWriter('output.xlsx')
>>> df1.to_excel(writer,'Sheet1')
>>> df2.to_excel(writer,'Sheet2')
>>> writer.save()
```

For compatibility with to_csv, to_excel serializes lists and dicts to strings before writing.

### pandas.io.formats.style.Styler.use

**Styler.use** *(styles)*

Set the styles on the current Styler, possibly using styles from **Styler.export**.

**Parameters**

- **styles**: list
  - list of style functions

**Returns**

- **self**: Styler

**See also:**

- **Styler.export**

### pandas.io.formats.style.Styler.where

**Styler.where** *(cond, value=None, other=None, subset=None, **kwargs)*

Apply a function elementwise, updating the HTML representation with a style which is selected in accordance with the return value of a function.

New in version 0.21.0.

**Parameters**

- **cond**: callable
  - cond should take a scalar and return a boolean

- **value**: str
  - applied when cond returns true

- **other**: str
  - applied when cond returns false

- **subset**: IndexSlice
  - a valid indexer to limit data to before applying the function. Consider using a pandas.IndexSlice
kwargs : dict
    pass along to cond

Returns

self [Styler]

See also:

Styler.applymap

34.19.2 Styler Attributes

Styler.env
Styler.template
Styler.loader

34.19.2.1 pandas.io.formats.style.Styler.env

Styler.env = <jinja2.environment.Environment object>

34.19.2.2 pandas.io.formats.style.Styler.template

Styler.template = <Template 'html.tpl'>

34.19.2.3 pandas.io.formats.style.Styler.loader

Styler.loader = <jinja2.loaders.PackageLoader object>

34.19.3 Style Application

Styler.apply(func[, axis, subset]) Apply a function column-wise, row-wise, or table-wise, updating the HTML representation with the result.

Styler.applymap(func[, subset]) Apply a function elementwise, updating the HTML representation with the result.

Styler.where(cond, value[, other, subset]) Apply a function elementwise, updating the HTML representation with a style which is selected in accordance with the return value of a function.

Styler.format(formatter[, subset]) Format the text display value of cells.

Styler.set_precision(precision) Set the precision used to render.

Styler.set_table_styles(table_styles) Set the table styles on a Styler.

Styler.set_table_attributes(attributes) Set the table attributes.

Styler.set_caption(caption) Set the caption on a Styler.

Styler.set_properties([subset]) Convenience method for setting one or more non-data dependent properties or each cell.

Styler.set_uuid(uuid) Set the uuid for a Styler.

Styler.clear() “Reset” the styler, removing any previously applied styles.
34.19.4 Built-in Styles

- `Styler.highlight_max([subset, color, axis])`: Highlight the maximum by shading the background.
- `Styler.highlight_min([subset, color, axis])`: Highlight the minimum by shading the background.
- `Styler.highlight_null([null_color])`: Shade the background `null_color` for missing values.
- `Styler.background_gradient([cmap, low, ...])`: Color the background in a gradient according to the data in each column (optionally row).
- `Styler.bar([subset, axis, color, width, align])`: Color the background `color` proportional to the values in each column.

34.19.5 Style Export and Import

- `Styler.render(**kwargs)`: Render the built up styles to HTML.
- `Styler.export()`: Export the styles to applied to the current Styler.
- `Styler.use(styles)`: Set the styles on the current Styler, possibly using styles from `Styler.export`.
- `Styler.to_excel(excel_writer[, sheet_name, ...])`: Write Styler to an excel sheet.

34.20 Plotting

The following functions are contained in the `pandas.plotting` module.

- `andrews_curves(frame, class_column[, ax, ...])`: Generates a matplotlib plot of Andrews curves, for visualising clusters of multivariate data. Andrews curves have the functional form:

  \[ f(t) = \frac{x_1}{\sqrt{2}} + x_2 \sin(t) + x_3 \cos(t) + x_4 \sin(2t) + x_5 \cos(2t) + \ldots \]

  Where `x` coefficients correspond to the values of each dimension and `t` is linearly spaced between -\( \pi \) and +\( \pi \). Each row of `frame` then corresponds to a single curve.

- `bootstrap_plot(series[, fig, size, samples])`: Bootstrap plot on mean, median and mid-range statistics.
- `deregister_matplotlib_converters()`: Remove pandas’ formatters and converters.
- `lag_plot(series[, lag, ax])`: Lag plot for time series.
- `parallel_coordinates(frame, class_column[, ...,])`: Parallel coordinates plotting.
- `radviz(frame, class_column[, ax, color, ...])`: Plot a multidimensional dataset in 2D.
- `register_matplotlib_converters([explicit])`: Register Pandas Formatters and Converters with matplotlib.
- `scatter_matrix(frame[, alpha, figsize, ax, ...])`: Draw a matrix of scatter plots.

34.20.1 pandas.plotting.andrews_curves

The `pandas.plotting.andrews_curves` function takes the following parameters:

- `frame`: DataFrame
- `class_column`: str or list of str
- `ax`: matplotlib Axes (optional)
- `samples`: int (default=200)
- `color`: str or list of str (default=None)
- `colormap`: str (default=None)
- **kwds**: additional keyword arguments

Generates a matplotlib plot of Andrews curves, for visualising clusters of multivariate data.

Andrews curves have the functional form:

\[ f(t) = \frac{x_1}{\sqrt{2}} + x_2 \sin(t) + x_3 \cos(t) + x_4 \sin(2t) + x_5 \cos(2t) + \ldots \]

Where `x` coefficients correspond to the values of each dimension and `t` is linearly spaced between -\( \pi \) and +\( \pi \). Each row of `frame` then corresponds to a single curve.

**Parameters**

- `frame`: DataFrame
Data to be plotted, preferably normalized to (0.0, 1.0)

**class_column**  [Name of the column containing class names]

**ax**  [matplotlib axes object, default None]

**samples**  [Number of points to plot in each curve]

**color: list or tuple, optional**

Colors to use for the different classes

**colormap**  : str or matplotlib colormap object, default None

Colormap to select colors from. If string, load colormap with that name from matplotlib.

**kwds: keywords**

Options to pass to matplotlib plotting method

**Returns**

**ax**: Matplotlib axis object

### 34.20.2 pandas.plotting.bootstrap_plot

**pandas.plotting.bootstrap_plot**  *(series, fig=None, size=50, samples=500, **kwds)*

Bootstrap plot on mean, median and mid-range statistics.

The bootstrap plot is used to estimate the uncertainty of a statistic by relaying on random sampling with replacement [R33]. This function will generate bootstrapping plots for mean, median and mid-range statistics for the given number of samples of the given size.

**Parameters**

**series**  : pandas.Series

Pandas Series from where to get the samplings for the bootstrapping.

**fig**  : matplotlib.figure.Figure, default None

If given, it will use the fig reference for plotting instead of creating a new one with default parameters.

**size**  : int, default 50

Number of data points to consider during each sampling. It must be greater or equal than the length of the series.

**samples**  : int, default 500

Number of times the bootstrap procedure is performed.

**kwds**  :

Options to pass to matplotlib plotting method.

**Returns**

**fig**: matplotlib.figure.Figure

Matplotlib figure

See also:

**pandas.DataFrame.plot**  Basic plotting for DataFrame objects.

**pandas.Series.plot**  Basic plotting for Series objects.
Examples

```python
>>> import numpy as np
>>> s = pd.Series(np.random.uniform(size=100))
>>> fig = pd.plotting.bootstrap_plot(s)
```

34.20.3 pandas.plotting.deregister_matplotlib_converters

```python
pandas.plotting.deregister_matplotlib_converters()
```

Removes the custom converters added by `register()`. This attempts to set the state of the registry back to the state before pandas registered its own units. Converters for pandas’ own types like Timestamp and Period are removed completely. Converters for types pandas overwrites, like `datetime.datetime`, are restored to their original value.

See also:

`deregister_matplotlib_converters`

34.20.4 pandas.plotting.lag_plot

```python
pandas.plotting.lag_plot(series, lag=1, ax=None, **kwds)
```

Lag plot for time series.

Parameters

- `series`: Time series
- `lag`: lag of the scatter plot, default 1
- `ax`: Matplotlib axis object, optional
- `kwds`: Matplotlib scatter method keyword arguments, optional

Returns

- `ax`: Matplotlib axis object

34.20.5 pandas.plotting.parallel_coordinates

```python
pandas.plotting.parallel_coordinates(frame, class_column, cols=None, ax=None, use_columns=False, xticks=None, colormap=None, axvlines=True, axvlines_kwds=None, sort_labels=False, **kwds)
```

Parallel coordinates plotting.

Parameters

- `frame`: DataFrame
- `class_column`: str
  - Column name containing class names
- `cols`: list, optional
  - A list of column names to use
ax: matplotlib.axis, optional
    matplotlib axis object

color: list or tuple, optional
    Colors to use for the different classes

use_columns: bool, optional
    If true, columns will be used as xticks

xticks: list or tuple, optional
    A list of values to use for xticks

colormap: str or matplotlib colormap, default None
    Colormap to use for line colors.

axvlines: bool, optional
    If true, vertical lines will be added at each xtick

axvlines_kwds: keywords, optional
    Options to be passed to axvline method for vertical lines

sort_labels: bool, False
    Sort class_column labels, useful when assigning colors
    New in version 0.20.0.

kwds: keywords
    Options to pass to matplotlib plotting method

Returns

ax: matplotlib axis object

Examples

```python
>>> from pandas import read_csv
>>> from pandas.tools.plotting import parallel_coordinates
>>> from matplotlib import pyplot as plt

>>> df = read_csv('https://raw.github.com/pandas-dev/pandas/master/pandas/tests/data/iris.csv')
>>> parallel_coordinates(df, 'Name', color=('#556270', '#4ECDC4', '#C7F464'))
>>> plt.show()
```

34.20.6 pandas.plotting.radviz

pandas.plotting.radviz(frame, class_column, ax=None, color=None, colormap=None, **kwds)

Plot a multidimensional dataset in 2D.

Each Series in the DataFrame is represented as a evenly distributed slice on a circle. Each data point is rendered in the circle according to the value on each Series. Highly correlated Series in the DataFrame are placed closer on the unit circle.
RadViz allow to project a N-dimensional data set into a 2D space where the influence of each dimension can be interpreted as a balance between the influence of all dimensions.

More info available at the original article describing RadViz.

**Parameters**
- **frame**: `DataFrame`
  - Pandas object holding the data.
- **class_column**: `str`
  - Column name containing the name of the data point category.
- **ax**: `matplotlib.axes.Axes`, optional
  - A plot instance to which to add the information.
- **color**: list[str] or tuple[str], optional
  - Assign a color to each category. Example: ['blue', 'green'].
- **colormap**: str or `matplotlib.colors.Colormap`, default None
  - Colormap to select colors from. If string, load colormap with that name from matplotlib.
- **kwds**: optional
  - Options to pass to matplotlib scatter plotting method.

**Returns**
- **axes**: [`matplotlib.axes.Axes`]

**See also:**
- **pandas.plotting.andrews_curves** Plot clustering visualization

**Examples**

```python
>>> df = pd.DataFrame({
...     'SepalLength': [6.5, 7.7, 5.1, 5.8, 7.6, 5.0, 5.4, 4.6, 
...                     6.7, 4.6],
...     'SepalWidth': [3.0, 3.8, 3.8, 2.7, 3.0, 2.3, 3.0, 3.2, 
...                     3.3, 3.6],
...     'PetalLength': [5.5, 6.7, 1.9, 5.1, 6.6, 3.3, 4.5, 1.4, 
...                     5.7, 1.0],
...     'PetalWidth': [1.8, 2.2, 0.4, 1.9, 2.1, 1.0, 1.5, 0.2, 
...                    2.1, 0.2],
...     'Category': ['virginica', 'virginica', 'setosa', 
...                  'virginica', 'virginica', 'versicolor', 
...                  'versicolor', 'setosa', 'virginica', 
...                  'setosa']
... })
>>> rad_viz = pd.plotting.radviz(df, 'Category')
```

34.20.7 **pandas.plotting.register_matplotlib_converters**

**pandas.plotting.register_matplotlib_converters**(explicit=True)

Register Pandas Formatters and Converters with matplotlib
This function modifies the global `matplotlib.units.registry` dictionary. Pandas adds custom converters for

- `pd.Timestamp`
- `pd.Period`
- `np.datetime64`
- `datetime.datetime`
- `datetime.date`
- `datetime.time`

See also:

deregister_matplotlib_converter

### 34.20.8 pandas.plotting.scatter_matrix

`pandas.plotting.scatter_matrix(frame, alpha=0.5, figsize=None, ax=None, grid=False, diagonal='hist', marker='.', density_kwds=None, hist_kwds=None, range_padding=0.05, **kwds)`

Draw a matrix of scatter plots.

**Parameters**

- **frame** [DataFrame]
- **alpha** : float, optional
  amount of transparency applied
- **figsize** : (float, float), optional
  a tuple (width, height) in inches
- **ax** [Matplotlib axis object, optional]
- **grid** : bool, optional
  setting this to True will show the grid
- **diagonal** : {'hist', 'kde'}
  pick between 'kde' and 'hist' for either Kernel Density Estimation or Histogram plot in the diagonal
- **marker** : str, optional
  Matplotlib marker type, default '.
- **hist_kwds** : other plotting keyword arguments
  To be passed to hist function
- **density_kwds** : other plotting keyword arguments
  To be passed to kernel density estimate plot
- **range_padding** : float, optional
  relative extension of axis range in x and y with respect to (x_max - x_min) or (y_max - y_min), default 0.05
**kwds** : other plotting keyword arguments

To be passed to scatter function

### Examples

```python
>>> df = DataFrame(np.random.randn(1000, 4), columns=['A', 'B', 'C', 'D'])
>>> scatter_matrix(df, alpha=0.2)
```

## 34.21 General utility functions

### 34.21.1 Working with options

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>describe_option(pat[, _print_desc])</code></td>
<td>Prints the description for one or more registered options.</td>
</tr>
<tr>
<td><code>reset_option(pat)</code></td>
<td>Reset one or more options to their default value.</td>
</tr>
<tr>
<td><code>get_option(pat)</code></td>
<td>Retrieves the value of the specified option.</td>
</tr>
<tr>
<td><code>set_option(pat, value)</code></td>
<td>Sets the value of the specified option.</td>
</tr>
<tr>
<td><code>option_context(*args)</code></td>
<td>Context manager to temporarily set options in the with statement context.</td>
</tr>
</tbody>
</table>

### 34.21.1.1 pandas.describe_option

```python
def pandas.describe_option(pat, _print_desc=False) = <pandas.core.config.CallableDynamicDoc object>
```

Prints the description for one or more registered options.

Call with not arguments to get a listing for all registered options.

Available options:

- compute.[use_bottleneck, use_numexpr]
- display.[chop_threshold, colheader_justify, column_space, date_dayfirst, date_yearfirst, encoding, expand_frame_repr, float_format]
- display.html.[border, table_schema, use_mathjax]
- display.[large_repr]
- display.latex.[escape, longtable, multicolumn, multicolumn_format, multirow, repr]
- display.[max_categories, max_columns, max_colwidth, max_info_columns, max_info_rows, max_rows, max_seq_items, memory_usage, multi_sparse, notebook_repr_html, pprint_nest_depth, precision, show_dimensions]
- display.unicode.[ambiguous_as_wide, east_asian_width]
- display.[width]
- html.[border]
- io.excel.xls.[writer]
- io.excel.xlsm.[writer]
- io.excel.xlsx.[writer]
Parameters  pat : str

Regexp pattern. All matching keys will have their description displayed.

_print_desc : bool, default True

If True (default) the description(s) will be printed to stdout. Otherwise, the descrip-
tion(s) will be returned as a unicode string (for testing).

Returns

None by default, the description(s) as a unicode string if _print_desc

is False

Notes

The available options with its descriptions:

compute.use_bottleneck  [bool] Use the bottleneck library to accelerate if it is installed, the default is True
Valid values: False,True [default: True] [currently: True]

compute.use_numexpr  [bool] Use the numexpr library to accelerate computation if it is installed, the default is True
Valid values: False,True [default: True] [currently: True]

display.chop_threshold  [float or None] if set to a float value, all float values smaller then the given threshold
will be displayed as exactly 0 by repr and friends. [default: None] [currently: None]

display.colheader_justify  ['left'/'right'] Controls the justification of column headers. used by DataFrameFor-
matter. [default: right] [currently: right]

display.column_space  No description available.  [default: 12] [currently: 12]

display.date_dayfirst  [boolean] When True, prints and parses dates with the day first, eg 20/01/2005 [default:
False] [currently: False]

display.date_yearfirst  [boolean] When True, prints and parses dates with the year first, eg 2005/01/20 [default:
False] [currently: False]

display.encoding  [str/unicode] Defaults to the detected encoding of the console. Specifies the encoding to be
used for strings returned by to_string, these are generally strings meant to be displayed on the console.
[default: UTF-8] [currently: UTF-8]

display.expand_frame_repr  [boolean] Whether to print out the full DataFrame repr for wide DataFrames
across multiple lines, max_columns is still respected, but the output will wrap-around across multiple
“pages” if its width exceeds display.width. [default: True] [currently: True]

display.float_format  [callable] The callable should accept a floating point number and return a string with
the desired format of the number.  This is used in some places like SeriesFormatter.  See for-
mats.format.EngFormatter for an example. [default: None] [currently: None]

display.html.border  [int] A border=value attribute is inserted in the <table> tag for the DataFrame
HTML repr. [default: 1] [currently: 1]
display.html.table_schema [boolean] Whether to publish a Table Schema representation for frontends that support it. (default: False) [currently: False]

display.html.use_mathjax [boolean] When True, Jupyter notebook will process table contents using MathJax, rendering mathematical expressions enclosed by the dollar symbol. (default: True) [currently: True]

display.large_repr ['truncate'/'info'] For DataFrames exceeding max_rows/max_cols, the repr (and HTML repr) can show a truncated table (the default from 0.13), or switch to the view from df.info() (the behaviour in earlier versions of pandas). [default: truncate] [currently: truncate]

display.latex.escape [bool] This specifies if the to_latex method of a Dataframe uses escapes special characters. Valid values: False,True [default: True] [currently: True]

display.latex.longtable [bool] This specifies if the to_latex method of a Dataframe uses the longtable format. Valid values: False,True [default: False] [currently: False]

display.latex.multicolumn [bool] This specifies if the to_latex method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False,True [default: True] [currently: True]

display.latex.multicolumn_format [bool] This specifies if the to_latex method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False,True [default: l] [currently: l]

display.latex.multirow [bool] This specifies if the to_latex method of a Dataframe uses multirows to pretty-print MultiIndex rows. Valid values: False,True [default: False] [currently: False]

display.latex.repr [boolean] Whether to produce a latex DataFrame representation for jupyter environments that support it. (default: False) [default: False] [currently: False]

display.max_categories [int] This sets the maximum number of categories pandas should output when printing out a Categorical or a Series of dtype “category”. [default: 8] [currently: 8]

display.max_columns [int] If max_cols is exceeded, switch to truncate view. Depending on large_repr, objects are either centrally truncated or printed as a summary view. ‘None’ value means unlimited.
In case python/IPython is running in a terminal and large_repr equals ‘truncate’ this can be set to 0 and pandas will auto-detect the width of the terminal and print a truncated object which fits the screen width. The IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to do correct auto-detection. [default: 0] [currently: 0]

display.max_colwidth [int] The maximum width in characters of a column in the repr of a pandas data structure. When the column overflows, a “…” placeholder is embedded in the output. [default: 50] [currently: 50]

display.max_info_columns [int] max_info_columns is used in DataFrame.info method to decide if per column information will be printed. [default: 100] [currently: 100]

display.max_info_rows [int or None] df.info() will usually show null-counts for each column. For large frames this can be quite slow. max_info_rows and max_info_cols limit this null check only to frames with smaller dimensions than specified. [default: 1690785] [currently: 1690785]

display.max_rows [int] If max_rows is exceeded, switch to truncate view. Depending on large_repr, objects are either centrally truncated or printed as a summary view. ‘None’ value means unlimited.
In case python/IPython is running in a terminal and large_repr equals ‘truncate’ this can be set to 0 and pandas will auto-detect the height of the terminal and print a truncated object which fits the screen height. The IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to do correct auto-detection. [default: 60] [currently: 15]

display.max_seq_items [int or None] when pretty-printing a long sequence, no more then max_seq_items will be printed. If items are omitted, they will be denoted by the addition of “…” to the resulting string.
If set to None, the number of items to be printed is unlimited. [default: 100] [currently: 100]
display.memory_usage [bool, string or None] This specifies if the memory usage of a DataFrame should be displayed when df.info() is called. Valid values True, False, 'deep' [default: True] [currently: True]

display.multi_sparse [boolean] “sparsify” MultiIndex display (don’t display repeated elements in outer levels within groups) [default: True] [currently: True]

display.notebook_repr_html [boolean] When True, IPython notebook will use html representation for pandas objects (if it is available). [default: True] [currently: True]

display.pprint_nest_depth [int] Controls the number of nested levels to process when pretty-printing [default: 3] [currently: 3]

display.precision [int] Floating point output precision (number of significant digits). This is only a suggestion [default: 6] [currently: 6]

display.show_dimensions [boolean or ‘truncate’] Whether to print out dimensions at the end of DataFrame repr. If ‘truncate’ is specified, only print out the dimensions if the frame is truncated (e.g. not display all rows and/or columns) [default: truncate] [currently: truncate]

display.unicode.ambiguous_as_wide [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance (default: False) [default: False] [currently: False]

display.unicode.east_asian_width [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance (default: False) [default: False] [currently: False]

display.width [int] Width of the display in characters. In case python/IPython is running in a terminal this can be set to None and pandas will correctly auto-detect the width. Note that the IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to correctly detect the width. [default: 80] [currently: 80]

html.border [int] A border=value attribute is inserted in the <table> tag for the DataFrame HTML repr. [default: 1] [currently: 1] (Deprecated, use display.html.border instead.)


io.hdf.default_format [format] default format writing format, if None, then put will default to ’fixed’ and append will default to ’table’ [default: None] [currently: None]

io.hdf.dropna_table [boolean] drop ALL nan rows when appending to a table [default: False] [currently: False]


mode.chained_assignment [string] Raise an exception, warn, or no action if trying to use chained assignment, The default is warn [default: warn] [currently: warn]

mode.sim_interactive [boolean] Whether to simulate interactive mode for purposes of testing [default: False] [currently: False]

mode.use_inf_as_na [boolean] True means treat None, NaN, INF, -INF as NA (old way), False means None and NaN are null, but INF, -INF are not NA (new way). [default: False] [currently: False]
**mode.use_inf_as_null**  [boolean] use_inf_as_null had been deprecated and will be removed in a future version. Use use_inf_as_na instead. [default: False] [currently: False] (Deprecated, use mode.use_inf_as_na instead.)

**plotting.matplotlib.register_converters**  [bool] Whether to register converters with matplotlib’s units registry for dates, times, datetimes, and Periods. Toggling to False will remove the converters, restoring any converters that pandas overwrote. [default: True] [currently: True]

### 34.21.1.2 pandas.reset_option

**pandas.reset_option**(pat) = `<pandas.core.config.CallableDynamicDoc object>`

Reset one or more options to their default value.

Pass “all” as argument to reset all options.

Available options:

- compute.[use_bottleneck, use_numexpr]
- display.[chop_threshold, colheader_justify, column_space, date_dayfirst, date_yearfirst, encoding, expand_frame_repr, float_format]
- display.html.[border, table_schema, use_mathjax]
- display.large_repr
- display.latex.[escape, longtable, multicolumn, multicolumn_format, multirow, repr]
- display.[max_categories, max_columns, max_colwidth, max_info_columns, max_info_rows, max_rows, max_seq_items, memory_usage, multi_sparse, notebook_repr_html, pprint_nest_depth, precision, show_dimensions]
- display.unicode.[ambiguous_as_wide, east_asian_width]
- display.[width]
- html.[border]
- io.excel.xls.[writer]
- io.excel.xlsm.[writer]
- io.excel.xlsx.[writer]
- io.hdf.[default_format, dropna_table]
- io.parquet.[engine]
- mode.[chained_assignment, sim_interactive, use_inf_as_na, use_inf_as_null]
- plotting.matplotlib.[register_converters]

**Parameters** pat : str/regex

If specified only options matching prefix* will be reset. Note: partial matches are supported for convenience, but unless you use the full option name (e.g. x.y.z.option_name), your code may break in future versions if new options with similar names are introduced.

**Returns**

None
Notes

The available options with its descriptions:

- **compute.use_bottleneck** [bool] Use the bottleneck library to accelerate if it is installed, the default is True
  Valid values: False,True [default: True] [currently: True]

- **compute.use_numexpr** [bool] Use the numexpr library to accelerate computation if it is installed, the default is True
  Valid values: False,True [default: True] [currently: True]

- **display.chop_threshold** [float or None] if set to a float value, all float values smaller then the given threshold will be displayed as exactly 0 by repr and friends. [default: None] [currently: None]

- **display.colheader_justify** [‘left’/’right’] Controls the justification of column headers. used by DataFrameFormatter. [default: right] [currently: right]

- **display.column_space** No description available. [default: 12] [currently: 12]

- **display.date_dayfirst** [boolean] When True, prints and parses dates with the day first, eg 20/01/2005 [default: False] [currently: False]

- **display.date_yearfirst** [boolean] When True, prints and parses dates with the year first, eg 2005/01/20 [default: False] [currently: False]

- **display.encoding** [str/unicode] Defaults to the detected encoding of the console. Specifies the encoding to be used for strings returned by to_string, these are generally strings meant to be displayed on the console. [default: UTF-8] [currently: UTF-8]

- **display.expand_frame_repr** [boolean] Whether to print out the full DataFrame repr for wide DataFrames across multiple lines, max_columns is still respected, but the output will wrap-around across multiple "pages" if its width exceeds display.width. [default: True] [currently: True]

- **display.float_format** [callable] The callable should accept a floating point number and return a string with the desired format of the number. This is used in some places like SeriesFormatter. See formats.format.EngFormatter for an example. [default: None] [currently: None]

- **display.html.border** [int] A border=value attribute is inserted in the <table> tag for the DataFrame HTML repr. [default: 1] [currently: 1]

- **display.html.table_schema** [boolean] Whether to publish a Table Schema representation for frontends that support it. (default: False) [default: False] [currently: False]

- **display.html.use_mathjax** [boolean] When True, Jupyter notebook will process table contents using MathJax, rendering mathematical expressions enclosed by the dollar symbol. (default: True) [default: True] [currently: True]

- **display.large_repr** [‘truncate’/’info’] For DataFrames exceeding max_rows/max_cols, the repr (and HTML repr) can show a truncated table (the default from 0.13), or switch to the view from df.info() (the behaviour in earlier versions of pandas). [default: truncate] [currently: truncate]

- **display.latex.escape** [bool] This specifies if the to_latex method of a Dataframe uses escapes special characters. Valid values: False,True [default: True] [currently: True]

- **display.latex.longtable :bool** This specifies if the to_latex method of a Dataframe uses the longtable format. Valid values: False,True [default: False] [currently: False]

- **display.latex.multicolumn** [bool] This specifies if the to_latex method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False,True [default: True] [currently: True]

- **display.latex.multicolumn_format** [bool] This specifies if the to_latex method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False,True [default: 1] [currently: 1]
**display.latex.multirow** [bool] This specifies if the to_latex method of a DataFrame uses multirows to pretty-print MultiIndex rows. Valid values: False, True [default: False] [currently: False]

**display.latex.repr** [boolean] Whether to produce a latex DataFrame representation for jupyter environments that support it. [default: False] [currently: False]

**display.max_categories** [int] This sets the maximum number of categories pandas should output when printing out a Categorical or a Series of dtype “category”. [default: 8] [currently: 8]

**display.max_columns** [int] If max_cols is exceeded, switch to truncate view. Depending on large_repr, objects are either centrally truncated or printed as a summary view. ‘None’ value means unlimited.

In case python/IPython is running in a terminal and large_repr equals ‘truncate’ this can be set to 0 and pandas will auto-detect the width of the terminal and print a truncated object which fits the screen width. The IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to do correct auto-detection. [default: 0] [currently: 0]

**display.max_colwidth** [int] The maximum width in characters of a column in the repr of a pandas data structure. When the column overflows, a “…” placeholder is embedded in the output. [default: 50] [currently: 50]

**display.max_info_columns** [int] max_info_columns is used in DataFrame.info method to decide if per column information will be printed. [default: 100] [currently: 100]

**display.max_info_rows** [int or None] df.info() will usually show null-counts for each column. For large frames this can be quite slow. max_info_rows and max_info_cols limit this null check only to frames with smaller dimensions than specified. [default: 1690785] [currently: 1690785]

**display.max_rows** [int] If max_rows is exceeded, switch to truncate view. Depending on large_repr, objects are either centrally truncated or printed as a summary view. ‘None’ value means unlimited.

In case python/IPython is running in a terminal and large_repr equals ‘truncate’ this can be set to 0 and pandas will auto-detect the height of the terminal and print a truncated object which fits the screen height. The IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to do correct auto-detection. [default: 60] [currently: 15]

**display.max_seq_items** [int or None] when pretty-printing a long sequence, no more then max_seq_items will be printed. If items are omitted, they will be denoted by the addition of “…” to the resulting string.

If set to None, the number of items to be printed is unlimited. [default: 100] [currently: 100]

**display.memory_usage** [bool, string or None] This specifies if the memory usage of a DataFrame should be displayed when df.info() is called. Valid values True, False, ‘deep’ [default: True] [currently: True]

**display.multi_sparse** [boolean] “sparsify” MultiIndex display (don’t display repeated elements in outer levels within groups) [default: True] [currently: True]

**display.notebook_repr_html** [boolean] When True, IPython notebook will use html representation for pandas objects (if it is available). [default: True] [currently: True]

**display.pprint_nest_depth** [int] Controls the number of nested levels to process when pretty-printing [default: 3] [currently: 3]

**display.precision** [int] Floating point output precision (number of significant digits). This is only a suggestion [default: 6] [currently: 6]

**display.show_dimensions** [boolean or ‘truncate’] Whether to print out dimensions at the end of DataFrame repr. If ‘truncate’ is specified, only print out the dimensions if the frame is truncated (e.g. not display all rows and/or columns) [default: truncate] [currently: truncate]

**display.unicode.ambiguous_as_wide** [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance [default: False] [currently: False]
**display.unicode.east_asian_width** [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance (default: False) [default: False] [currently: False]

**display.width** [int] Width of the display in characters. In case python/IPython is running in a terminal this can be set to None and pandas will correctly auto-detect the width. Note that the IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to correctly detect the width. [default: 80] [currently: 80]

**html.border** [int] A border=value attribute is inserted in the <table> tag for the DataFrame HTML repr. [default: 1] [currently: 1] (Deprecated, use display.html.border instead.)


**io.hdf.default_format** [format] default format writing format, if None, then put will default to ‘fixed’ and append will default to ‘table’ [default: None] [currently: None]

**io.hdf.dropna_table** [boolean] drop ALL nan rows when appending to a table [default: False] [currently: False]


**mode.chained_assignment** [string] Raise an exception, warn, or no action if trying to use chained assignment, The default is warn [default: warn] [currently: warn]

**mode.sim_interactive** [boolean] Whether to simulate interactive mode for purposes of testing [default: False] [currently: False]

**mode.use_inf_as_na** [boolean] True means treat None, NaN, INF, -INF as NA (old way), False means None and NaN are null, but INF, -INF are not NA (new way). [default: False] [currently: False]

**mode.use_inf_as_null** [boolean] use_inf_as_null had been deprecated and will be removed in a future version. Use use_inf_as_na instead. [default: False] [currently: False] (Deprecated, use mode.use_inf_as_na instead.)

**plotting.matplotlib.register_converters** [bool] Whether to register converters with matplotlib’s units registry for dates, times, datetimes, and Periods. Toggling to False will remove the converters, restoring any converters that pandas overwrote. [default: True] [currently: True]

### 34.21.1.3 pandas.get_option

pandas.get_option(pat) = <pandas.core.config.CallableDynamicDoc object>

Retrieves the value of the specified option.

Available options:

- compute.[use_bottleneck, use_numexpr]
- display.[chop_threshold, colheader_justify, column_space, date_dayfirst, date_yearfirst, encoding, expand_frame_repr, float_format]
- display.html.[border, table_schema, use_mathjax]
- display.[large_repr]
• display.latex.[escape, longtable, multicolumn, multicolumn_format, multirow, repr]
• display.[max_categories, max_columns, max_colwidth, max_info_columns, max_info_rows, max_rows,
  max_seq_items, memory_usage, multi_sparse, notebook_repr_html, pprint_nest_depth, precision,
  show_dimensions]
• display.unicode.[ambiguous_as_wide, east_asian_width]
• display.[width]
• html.[border]
• io.excel.xls.[writer]
• io.excel.xlsm.[writer]
• io.excel.xlsx.[writer]
• io.hdf.[default_format, dropna_table]
• io.parquet.[engine]
• mode.[chained_assignment, sim_interactive, use_inf_as_na, use_inf_as_null]
• plotting.matplotlib.[register_converters]

Parameters pat : str

Regexp which should match a single option. Note: partial matches are supported for
convenience, but unless you use the full option name (e.g. x.y.z.option_name), your
code may break in future versions if new options with similar names are introduced.

Returns

result  [the value of the option]

Raises

OptionError  [if no such option exists]

Notes

The available options with its descriptions:

compute.use_bottleneck  [bool] Use the bottleneck library to accelerate if it is installed, the default is True
  Valid values: False,True [default: True] [currently: True]

compute.use_numexpr  [bool] Use the numexpr library to accelerate computation if it is installed, the default
  is True Valid values: False,True [default: True] [currently: True]

display.chop_threshold  [float or None] if set to a float value, all float values smaller then the given threshold
  will be displayed as exactly 0 by repr and friends. [default: None] [currently: None]

display.colheader_justify  ['left'/'right'] Controls the justification of column headers. used by DataFrameFor-
matter. [default: right] [currently: right]

display.column_space No description available.  [default: 12] [currently: 12]

display.date_dayfirst  [boolean] When True, prints and parses dates with the day first, eg 20/01/2005 [default:
  False] [currently: False]

display.date_yearfirst  [boolean] When True, prints and parses dates with the year first, eg 2005/01/20 [default:
  False] [currently: False]
display.encoding [str/unicode] Defaults to the detected encoding of the console. Specifies the encoding to be used for strings returned by to_string, these are generally strings meant to be displayed on the console. [default: UTF-8] [currently: UTF-8]

display.expand_frame_repr [boolean] Whether to print out the full DataFrame repr for wide DataFrames across multiple lines, max_columns is still respected, but the output will wrap-around across multiple “pages” if its width exceeds display.width. [default: True] [currently: True]

display.float_format [callable] The callable should accept a floating point number and return a string with the desired format of the number. This is used in some places like SeriesFormatter. See formats.format.EngFormatter for an example. [default: None] [currently: None]

display.html.border [int] A border=value attribute is inserted in the <table> tag for the DataFrame HTML repr. [default: 1] [currently: 1]

display.html.table_schema [boolean] Whether to publish a Table Schema representation for frontends that support it. (default: False) [default: False] [currently: False]

display.html.use_mathjax [boolean] When True, Jupyter notebook will process table contents using MathJax, rendering mathematical expressions enclosed by the dollar symbol. (default: True) [default: True] [currently: True]

display.large_repr ['truncate’/’info’] For DataFrames exceeding max_rows/max_cols, the repr (and HTML repr) can show a truncated table (the default from 0.13), or switch to the view from df.info() (the behaviour in earlier versions of pandas). [default: truncate] [currently: truncate]

display.latex.escape [bool] This specifies if the to_latex method of a Dataframe uses escapes special characters. Valid values: False,True [default: True] [currently: True]

display.latex.longtable :bool This specifies if the to_latex method of a Dataframe uses the longtable format. Valid values: False,True [default: False] [currently: False]

display.latex.multicolumn [bool] This specifies if the to_latex method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False,True [default: True] [currently: True]

display.latex.multicolumn_format [bool] This specifies if the to_latex method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False,True [default: l] [currently: l]

display.latex.multirow [bool] This specifies if the to_latex method of a Dataframe uses multirows to pretty-print MultiIndex rows. Valid values: False,True [default: False] [currently: False]

display.latex.repr [boolean] Whether to produce a latex DataFrame representation for jupyter environments that support it. (default: False) [default: False] [currently: False]

display.max_categories [int] This sets the maximum number of categories pandas should output when printing out a Categorical or a Series of dtype “category”. [default: 8] [currently: 8]

display.max_columns [int] If max_cols is exceeded, switch to truncate view. Depending on large_repr, objects are either centrally truncated or printed as a summary view. ‘None’ value means unlimited.

In case python/IPython is running in a terminal and large_repr equals ‘truncate’ this can be set to 0 and pandas will auto-detect the width of the terminal and print a truncated object which fits the screen width. The IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to do correct auto-detection. [default: 0] [currently: 0]

display.max_colwidth [int] The maximum width in characters of a column in the repr of a pandas data structure. When the column overflows, a “…” placeholder is embedded in the output. [default: 50] [currently: 50]

display.max_info_columns [int] max_info_columns is used in DataFrame.info method to decide if per column information will be printed. [default: 100] [currently: 100]
**display.max_info_rows** [int or None] df.info() will usually show null-counts for each column. For large frames this can be quite slow. max_info_rows and max_info_cols limit this null check only to frames with smaller dimensions than specified. [default: 1690785] [currently: 1690785]

**display.max_rows** [int] If max_rows is exceeded, switch to truncate view. Depending on large_repr, objects are either centrally truncated or printed as a summary view. ‘None’ value means unlimited.

In case python/IPython is running in a terminal and large_repr equals ‘truncate’ this can be set to 0 and pandas will auto-detect the height of the terminal and print a truncated object which fits the screen height. The IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to do correct auto-detection. [default: 60] [currently: 15]

**display.max_seq_items** [int or None] when pretty-printing a long sequence, no more then max_seq_items will be printed. If items are omitted, they will be denoted by the addition of “…” to the resulting string.

If set to None, the number of items to be printed is unlimited. [default: 100] [currently: 100]

**display.memory_usage** [bool, string or None] This specifies if the memory usage of a DataFrame should be displayed when df.info() is called. Valid values True, False, ‘deep’ [default: True] [currently: True]

**display.multi_sparse** [boolean] “sparsify” MultiIndex display (don’t display repeated elements in outer levels within groups) [default: True] [currently: True]

**display.notebook_repr_html** [boolean] When True, IPython notebook will use html representation for pandas objects (if it is available). [default: True] [currently: True]

**display.pprint_nest_depth** [int] Controls the number of nested levels to process when pretty-printing [default: 3] [currently: 3]

**display.precision** [int] Floating point output precision (number of significant digits). This is only a suggestion [default: 6] [currently: 6]

**display.show_dimensions** [boolean or ‘truncate’) Whether to print out dimensions at the end of DataFrame repr. If ‘truncate’ is specified, only print out the dimensions if the frame is truncated (e.g. not display all rows and/or columns) [default: truncate] [currently: truncate]

**display.unicode.ambiguous_as_wide** [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance (default: False) [default: False] [currently: False]

**display.unicode.east_asian_width** [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance (default: False) [default: False] [currently: False]

**display.width** [int] Width of the display in characters. In case python/IPython is running in a terminal this can be set to None and pandas will correctly auto-detect the width. Note that the IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to correctly detect the width. [default: 80] [currently: 80]

**html.border** [int] A border=value attribute is inserted in the <table> tag for the DataFrame HTML repr. [default: 1] [currently: 1] (Deprecated, use display.html.border instead.)


**io.hdf.default_format** [format] default format writing format, if None, then put will default to ‘fixed’ and append will default to ‘table’ [default: None] [currently: None]
io.hdf.dropna_table [boolean] drop ALL nan rows when appending to a table [default: False] [currently: False]
mode.chained_assignment [string] Raise an exception, warn, or no action if trying to use chained assignment, The default is warn [default: warn] [currently: warn]
mode.sim_interactive [boolean] Whether to simulate interactive mode for purposes of testing [default: False] [currently: False]
mode.use_inf_as_na [boolean] True means treat None, NaN, INF, -INF as NA (old way), False means None and NaN are null, but INF, -INF are not NA (new way). [default: False] [currently: False] (Deprecated, use mode.use_inf_as_na instead.)
mode.use_inf_as_null [boolean] use_inf_as_null had been deprecated and will be removed in a future version. Use use_inf_as_na instead. [default: False] [currently: False] (Deprecated, use mode.use_inf_as_na instead.)
plotting.matplotlib.register_converters [bool] Whether to register converters with matplotlib’s units registry for dates, times, datetimes, and Periods. Toggling to False will remove the converters, restoring any converters that pandas overwrote. [default: True] [currently: True]

34.21.1.4 pandas.set_option

pandas.set_option(\textit{pat}, \textit{value}) = <pandas.core.config.CallableDynamicDoc object>

Sets the value of the specified option.

Available options:

• compute.[use_bottleneck, use_numexpr]
• display.[chop_threshold, colheader_justify, column_space, date_dayfirst, date_yearfirst, encoding, expand_frame_repr, float_format]
• display.html.[border, table_schema, use_mathjax]
• display.[large_repr]
• display.latex.[escape, longtable, multicolumn, multicolumn_format, multirow, repr]
• display.[max_categories, max_columns, max_colwidth, max_info_columns, max_info_rows, max_rows, max_seq_items, memory_usage, multi_sparse, notebook_repr_html, pprint_nest_depth, precision, show_dimensions]
• display.unicode.[ambiguous_as_wide, east_asian_width]
• display.[width]
• html.[border]
• io.excel.xls.[writer]
• io.excel.xlsxm.[writer]
• io.excel.xlxs.[writer]
• io.hdf.[default_format, dropna_table]
• io.parquet.[engine]
• mode.[chained_assignment, sim_interactive, use_inf_as_na, use_inf_as_null]
• plotting.matplotlib.[register_converters]
Parameters  

**pat** : str  
Regexp which should match a single option. Note: partial matches are supported for convenience, but unless you use the full option name (e.g. x.y.z.option_name), your code may break in future versions if new options with similar names are introduced.

**value** :
new value of option.

Returns

None

Raises

**OptionError** if no such option exists

Notes

The available options with its descriptions:

- **compute.use_bottleneck** [bool] Use the bottleneck library to accelerate if it is installed, the default is True  
  Valid values: False, True [default: True] [currently: True]

- **compute.use_numexpr** [bool] Use the numexpr library to accelerate computation if it is installed, the default is True  
  Valid values: False, True [default: True] [currently: True]

- **display.chop_threshold** [float or None] if set to a float value, all float values smaller then the given threshold will be displayed as exactly 0 by repr and friends. [default: None] [currently: None]

- **display.colheader_justify** ['left'/'right'] Controls the justification of column headers. used by DataFrameFormatter. [default: right] [currently: right]

- **display.column_space** No description available. [default: 12] [currently: 12]

- **display.date_dayfirst** [boolean] When True, prints and parses dates with the day first, eg 20/01/2005 [default: False] [currently: False]

- **display.date_yearfirst** [boolean] When True, prints and parses dates with the year first, eg 2005/01/20 [default: False] [currently: False]

- **display.encoding** [str/unicode] Defaults to the detected encoding of the console. Specifies the encoding to be used for strings returned by to_string, these are generally strings meant to be displayed on the console.  
  [default: UTF-8] [currently: UTF-8]

- **display.expand_frame_repr** [boolean] Whether to print out the full DataFrame repr for wide DataFrames across multiple lines, max_columns is still respected, but the output will wrap-around across multiple “pages” if its width exceeds display.width. [default: True] [currently: True]

- **display.float_format** [callable] The callable should accept a floating point number and return a string with the desired format of the number. This is used in some places like SeriesFormatter. See formats.format.EngFormatter for an example. [default: None] [currently: None]

- **display.html.border** [int] A border=value attribute is inserted in the &lt;table&gt; tag for the DataFrame HTML repr. [default: 1] [currently: 1]

- **display.html.table_schema** [boolean] Whether to publish a Table Schema representation for frontends that support it. [default: False] [currently: False]

- **display.html.use_mathjax** [boolean] When True, Jupyter notebook will process table contents using MathJax, rendering mathematical expressions enclosed by the dollar symbol. [default: True] [currently: True]
<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
<th>Default</th>
<th>Current Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>display.large_repr</code></td>
<td>For DataFrames exceeding <code>max_rows/max_cols</code>, the repr (and HTML repr) can show a truncated table (the default from 0.13), or switch to the view from <code>df.info()</code> (the behaviour in earlier versions of pandas). [default: truncate] [currently: truncate]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><code>display.latex.escape</code></td>
<td>This specifies if the <code>to_latex</code> method of a Dataframe uses escapes special characters. Valid values: False, True [default: True] [currently: True]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><code>display.latex.longtable</code></td>
<td>This specifies if the <code>to_latex</code> method of a Dataframe uses the longtable format. Valid values: False, True [default: False] [currently: False]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><code>display.latex.multicolumn</code></td>
<td>This specifies if the <code>to_latex</code> method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False, True [default: True] [currently: True]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><code>display.latex.multicolumn_format</code></td>
<td>This specifies if the <code>to_latex</code> method of a Dataframe uses multicolumns to pretty-print MultiIndex columns. Valid values: False, True [default: l] [currently: l]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><code>display.latex.multirow</code></td>
<td>This specifies if the <code>to_latex</code> method of a Dataframe uses multirows to pretty-print MultiIndex rows. Valid values: False, True [default: False] [currently: False]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><code>display.latex.repr</code></td>
<td>Whether to produce a latex DataFrame representation for jupyter environments that support it. [default: False]</td>
<td>False</td>
<td>False</td>
</tr>
<tr>
<td><code>display.max_categories</code></td>
<td>Sets the maximum number of categories pandas should output when printing out a <code>Categorical</code> or a Series of dtype “category”. [default: 8] [currently: 8]</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td><code>display.max_columns</code></td>
<td>If <code>max_cols</code> is exceeded, switch to truncate view. Depending on <code>large_repr</code>, objects are either centrally truncated or printed as a summary view. ‘None’ value means unlimited.</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td><code>display.max_colwidth</code></td>
<td>The maximum width in characters of a column in the repr of a pandas data structure. When the column overflows, a “…” placeholder is embedded in the output. [default: 50] [currently: 50]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><code>display.max_info_columns</code></td>
<td><code>max_info_columns</code> is used in DataFrame.info method to decide if per column information will be printed. [default: 100] [currently: 100]</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><code>display.max_info_rows</code></td>
<td><code>df.info()</code> will usually show null-counts for each column. For large frames this can be quite slow. <code>max_info_rows</code> and <code>max_info_cols</code> limit this null check only to frames with smaller dimensions than specified. [default: 1690785] [currently: 1690785]</td>
<td>1690785</td>
<td>1690785</td>
</tr>
<tr>
<td><code>display.max_rows</code></td>
<td>If <code>max_rows</code> is exceeded, switch to truncate view. Depending on <code>large_repr</code>, objects are either centrally truncated or printed as a summary view. ‘None’ value means unlimited.</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td><code>display.max_seq_items</code></td>
<td>When pretty-printing a long sequence, no more than <code>max_seq_items</code> will be printed. If items are omitted, they will be denoted by the addition of “…” to the resulting string. [default: 100] [currently: 100]</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><code>display.memory_usage</code></td>
<td>This specifies if the memory usage of a DataFrame should be displayed when <code>df.info()</code> is called. Valid values True,False,’deep’ [default: True] [currently: True]</td>
<td>True</td>
<td>True</td>
</tr>
<tr>
<td><code>display.multi_sparse</code></td>
<td>“sparsify” MultiIndex display (don’t display repeated elements in outer levels within groups) [default: True] [currently: True]</td>
<td>True</td>
<td>True</td>
</tr>
</tbody>
</table>
**display.notebook_repr_html** [boolean] When True, IPython notebook will use html representation for pandas objects (if it is available). [default: True] [currently: True]

**display.pprint_nest_depth** [int] Controls the number of nested levels to process when pretty-printing [default: 3] [currently: 3]

**display.precision** [int] Floating point output precision (number of significant digits). This is only a suggestion [default: 6] [currently: 6]

**display.show_dimensions** [boolean or ‘truncate’) Whether to print out dimensions at the end of DataFrame repr. If ‘truncate’ is specified, only print out the dimensions if the frame is truncated (e.g. not display all rows and/or columns) [default: truncate] [currently: truncate]

**display.unicode.ambiguous_as_wide** [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance [default: False] [currently: False]

**display.unicode.east_asian_width** [boolean] Whether to use the Unicode East Asian Width to calculate the display text width. Enabling this may affect to the performance [default: False] [currently: False]

**display.width** [int] Width of the display in characters. In case python/IPython is running in a terminal this can be set to None and pandas will correctly auto-detect the width. Note that the IPython notebook, IPython qtconsole, or IDLE do not run in a terminal and hence it is not possible to correctly detect the width. [default: 80] [currently: 80]

**html.border** [int] A border=value attribute is inserted in the <table> tag for the DataFrame HTML repr. [default: 1] [currently: 1] (Deprecated, use display.html.border instead.)


**io.hdf.default_format** [format] default format writing format, if None, then put will default to ‘fixed’ and append will default to ‘table’ [default: None] [currently: None]

**io.hdf.dropna_table** [boolean] drop ALL nan rows when appending to a table [default: False] [currently: False]


**mode.chained_assignment** [string] Raise an exception, warn, or no action if trying to use chained assignment, The default is warn [default: warn] [currently: warn]

**mode.sim_interactive** [boolean] Whether to simulate interactive mode for purposes of testing [default: False] [currently: False]

**mode.use_inf_as_na** [boolean] True means treat None, NaN, INF, -INF as NA (old way), False means None and NaN are null, but INF, -INF are not NA (new way). [default: False] [currently: False]

**mode.use_inf_as_null** [boolean] use_inf_as_null had been deprecated and will be removed in a future version. Use use_inf_as_na instead. [default: False] [currently: False] (Deprecated, use mode.use_inf_as_na instead.)

**plotting.matplotlib.register_converters** [bool] Whether to register converters with matplotlib’s units registry for dates, times, datetimes, and Periods. Toggling to False will remove the converters, restoring any converters that pandas overwrote. [default: True] [currently: True]
class pandas.option_context(*args)

Context manager to temporarily set options in the with statement context.

You need to invoke as option_context(pat, val, [(pat, val), ...]).

Examples

```python
>>> with option_context('display.max_rows', 10, 'display.max_columns', 5):
...  ...
```

34.21.2 Testing functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>testing.assert_frame_equal(left, right[, ...])</td>
<td>Check that left and right DataFrame are equal.</td>
</tr>
<tr>
<td>testing.assert_series_equal(left, right[, ...])</td>
<td>Check that left and right Series are equal.</td>
</tr>
<tr>
<td>testing.assert_index_equal(left, right[, ...])</td>
<td>Check that left and right Index are equal.</td>
</tr>
</tbody>
</table>

34.21.2.1 pandas.testing.assert_frame_equal

```python
pandas.testing.assert_frame_equal(left, right, check_dtype=True, check_index_type='equiv', check_column_type='equiv', check_frame_type=True, check_less_precise=False, by_blocks=False, check_datetimelike_compat=False, check_categorical=True, check_like=False, obj='DataFrame')
```

Check that left and right DataFrame are equal.

Parameters |
---|---
**left** [DataFrame] |
**right** [DataFrame] |
**check_dtypes** : bool, default True

Whether to check the DataFrame dtype is identical.

**check_index_type** : bool / string {'equiv'}, default False

Whether to check the Index class, dtype and inferred_type are identical.

**check_column_type** : bool / string {'equiv'}, default False

Whether to check the columns class, dtype and inferred_type are identical.

**check_frame_type** : bool, default False

Whether to check the DataFrame class is identical.

**check_less_precise** : bool or int, default False

Whether to check the DataFrame is less precise.
Specify comparison precision. Only used when check_exact is False. 5 digits (False) or 3 digits (True) after decimal points are compared. If int, then specify the digits to compare

**check_names** : bool, default True

Whether to check the Index names attribute.

**by_blocks** : bool, default False

Specify how to compare internal data. If False, compare by columns. If True, compare by blocks.

**check_exact** : bool, default False

Whether to compare number exactly.

**check_datetimelike_compat** : bool, default False

Compare datetime-like which is comparable ignoring dtype.

**check_categorical** : bool, default True

Whether to compare internal Categorical exactly.

**check_like** : bool, default False

If true, ignore the order of rows & columns

**obj** : str, default ‘DataFrame’

Specify object name being compared, internally used to show appropriate assertion message

### 34.21.2.2 pandas.testing.assert_series_equal

**pandas.testing.assert_series_equal**(left, right, check_dtype=True, check_index_type='equiv', check_series_type=True, check_less_precise=False, check_names=True, check_exact=False, check_datetimelike_compat=False, check_categorical=True, obj='Series')

Check that left and right Series are equal.

**Parameters**

- **left** [Series]
- **right** [Series]

**check_dtype** : bool, default True

Whether to check the Series dtype is identical.

**check_index_type** : bool / string {'equiv'}, default ‘equiv’

Whether to check the Index class, dtype and inferred_type are identical.

**check_series_type** : bool, default True

Whether to check the Series class is identical.

**check_less_precise** : bool or int, default False

Specify comparison precision. Only used when check_exact is False. 5 digits (False) or 3 digits (True) after decimal points are compared. If int, then specify the digits to compare
check_exact : bool, default False
Whether to compare number exactly.

check_names : bool, default True
Whether to check the Series and Index names attribute.

check_datetimelike_compat : bool, default False
Compare datetime-like which is comparable ignoring dtype.

check_categorical : bool, default True
Whether to compare internal Categorical exactly.

obj : str, default ‘Series’
Specify object name being compared, internally used to show appropriate assertion message

34.21.2.3 pandas.testing.assert_index_equal

pandas.testing.assert_index_equal(left, right, exact=‘equiv’, check_names=True,
check_less_precise=False, check_exact=True,
check_categorical=True, obj=‘Index’)

Check that left and right Index are equal.

Parameters

left [Index]
right [Index]

exact : bool / string {‘equiv’}, default False
Whether to check the Index class, dtype and inferred_type are identical. If ‘equiv’, then RangeIndex can be substituted for Int64Index as well.

check_names : bool, default True
Whether to check the names attribute.

check_less_precise : bool or int, default False
Specify comparison precision. Only used when check_exact is False. 5 digits (False) or 3 digits (True) after decimal points are compared. If int, then specify the digits to compare

check_exact : bool, default True
Whether to compare number exactly.

check_categorical : bool, default True
Whether to compare internal Categorical exactly.

obj : str, default ‘Index’
Specify object name being compared, internally used to show appropriate assertion message

34.21.3 Exceptions and warnings
pandas: powerful Python data analysis toolkit, Release 0.23.2

<table>
<thead>
<tr>
<th>errors.DtypeWarning</th>
<th>Warning raised when reading different dtypes in a column from a file.</th>
</tr>
</thead>
<tbody>
<tr>
<td>errors.EmptyDataError</td>
<td>Exception that is thrown in pd.read_csv (by both the C and Python engines) when empty data or header is encountered.</td>
</tr>
<tr>
<td>errors.OutOfBoundsDatetime</td>
<td></td>
</tr>
<tr>
<td>errors.ParserError</td>
<td>Exception that is raised by an error encountered in pd.read_csv.</td>
</tr>
<tr>
<td>errors.ParserWarning</td>
<td>Warning raised when reading a file that doesn’t use the default ‘c’ parser.</td>
</tr>
<tr>
<td>errors.PerformanceWarning</td>
<td>Warning raised when there is a possible performance impact.</td>
</tr>
<tr>
<td>errors.UnsortedIndexError</td>
<td>Error raised when attempting to get a slice of a MultiIndex, and the index has not been lexsorted.</td>
</tr>
<tr>
<td>errors.UnsupportedFunctionCall</td>
<td>Exception raised when attempting to call a numpy function on a pandas object, but that function is not supported by the object e.g.</td>
</tr>
</tbody>
</table>

34.21.3.1 pandas.errors.DtypeWarning

**exception** pandas.errors.DtypeWarning

Warning raised when reading different dtypes in a column from a file.

Raised for a dtype incompatibility. This can happen whenever read_csv or read_table encounter non-uniform dtypes in a column(s) of a given CSV file.

See also:

- **pandas.read_csv** Read CSV (comma-separated) file into a DataFrame.
- **pandas.read_table** Read general delimited file into a DataFrame.

**Notes**

This warning is issued when dealing with larger files because the dtype checking happens per chunk read.

Despite the warning, the CSV file is read with mixed types in a single column which will be an object type. See the examples below to better understand this issue.

**Examples**

This example creates and reads a large CSV file with a column that contains `int` and `str`.

```python
>>> df = pd.DataFrame({'a': ([1] * 100000 + ['X'] * 100000 +
... [1] * 100000),
... 'b': ['b'] * 300000})
>>> df.to_csv('test.csv', index=False)
>>> df2 = pd.read_csv('test.csv')
... # DtypeWarning: Columns (0) have mixed types
```

Important to notice that `df2` will contain both `str` and `int` for the same input, ‘1’.
One way to solve this issue is using the `dtype` parameter in the `read_csv` and `read_table` functions to explicit the conversion:

```python
>>> df2 = pd.read_csv('test.csv', sep=',', dtype={'a': str})
```

No warning was issued.

### 34.21.3.2 pandas.errors.EmptyDataError

**exception pandas.errors.EmptyDataError**

Exception that is thrown in `pd.read_csv` (by both the C and Python engines) when empty data or header is encountered.

### 34.21.3.3 pandas.errors.OutOfBoundsDatetime

**exception pandas.errors.OutOfBoundsDatetime**

### 34.21.3.4 pandas.errors.ParserError

**exception pandas.errors.ParserError**

Exception that is raised by an error encountered in `pd.read_csv`.

### 34.21.3.5 pandas.errors.ParserWarning

**exception pandas.errors.ParserWarning**

Warning raised when reading a file that doesn’t use the default ‘c’ parser.

Raised by `pd.read_csv` and `pd.read_table` when it is necessary to change parsers, generally from the default ‘c’ parser to ‘python’.

It happens due to a lack of support or functionality for parsing a particular attribute of a CSV file with the requested engine.

Currently, ‘c’ unsupported options include the following parameters:

1. `sep` other than a single character (e.g. regex separators)
2. `skipfooter` higher than 0
3. `sep=None` with `delim_whitespace=False`
The warning can be avoided by adding `engine='python'` as a parameter in `pd.read_csv` and `pd.read_table` methods.

**See also:**

- **pd.read_csv** Read CSV (comma-separated) file into DataFrame.
- **pd.read_table** Read general delimited file into DataFrame.

**Examples**

Using a `sep` in `pd.read_csv` other than a single character:

```python
>>> import io
>>> csv = u'''
... a;b;c
... 1;1,8
... 1;2,1'''
>>> df = pd.read_csv(io.StringIO(csv), sep='[;,]')
... # ParserWarning: Falling back to the 'python' engine...
```

Adding `engine='python'` to `pd.read_csv` removes the Warning:

```python
>>> df = pd.read_csv(io.StringIO(csv), sep='[;,]', engine='python')
```

---

34.21.3.6 **pandas.errors.PerformanceWarning**

**exception pandas.errors.PerformanceWarning**

Warning raised when there is a possible performance impact.

34.21.3.7 **pandas.errors.UnsortedIndexError**

**exception pandas.errors.UnsortedIndexError**

Error raised when attempting to get a slice of a MultiIndex, and the index has not been lexsorted. Subclass of `KeyError`.

New in version 0.20.0.

34.21.3.8 **pandas.errors.UnsupportedFunctionCall**

**exception pandas.errors.UnsupportedFunctionCall**

Exception raised when attempting to call a numpy function on a pandas object, but that function is not supported by the object e.g. `np.cumsum(groupby_object)`.

34.21.4 **Data types related functionality**

| **api.types.union_categoricals**(to_union[, ...]) | Combine list-like of Categorical-like, unioning categories. |
| **api.types.infer_dtype** | Efficiently infer the type of a passed val, or list-like array of values. |
Table 184 – continued from previous page

<table>
<thead>
<tr>
<th>api.types.pandas_dtype</th>
<th>(dtype) Converts input into a pandas only dtype object or a numpy dtype object.</th>
</tr>
</thead>
</table>

34.21.4.1 pandas.api.types.union_categoricals

pandas.api.types.union_categoricals(\(\text{to\_union}, sort\_categories=False, ignore\_order=False\))

Combine list-like of Categorical-like, unioning categories. All categories must have the same dtype.

New in version 0.19.0.

Parameters to_union : list-like of Categorical, CategoricalIndex, or Series with dtype='category'

sort_categories : boolean, default False

If true, resulting categories will be lexsorted, otherwise they will be ordered as they appear in the data.

ignore_order: boolean, default False

If true, the ordered attribute of the Categoricals will be ignored. Results in an unordered categorical.

Returns result [Categorical]

Raises TypeError

• all inputs do not have the same dtype
• all inputs do not have the same ordered property
• all inputs are ordered and their categories are not identical
• sort_categories=True and Categoricals are ordered

ValueError

Empty list of categoricals passed

Notes

To learn more about categories, see link

Examples

```python
>>> from pandas.api.types import union_categoricals
```

If you want to combine categoricals that do not necessarily have the same categories, union_categoricals will combine a list-like of categoricals. The new categories will be the union of the categories being combined.

```python
>>> a = pd.Categorical(["b", "c"])
>>> b = pd.Categorical(["a", "b"])
>>> union_categoricals([a, b])
```
By default, the resulting categories will be ordered as they appear in the `categories` of the data. If you want the categories to be lexsorted, use `sort_categories=True` argument.

```python
>>> union_categoricals([a, b], sort_categories=True)
[b, c, a, b]
Categories (3, object): [a, b, c]
```

`union_categoricals` also works with the case of combining two categoricals of the same categories and order information (e.g. what you could also `append` for).

```python
>>> a = pd.Categorical(["a", "b"], ordered=True)
>>> b = pd.Categorical(["a", "b", "a"], ordered=True)
>>> union_categoricals([a, b])
[a, b, a, b, a]
Categories (2, object): [a < b]
```

Raises `TypeError` because the categories are ordered and not identical.

```python
>>> a = pd.Categorical(["a", "b"], ordered=True)
>>> b = pd.Categorical(["a", "b", "c"], ordered=True)
>>> union_categoricals([a, b])
TypeError: to union ordered Categoricals, all categories must be the same
```

New in version 0.20.0

Ordered categoricals with different categories or orderings can be combined by using the `ignore_ordered=True` argument.

```python
>>> a = pd.Categorical(["a", "b", "c"], ordered=True)
>>> b = pd.Categorical(["c", "b", "a"], ordered=True)
>>> union_categoricals([a, b], ignore_order=True)
[a, b, c, b, a]
Categories (3, object): [a, b, c]
```

`union_categoricals` also works with a `CategoricalIndex` or `Series` containing categorical data, but note that the resulting array will always be a plain `Categorical`.

```python
>>> a = pd.Series(["b", "c"], dtype='category')
>>> b = pd.Series(["a", "b"], dtype='category')
>>> union_categoricals([a, b])
[b, c, a, b]
Categories (3, object): [b, c, a]
```

### 34.21.4.2 pandas.api.types.infer_dtype

`pandas.api.types.infer_dtype()`

Efficiently infer the type of a passed val, or list-like array of values. Return a string describing the type.

**Parameters**

- `value` [scalar, list, ndarray, or pandas type]
- `skipna` : bool, default False
Ignore NaN values when inferring the type. The default of False will be deprecated in a later version of pandas.

New in version 0.21.0.

**Returns**

string describing the common type of the input data.

Results can include:

- string
- unicode
- bytes
- floating
- integer
- mixed-integer
- mixed-integer-float
- decimal
- complex
- categorical
- boolean
- datetime64
- datetime
- date
- timedelta64
- timedelta
- time
- period
- mixed

**Raises**

TypeError if ndarray-like but cannot infer the dtype

**Notes**

- ‘mixed’ is the catchall for anything that is not otherwise specialized
- ‘mixed-integer-float’ are floats and integers
- ‘mixed-integer’ are integers mixed with non-integers
Examples

```python
>>> infer_dtype(['foo', 'bar'])
'string'

>>> infer_dtype(['a', np.nan, 'b'], skipna=True)
'string'

>>> infer_dtype(['a', np.nan, 'b'], skipna=False)
'mixed'

>>> infer_dtype(['a', 'foo', 'bar'])
'bytes'

>>> infer_dtype([1, 2, 3])
'integer'

>>> infer_dtype([1, 2, 3.5])
'mixed-integer-float'

>>> infer_dtype([1.0, 2.0, 3.5])
'floating'

>>> infer_dtype(['a', 1])
'mixed-integer'

>>> infer_dtype([Decimal(1), Decimal(2.0)])
'decimal'

>>> infer_dtype([True, False])
'boolean'

>>> infer_dtype([True, False, np.nan])
'mixed'

>>> infer_dtype([pd.Timestamp('2013-01-01')])
'datetime'

>>> infer_dtype([datetime.date(2013, 1, 1)])
'date'

>>> infer_dtype([np.datetime64('2013-01-01')])
'datetime64'

>>> infer_dtype([datetime.timedelta(0, 1, 1)])
'timedelta'

>>> infer_dtype(pd.Series(list('aabc')).astype('category'))
'categorical'
```
### 34.21.4.3 pandas.api.types.pandas_dtype

Converting input into a pandas only dtype object or a numpy dtype object.

**Parameters**

- **dtype** [object to be converted]

**Returns**

- `np.dtype` or a `pandas` dtype

#### Dtype introspection

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>api.types.is_bool_dtype(arr_or_dtype)</code></td>
<td>Check whether the provided array or dtype is of a boolean dtype.</td>
</tr>
<tr>
<td><code>api.types.is_categorical_dtype(arr_or_dtype)</code></td>
<td>Check whether an array-like or dtype is of the Categorical dtype.</td>
</tr>
<tr>
<td><code>api.types.is_complex_dtype(arr_or_dtype)</code></td>
<td>Check whether the provided array or dtype is of a complex dtype.</td>
</tr>
<tr>
<td><code>api.types.is_datetime64_any_dtype(arr_or_dtype)</code></td>
<td>Check whether the provided array or dtype is of the datetime64 dtype.</td>
</tr>
<tr>
<td><code>api.types.is_datetime64_dtypes(arr_or_dtype)</code></td>
<td>Check whether an array-like or dtype is of the datetime64 dtype.</td>
</tr>
<tr>
<td><code>api.types.is_datetime64_ns_dtype(arr_or_dtype)</code></td>
<td>Check whether the provided array or dtype is of the datetime64[ns] dtype.</td>
</tr>
<tr>
<td><code>api.types.is_datetime64tz_dtype(arr_or_dtype)</code></td>
<td>Check whether an array-like or dtype is of a DatetimeTZDtype dtype.</td>
</tr>
<tr>
<td><code>api.types.is_extension_type(arr)</code></td>
<td>Check whether an array-like is of a pandas extension class instance.</td>
</tr>
<tr>
<td><code>api.types.is_float_dtype(arr_or_dtype)</code></td>
<td>Check whether the provided array or dtype is of a float dtype.</td>
</tr>
<tr>
<td><code>api.types.is_int64_dtype(arr_or_dtype)</code></td>
<td>Check whether the provided array or dtype is of the int64 dtype.</td>
</tr>
<tr>
<td><code>api.types.is_integer_dtype(arr_or_dtype)</code></td>
<td>Check whether the provided array or dtype is of an integer dtype.</td>
</tr>
<tr>
<td><code>api.types.is_interval_dtype(arr_or_dtype)</code></td>
<td>Check whether an array-like or dtype is of the Interval dtype.</td>
</tr>
<tr>
<td><code>api.types.is_numeric_dtype(arr_or_dtype)</code></td>
<td>Check whether the provided array or dtype is of a numeric dtype.</td>
</tr>
<tr>
<td><code>api.types.is_object_dtype(arr_or_dtype)</code></td>
<td>Check whether an array-like or dtype is of the object dtype.</td>
</tr>
<tr>
<td><code>api.types.is_period_dtype(arr_or_dtype)</code></td>
<td>Check whether an array-like or dtype is of the Period dtype.</td>
</tr>
<tr>
<td><code>api.types.is_signed_integer_dtype(arr_or_dtype)</code></td>
<td>Check whether the provided array or dtype is of a signed integer dtype.</td>
</tr>
<tr>
<td><code>api.types.is_string_dtype(arr_or_dtype)</code></td>
<td>Check whether the provided array or dtype is of the string dtype.</td>
</tr>
<tr>
<td><code>api.types.is_timedelta64_dtypes(arr_or_dtype)</code></td>
<td>Check whether an array-like or dtype is of the timedelta64 dtype.</td>
</tr>
<tr>
<td><code>api.types.is_timedelta64_ns_dtype(arr_or_dtype)</code></td>
<td>Check whether the provided array or dtype is of the timedelta64[ns] dtype.</td>
</tr>
</tbody>
</table>

Continued on next page
Table 185 – continued from previous page

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>api.types.is_unsigned_integer_dtype</code></td>
<td>Check whether the provided array or dtype is of an unsigned integer dtype.</td>
</tr>
<tr>
<td><code>api.types.is_sparse</code></td>
<td>Check whether an array-like is a pandas sparse array.</td>
</tr>
</tbody>
</table>

### 34.21.4.4 pandas.api.types.is_bool_dtype

#### pandas.api.types.is_bool_dtype(arr_or_dtype)

Check whether the provided array or dtype is of a boolean dtype.

**Parameters**

- **arr_or_dtype**: array-like
  
  The array or dtype to check.

**Returns**

- **boolean**: Whether or not the array or dtype is of a boolean dtype.

**Examples**

```python
>>> is_bool_dtype(str)
False
>>> is_bool_dtype(int)
False
>>> is_bool_dtype(bool)
True
>>> is_bool_dtype(np.bool)
True
>>> is_bool_dtype(np.array(['a', 'b']))
False
>>> is_bool_dtype(pd.Series([1, 2]))
False
>>> is_bool_dtype(np.array([True, False]))
True
```

### 34.21.4.5 pandas.api.types.is_categorical_dtype

#### pandas.api.types.is_categorical_dtype(arr_or_dtype)

Check whether an array-like or dtype is of the Categorical dtype.

**Parameters**

- **arr_or_dtype**: array-like
  
  The array-like or dtype to check.

**Returns**

- **boolean**: Whether or not the array-like or dtype is of the Categorical dtype.

**Examples**

```python
>>> is_categorical_dtype(object)
False
>>> is_categorical_dtype(CategoricalDtype())
True
```
>>> is_categorical_dtype([1, 2, 3])
False
>>> is_categorical_dtype(pd.Categorical([1, 2, 3]))
True
>>> is_categorical_dtype(pd.CategoricalIndex([1, 2, 3]))
True

34.21.4.6 pandas.api.types.is_complex_dtype

pandas.api.types.is_complex_dtype(arr_or_dtype)
Check whether the provided array or dtype is of a complex dtype.

Parameters arr_or_dtype : array-like
The array or dtype to check.

Returns

    boolean [Whether or not the array or dtype is of a complex dtype.]

Examples

>>> is_complex_dtype(str)
False
>>> is_complex_dtype(int)
False
>>> is_complex_dtype(np.complex)
True
>>> is_complex_dtype(np.array(['a', 'b']))
False
>>> is_complex_dtype(pd.Series([1, 2]))
False
>>> is_complex_dtype(np.array([1 + 1j, 5]))
True

34.21.4.7 pandas.api.types.is_datetime64_any_dtype

pandas.api.types.is_datetime64_any_dtype(arr_or_dtype)
Check whether the provided array or dtype is of the datetime64 dtype.

Parameters arr_or_dtype : array-like
The array or dtype to check.

Returns

    boolean [Whether or not the array or dtype is of the datetime64 dtype.]

Examples
```python
>>> is_datetime64_any_dtype(str)
False
>>> is_datetime64_any_dtype(int)
False
>>> is_datetime64_any_dtype(np.datetime64)  # can be tz-naive
True
>>> is_datetime64_any_dtype(DatetimeTZDtype("ns", "US/Eastern"))
True
>>> is_datetime64_any_dtype(np.array(["a", "b"]))
False
>>> is_datetime64_any_dtype(np.array([1, 2]))
False
>>> is_datetime64_any_dtype(np.array([], dtype=np.datetime64))
True
>>> is_datetime64_any_dtype(pd.DatetimeIndex([1, 2, 3],
                                            dtype=np.datetime64))
True
```

34.21.4.8 pandas.api.types.is_datetime64_dtype

pandas.api.types.is_datetime64_dtype(arr_or_dtype)

Check whether an array-like or dtype is of the datetime64 dtype.

Parameters

arr_or_dtype : array-like

The array-like or dtype to check.

Returns

boolean : Whether or not the array-like or dtype is of the datetime64 dtype.

Examples

```python
>>> is_datetime64_dtype(object)
False
>>> is_datetime64_dtype(np.datetime64)
True
>>> is_datetime64_dtype(np.array([], dtype=int))
False
>>> is_datetime64_dtype(np.array([], dtype=np.datetime64))
True
>>> is_datetime64_dtype([1, 2, 3])
False
```

34.21.4.9 pandas.api.types.is_datetime64_ns_dtype

pandas.api.types.is_datetime64_ns_dtype(arr_or_dtype)

Check whether the provided array or dtype is of the datetime64[ns] dtype.

Parameters

arr_or_dtype : array-like

The array or dtype to check.

Returns

boolean [Whether or not the array or dtype is of the datetime64[ns] dtype.]
Examples

```python
>>> is_datetime64_ns_dtype(str)
False
>>> is_datetime64_ns_dtype(int)
False
>>> is_datetime64_ns_dtype(np.datetime64)  # no unit
False
>>> is_datetime64_ns_dtype(DatetimeTZDtype("ns", "US/Eastern"))
True
>>> is_datetime64_ns_dtype(np.array(['a', 'b']))
False
>>> is_datetime64_ns_dtype(np.array([1, 2]))
False
>>> is_datetime64_ns_dtype(np.array([], dtype=np.datetime64))  # no unit
False
>>> is_datetime64_ns_dtype(np.array([], dtype="datetime64[ps]"))  # wrong unit
False
>>> is_datetime64_ns_dtype(pd.DatetimeIndex([1, 2, 3],
                                           dtype=np.datetime64))  # has 'ns' unit
True
```

34.21.4.10 pandas.api.types.is_datetime64tz_dtype

pandas.api.types.is_datetime64tz_dtype(arr_or_dtype)
Check whether an array-like or dtype is of a DatetimeTZDtype dtype.

Parameters arr_or_dtype : array-like
The array-like or dtype to check.

Returns boolean : Whether or not the array-like or dtype is of
a DatetimeTZDType dtype.

Examples

```python
>>> is_datetime64tz_dtype(object)
False
>>> is_datetime64tz_dtype([1, 2, 3])
False
>>> is_datetime64tz_dtype(pd.DatetimeIndex([1, 2, 3]))  # tz-naive
False
>>> is_datetime64tz_dtype(pd.DatetimeIndex([1, 2, 3], tz="US/Eastern"))
True
```

```python
dtype = DatetimeTZDtype("ns", tz="US/Eastern")
s = pd.Series([], dtype=dtype)
is_datetime64tz_dtype(dtype)
True
>>> is_datetime64tz_dtype(s)
True
```
34.21.4.11 pandas.api.types.is_extension_type

pandas.api.types.is_extension_type(arr)

Check whether an array-like is of a pandas extension class instance.

Extension classes include categoricals, pandas sparse objects (i.e. classes represented within the pandas library and not ones external to it like scipy sparse matrices), and datetime-like arrays.

Parameters arr : array-like

The array-like to check.

Returns boolean : Whether or not the array-like is of a pandas extension class instance.

Examples

```python
>>> is_extension_type([1, 2, 3])
False
>>> is_extension_type(np.array([1, 2, 3]))
False
>>> cat = pd.Categorical([1, 2, 3])
>>> is_extension_type(cat)
True
>>> is_extension_type(pd.Series(cat))
True
>>> is_extension_type(pd.SparseArray([1, 2, 3]))
True
>>> is_extension_type(pd.SparseSeries([1, 2, 3]))
True
>>> from scipy.sparse import bsr_matrix
>>> is_extension_type(bsr_matrix([1, 2, 3]))
False
>>> is_extension_type(pd.DatetimeIndex([1, 2, 3]))
False
>>> is_extension_type(pd.DatetimeIndex([1, 2, 3], tz="US/Eastern"))
True
>>> >>>
>>> dtype = DatetimeTZDtype("ns", tz="US/Eastern")
>>> s = pd.Series([], dtype=dtype)
>>> is_extension_type(s)
True
```

34.21.4.12 pandas.api.types.is_float_dtype

pandas.api.types.is_float_dtype(arr_or_dtype)

Check whether the provided array or dtype is of a float dtype.

Parameters arr_or_dtype : array-like

The array or dtype to check.

Returns
boolean [Whether or not the array or dtypes is of a float dtype.]

Examples

```python
>>> is_float_dtype(str)
False
>>> is_float_dtype(int)
False
>>> is_float_dtype(float)
True
>>> is_float_dtype(np.array(['a', 'b']))
False
>>> is_float_dtype(pd.Series([1, 2]))
False
>>> is_float_dtype(pd.Index([1, 2.]))
True
```

34.21.4.13 pandas.api.types.is_int64_dtype

pandas.api.types.is_int64_dtype(arr_or_dtype)

Check whether the provided array or dtypes is of the int64 dtype.

Parameters

**arr_or_dtype**: array-like

The array or dtypes to check.

Returns

boolean [Whether or not the array or dtypes is of the int64 dtype.]

Notes

Depending on system architecture, the return value of `is_int64_dtype(int)` will be True if the OS uses 64-bit integers and False if the OS uses 32-bit integers.

Examples

```python
>>> is_int64_dtype(str)
False
>>> is_int64_dtype(np.int32)
False
>>> is_int64_dtype(np.int64)
True
>>> is_int64_dtype(float)
False
>>> is_int64_dtype(np.uint64)  # unsigned
False
>>> is_int64_dtype(np.array(['a', 'b']))
False
>>> is_int64_dtype(np.array([1, 2], dtype=np.int64))
True
>>> is_int64_dtype(pd.Index([1, 2.]))  # float
False
```
>>> is_int64_dtype(np.array([1, 2], dtype=np.uint32))  # unsigned
False

34.21.4.14 pandas.api.types.is_integer_dtype

pandas.api.types.is_integer_dtype(arr_or_dtype)
Check whether the provided array or dtype is of an integer dtype.
Unlike in in_any_int_dtype, timedelta64 instances will return False.

Parameters
arr_or_dtype : array-like
  The array or dtype to check.

Returns
boolean : Whether or not the array or dtype is of an integer dtype
and not an instance of timedelta64.

Examples

>>> is_integer_dtype(str)
False
>>> is_integer_dtype(int)
True
>>> is_integer_dtype(float)
False
>>> is_integer_dtype(np.uint64)
True
>>> is_integer_dtype(np.datetime64)
False
>>> is_integer_dtype(np.timedelta64)
False
>>> is_integer_dtype(np.array(['a', 'b']))
False
>>> is_integer_dtype(pd.Series([1, 2]))
True
>>> is_integer_dtype(np.array([], dtype=np.timedelta64))
False
>>> is_integer_dtype(pd.Index([1, 2.]))  # float
False

34.21.4.15 pandas.api.types.is_interval_dtype

pandas.api.types.is_interval_dtype(arr_or_dtype)
Check whether an array-like or dtype is of the Interval dtype.

Parameters
arr_or_dtype : array-like
  The array-like or dtype to check.

Returns
boolean : Whether or not the array-like or dtype is
of the Interval dtype.
Examples

```python
>>> is_interval_dtype(object)
False
>>> is_interval_dtype(IntervalDtype())
True
>>> is_interval_dtype([1, 2, 3])
False
>>> interval = pd.Interval(1, 2, closed="right")
>>> is_interval_dtype(interval)
False
>>> is_interval_dtype(pd.IntervalIndex([interval]))
True
```

34.21.4.16 pandas.api.types.is_numeric_dtype

pandas.api.types.is_numeric_dtype(arr_or_dtype)

Check whether the provided array or dtype is of a numeric dtype.

Parameters

- **arr_or_dtype** : array-like
  
  The array or dtype to check.

Returns

- **boolean** [Whether or not the array or dtype is of a numeric dtype.]

Examples

```python
>>> is_numeric_dtype(str)
False
>>> is_numeric_dtype(int)
True
>>> is_numeric_dtype(float)
True
>>> is_numeric_dtype(np.uint64)
True
>>> is_numeric_dtype(np.datetime64)
False
>>> is_numeric_dtype(np.timedelta64)
False
>>> is_numeric_dtype(np.array(["a", "b"]))
False
>>> is_numeric_dtype(pd.Series([1, 2]))
True
>>> is_numeric_dtype(pd.Index([1, 2.]))
True
>>> is_numeric_dtype(np.array([], dtype=np.timedelta64))
False
```

34.21.4.17 pandas.api.types.is_object_dtype

pandas.api.types.is_object_dtype(arr_or_dtype)

Check whether an array-like or dtype is of the object dtype.
Parameters `arr_or_dtype` : array-like

The array-like or dtype to check.

Returns

```
boolean [Whether or not the array-like or dtype is of the object dtype.]
```

**Examples**

```python
>>> is_object_dtype(object)
True
>>> is_object_dtype(int)
False
>>> is_object_dtype(np.array([], dtype=object))
True
>>> is_object_dtype(np.array([], dtype=int))
False
>>> is_object_dtype([1, 2, 3])
False
```

### 34.21.4.18 pandas.api.types.is_period_dtype

pandas.api.types.is_period_dtype(arr_or_dtype)

Check whether an array-like or dtype is of the Period dtype.

**Parameters** `arr_or_dtype` : array-like

The array-like or dtype to check.

**Returns**

```
boolean [Whether or not the array-like or dtype is of the Period dtype.]
```

**Examples**

```python
>>> is_period_dtype(object)
False
>>> is_period_dtype(PeriodDtype(freq="D"))
True
>>> is_period_dtype([1, 2, 3])
False
>>> is_period_dtype(pd.Period("2017-01-01"))
False
>>> is_period_dtype(pd.PeriodIndex([], freq="A"))
True
```

### 34.21.4.19 pandas.api.types.is_signed_integer_dtype

pandas.api.types.is_signed_integer_dtype(arr_or_dtype)

Check whether the provided array or dtype is of a signed integer dtype.

Unlike in `in_any_int_dtype`, timedelta64 instances will return False.

**Parameters** `arr_or_dtype` : array-like
The array or dtype to check.

**Returns** boolean: Whether or not the array or dtype is of a signed integer dtype and not an instance of timedelta64.

**Examples**

```python
>>> is_signed_integer_dtype(str)
False
>>> is_signed_integer_dtype(int)
True
>>> is_signed_integer_dtype(float)
False
>>> is_signed_integer_dtype(np.uint64)  # unsigned
False
>>> is_signed_integer_dtype(np.datetime64)
False
>>> is_signed_integer_dtype(np.timedelta64)
False
>>> is_signed_integer_dtype(np.array(['a', 'b']))
False
>>> is_signed_integer_dtype(pd.Series([1, 2]))
True
>>> is_signed_integer_dtype(np.array([], dtype=np.timedelta64))
False
>>> is_signed_integer_dtype(pd.Index([1, 2.]))  # float
False
>>> is_signed_integer_dtype(np.array([1, 2], dtype=np.uint32))  # unsigned
False
```

34.21.4.20 pandas.api.types.is_string_dtype

**pandas.api.types.is_string_dtype(arr_or_dtype)**

Check whether the provided array or dtype is of the string dtype.

**Parameters** arr_or_dtype : array-like

The array or dtype to check.

**Returns**

boolean [Whether or not the array or dtype is of the string dtype.]

**Examples**

```python
>>> is_string_dtype(str)
True
>>> is_string_dtype(object)
True
>>> is_string_dtype(int)
False
>>> is_string_dtype(np.array(['a', 'b']))
True
```
>>> is_string_dtype(pd.Series([1, 2]))
False

34.21.4.21 pandas.api.types.is_timedelta64_dtype

pandas.api.types.is_timedelta64_dtype(arr_or_dtype)
Check whether an array-like or dtype is of the timedelta64 dtype.

Parameters arr_or_dtype : array-like
The array-like or dtype to check.

Returns boolean : Whether or not the array-like or dtype is of the timedelta64 dtype.

Examples

>>> is_timedelta64_dtype(object)
False
>>> is_timedelta64_dtype(np.timedelta64)
True
>>> is_timedelta64_dtype([1, 2, 3])
False
>>> is_timedelta64_dtype(pd.Series([], dtype="timedelta64[ns]"))
True
>>> is_timedelta64_dtype('0 days')
False

34.21.4.22 pandas.api.types.is_timedelta64_ns_dtype

pandas.api.types.is_timedelta64_ns_dtype(arr_or_dtype)
Check whether the provided array or dtype is of the timedelta64[ns] dtype.
This is a very specific dtype, so generic ones like np.timedelta64 will return False if passed into this function.

Parameters arr_or_dtype : array-like
The array or dtype to check.

Returns boolean : Whether or not the array or dtype is of the timedelta64[ns] dtype.

Examples

>>> is_timedelta64_ns_dtype(np.dtype('m8[ns]'))
True
>>> is_timedelta64_ns_dtype(np.dtype('m8[ps]'))  # Wrong frequency
False
>>> is_timedelta64_ns_dtype(np.array([1, 2], dtype='m8[ns]'))
True
>>> is_timedelta64_ns_dtype(np.array([1, 2], dtype=np.timedelta64))
False

34.21. General utility functions
34.21.4.23 pandas.api.types.is_unsigned_integer_dtype

pandas.api.types.is_unsigned_integer_dtype(arr_or_dtype)

Check whether the provided array or dtype is of an unsigned integer dtype.

Parameters arr_or_dtype : array-like
    The array or dtype to check.

Returns boolean : Whether or not the array or dtype is of an
    unsigned integer dtype.

Examples

```python
>>> is_unsigned_integer_dtype(str)
False
>>> is_unsigned_integer_dtype(int)  # signed
False
>>> is_unsigned_integer_dtype(float)
False
>>> is_unsigned_integer_dtype(np.uint64)
True
>>> is_unsigned_integer_dtype(np.array(['a', 'b']))
False
>>> is_unsigned_integer_dtype(pd.Series([1, 2]))  # signed
False
>>> is_unsigned_integer_dtype(pd.Index([1, 2.]))  # float
False
>>> is_unsigned_integer_dtype(np.array([1, 2], dtype=np.uint32))
True
```

34.21.4.24 pandas.api.types.is_sparse

pandas.api.types.is_sparse(arr)

Check whether an array-like is a pandas sparse array.

Parameters arr : array-like
    The array-like to check.

Returns

boolean [Whether or not the array-like is a pandas sparse array.]

Examples

```python
>>> is_sparse(np.array([1, 2, 3]))
False
>>> is_sparse(pd.SparseArray([1, 2, 3]))
True
>>> is_sparse(pd.SparseSeries([1, 2, 3]))
True
```

This function checks only for pandas sparse array instances, so sparse arrays from other libraries will return False.
```python
>>> from scipy.sparse import bsr_matrix
>>> is_sparse(bsr_matrix([1, 2, 3]))
False
```

Iterable introspection

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>api.types.is_dict_like(obj)</code></td>
<td>Check if the object is dict-like.</td>
</tr>
<tr>
<td><code>api.types.is_file_like(obj)</code></td>
<td>Check if the object is file-like object.</td>
</tr>
<tr>
<td><code>api.types.is_list_like(obj)</code></td>
<td>Check if the object is list-like.</td>
</tr>
<tr>
<td><code>api.types.is_named_tuple(obj)</code></td>
<td>Check if the object is a named tuple.</td>
</tr>
<tr>
<td><code>api.types.is_iterator(obj)</code></td>
<td>Check if the object is an iterator.</td>
</tr>
</tbody>
</table>

### 34.21.4.25 pandas.api.types.is_dict_like

`pandas.api.types.is_dict_like(obj)`  
Check if the object is dict-like.

**Parameters**

- `obj` [The object to check.]

**Returns** `is_dict_like` : bool

Whether `obj` has dict-like properties.

```python
>>> is_dict_like({1: 2})
True
>>> is_dict_like([1, 2, 3])
False
```

### 34.21.4.26 pandas.api.types.is_file_like

`pandas.api.types.is_file_like(obj)`  
Check if the object is a file-like object.

For objects to be considered file-like, they must be an iterator AND have either a `read` and/or `write` method as an attribute.

Note: file-like objects must be iterable, but iterable objects need not be file-like.

**Parameters**

- `obj` [The object to check.]

**Returns** `is_file_like` : bool

Whether `obj` has file-like properties.

New in version 0.20.0.
Examples

```python
>>> buffer(StringIO("data"))
>>> is_file_like(buffer)
True
>>> is_file_like([1, 2, 3])
False
```

34.21.4.27 pandas.api.types.is_list_like

pandas.api.types.is_list_like(obj)
Check if the object is list-like.

Objects that are considered list-like are for example Python lists, tuples, sets, NumPy arrays, and Pandas Series. Strings and datetime objects, however, are not considered list-like.

Parameters

- **obj** [The object to check.]

Returns is_list_like : bool

Whether `obj` has list-like properties.

Examples

```python
>>> is_list_like([1, 2, 3])
True
>>> is_list_like([1, 2, 3])
True
>>> is_list_like(datetime(2017, 1, 1))
False
>>> is_list_like("foo")
False
>>> is_list_like(1)
False
```

34.21.4.28 pandas.api.types.is_named_tuple

pandas.api.types.is_named_tuple(obj)
Check if the object is a named tuple.

Parameters

- **obj** [The object to check.]

Returns is_named_tuple : bool

Whether `obj` is a named tuple.

Examples
>>> Point = namedtuple("Point", ["x", "y"])  
>>> p = Point(1, 2)  
>>> is_named_tuple(p)  
True  
>>> is_named_tuple((1, 2))  
False

34.21.4.29 pandas.api.types.is_iterator

pandas.api.types.is_iterator(obj)
Check if the object is an iterator.

For example, lists are considered iterators but not strings or datetime objects.

Parameters

obj [The object to check.]

Returns is_iter : bool
Whether obj is an iterator.

Examples

>>> is_iterator([1, 2, 3])
True
>>> is_iterator(datetime(2017, 1, 1))
False
>>> is_iterator("foo")
False
>>> is_iterator(1)
False

Scalar introspection

api.types.is_bool
api.types.is_categorical(arr) Check whether an array-like is a Categorical instance.
api.types.is_complex
api.types.is_datetimetz(arr) Check whether an array-like is a datetime array-like with a timezone component in its dtype.
api.types.is_float
api.types.is_hashable(obj) Return True if hash(obj) will succeed, False otherwise.
api.types.is_integer
api.types.is_interval
api.types.is_number(obj) Check if the object is a number.
api.types.is_period(arr) Check whether an array-like is a periodical index.
api.types.is_re(obj) Check if the object is a regex pattern instance.
api.types.is_re_compilable(obj) Check if the object can be compiled into a regex pattern instance.
api.types.is_scalar
Return True if given value is scalar.
34.21.4.30 pandas.api.types.is_bool

pandas.api.types.is_bool()

34.21.4.31 pandas.api.types.is_categorical

pandas.api.types.is_categorical(arr)

Check whether an array-like is a Categorical instance.

Parameters arr : array-like

The array-like to check.

Returns

boolean [Whether or not the array-like is of a Categorical instance.]

Examples

```python
>>> is_categorical([1, 2, 3])
False
```

Categoricals, Series Categoricals, and CategoricalIndex will return True.

```python
>>> cat = pd.Categorical([1, 2, 3])
>>> is_categorical(cat)
True
>>> is_categorical(pd.Series(cat))
True
>>> is_categorical(pd.CategoricalIndex([1, 2, 3]))
True
```

34.21.4.32 pandas.api.types.is_complex

pandas.api.types.is_complex()

34.21.4.33 pandas.api.types.is_datetimetz

pandas.api.types.is_datetimetz(arr)

Check whether an array-like is a datetime array-like with a timezone component in its dtype.

Parameters arr : array-like

The array-like to check.

Returns boolean : Whether or not the array-like is a datetime array-like with a timezone component in its dtype.

Examples

```python
>>> is_datetimetz([1, 2, 3])
False
```
Although the following examples are both DatetimeIndex objects, the first one returns False because it has no timezone component unlike the second one, which returns True.

```python
>>> is_datetimetz(pd.DatetimeIndex([1, 2, 3]))
False
>>> is_datetimetz(pd.DatetimeIndex([1, 2, 3], tz="US/Eastern"))
True
```

The object need not be a DatetimeIndex object. It just needs to have a dtype which has a timezone component.

```python
>>> dtype = DatetimeTZDtype("ns", tz="US/Eastern")
>>> s = pd.Series([], dtype=dtype)
>>> is_datetimetz(s)
True
```

### 34.21.4.34 pandas.api.types.is_float

`pandas.api.types.is_float()`

### 34.21.4.35 pandas.api.types.is_hashable

`pandas.api.types.is_hashable(obj)`

Return True if hash(obj) will succeed, False otherwise.

Some types will pass a test against collections.Hashable but fail when they are actually hashed with hash(). Distinguish between these and other types by trying the call to hash() and seeing if they raise TypeError.

**Examples**

```python
>>> a = ([])
>>> isinstance(a, collections.Hashable)
True
>>> is_hashable(a)
False
```

### 34.21.4.36 pandas.api.types.is_integer

`pandas.api.types.is_integer()`

### 34.21.4.37 pandas.api.types.is_interval

`pandas.api.types.is_interval()`

### 34.21.4.38 pandas.api.types.is_number

`pandas.api.types.is_number(obj)`

Check if the object is a number.

Returns True when the object is a number, and False if is not.

**Parameters**

- `obj`: any type
The object to check if is a number.

**Returns** is_number : bool

Whether *obj* is a number or not.

See also:

**pandas.api.types.is_integer** checks a subgroup of numbers

**Examples**

```python
>>> pd.api.types.is_number(1)
True
>>> pd.api.types.is_number(7.15)
True
```

Booleans are valid because they are int subclass.

```python
>>> pd.api.types.is_number(False)
True
>>> pd.api.types.is_number("foo")
False
>>> pd.api.types.is_number("5")
False
```

### 34.21.4.39 pandas.api.types.is_period

**pandas.api.types.is_period**(*arr*)

Check whether an array-like is a periodical index.

**Parameters**

*arr*: array-like

The array-like to check.

**Returns**

**boolean** [Whether or not the array-like is a periodical index.]

**Examples**

```python
>>> is_period([1, 2, 3])
False
>>> is_period(pd.Index([1, 2, 3]))
False
>>> is_period(pd.PeriodIndex(["2017-01-01"], freq="D"))
True
```

### 34.21.4.40 pandas.api.types.is_re

**pandas.api.types.is_re**(*obj*)

Check if the object is a regex pattern instance.
Parameters

obj [The object to check.]

Returns is_regex : bool
    Whether obj is a regex pattern.

Examples

>>> is_re(re.compile(".*")
True
>>> is_re("foo")
False

34.21.4.41 pandas.api.types.is_re_compilable

pandas.api.types.is_re_compilable(obj)
Check if the object can be compiled into a regex pattern instance.

Parameters

obj [The object to check.]

Returns is_regex_compilable : bool
    Whether obj can be compiled as a regex pattern.

Examples

>>> is_re_compilable(".*")
True
>>> is_re_compilable(1)
False

34.21.4.42 pandas.api.types.is_scalar

pandas.api.types.is_scalar()
Return True if given value is scalar.

This includes: - numpy array scalar (e.g. np.int64) - Python builtin numerics - Python builtin byte arrays and strings - None - instances of datetime.datetime - instances of datetime.timedelta - Period - instances of decimal.Decimal - Interval - DateOffset

34.22 Extensions

These are primarily intended for library authors looking to extend pandas objects.

Documentation:

- Register a custom accessor on DataFrame objects.
- Register a custom accessor on Series objects.
- Register a custom accessor on Index objects.
Table 188 – continued from previous page

<table>
<thead>
<tr>
<th>api.extensions.ExtensionDtype</th>
<th>A custom data type, to be paired with an ExtensionArray.</th>
</tr>
</thead>
<tbody>
<tr>
<td>api.extensions.ExtensionArray</td>
<td>Abstract base class for custom 1-D array types.</td>
</tr>
</tbody>
</table>

### 34.22.1 pandas.api.extensions.register_dataframe_accessor

**pandas.api.extensions.register_dataframe_accessor** *(name)*

Register a custom accessor on DataFrame objects.

**Parameters**

- **name**: str
  
  Name under which the accessor should be registered. A warning is issued if this name conflicts with a preexisting attribute.

**See also:**

register_series_accessor, register_index_accessor

**Notes**

When accessed, your accessor will be initialized with the pandas object the user is interacting with. So the signature must be:

```python
def __init__(self, pandas_object):
```

For consistency with pandas methods, you should raise an `AttributeError` if the data passed to your accessor has an incorrect dtype.

```python
>>> pd.Series(['a', 'b']).dt
Traceback (most recent call last):
...
AttributeError: Can only use .dt accessor with datetimelike values
```

**Examples**

In your library code:

```python
import pandas as pd

@pd.api.extensions.register_dataframe_accessor("geo")
class GeoAccessor(object):
    def __init__(self, pandas_obj):
        self._obj = pandas_obj

    @property
    def center(self):
        # return the geographic center point of this DataFrame
        lat = self._obj.latitude
        lon = self._obj.longitude
        return (float(lon.mean()), float(lat.mean()))

    def plot(self):
```

(continues on next page)
Back in an interactive IPython session:

```python
>>> ds = pd.DataFrame([('longitude': np.linspace(0, 10),
                       'latitude': np.linspace(0, 20))]
```

```python
>>> ds.geo.center
(5.0, 10.0)
>>> ds.geo.plot()
# plots data on a map
```

### 34.22.2 pandas.api.extensions.register_series_accessor

`pandas.api.extensions.register_series_accessor(name)`

Register a custom accessor on Series objects.

**Parameters**

- `name`: str
  
  Name under which the accessor should be registered. A warning is issued if this name conflicts with a preexisting attribute.

**See also**:

- `register_dataframe_accessor`, `register_index_accessor`

**Notes**

When accessed, your accessor will be initialized with the pandas object the user is interacting with. So the signature must be:

```python
def __init__(self, pandas_object):
```

For consistency with pandas methods, you should raise an `AttributeError` if the data passed to your accessor has an incorrect dtype.

```python
>>> pd.Series(['a', 'b']).dt
Traceback (most recent call last):
...  
AttributeError: Can only use .dt accessor with datetimelike values
```

**Examples**

In your library code:

```python
import pandas as pd

@pd.api.extensions.register_dataframe_accessor("geo")
class GeoAccessor(object):
    def __init__(self, pandas_obj):
        self._obj = pandas_obj

@property
```
def center(self):
    # return the geographic center point of this DataFrame
    lat = self._obj.latitude
    lon = self._obj.longitude
    return (float(lon.mean()), float(lat.mean()))

def plot(self):
    # plot this array's data on a map, e.g., using Cartopy
    pass

Back in an interactive IPython session:

```python
>>> ds = pd.DataFrame({'longitude': np.linspace(0, 10),
                      'latitude': np.linspace(0, 20)})
>>> ds.geo.center
(5.0, 10.0)
```

34.22.3 pandas.api.extensions.register_index_accessor

pandas.api.extensions.register_index_accessor(name)

Register a custom accessor on Index objects.

Parameters

- **name**: str
  
  Name under which the accessor should be registered. A warning is issued if this name conflicts with a preexisting attribute.

See also:

- register_dataframe_accessor, register_series_accessor

Notes

When accessed, your accessor will be initialized with the pandas object the user is interacting with. So the signature must be

```python
def __init__(self, pandas_object):
```

For consistency with pandas methods, you should raise an `AttributeError` if the data passed to your accessor has an incorrect dtype.

```python
>>> pd.Series(['a', 'b']).dt
Traceback (most recent call last):
  ...
AttributeError: Can only use .dt accessor with datetimelike values
```

Examples

In your library code:
```python
import pandas as pd

@pd.api.extensions.register_dataframe_accessor("geo")
class GeoAccessor(object):
    def __init__(self, pandas_obj):
        self._obj = pandas_obj

@property
def center(self):
    # return the geographic center point of this DataFrame
    lat = self._obj.latitude
    lon = self._obj.longitude
    return (float(lon.mean()), float(lat.mean()))

def plot(self):
    # plot this array's data on a map, e.g., using Cartopy
    pass

Back in an interactive IPython session:
>>> ds = pd.DataFrame({'longitude': np.linspace(0, 10),
...                   'latitude': np.linspace(0, 20)})
>>> ds.geo.center
(5.0, 10.0)
>>> ds.geo.plot()
# plots data on a map
```

### 34.22.4 pandas.api.extensions.ExtensionDtype

```python
class pandas.api.extensions.ExtensionDtype
A custom data type, to be paired with an ExtensionArray.

New in version 0.23.0.

**Notes**

The interface includes the following abstract methods that must be implemented by subclasses:

- type
- name
  - construct_from_string

The `na_value` class attribute can be set to the default NA value for this type. `numpy.nan` is used by default.

This class does not inherit from `abc.ABCMeta` for performance reasons. Methods and properties required by the interface raise `pandas.errors.AbstractMethodError` and no `register` method is provided for registering virtual subclasses.

**Attributes**
kind
A character code (one of ‘biufcmMOSUV’), default ‘O’

name
A string identifying the data type.

names
Ordered list of field names, or None if there are no fields.

type
The scalar type for the array, e.g.

34.22.4.1 pandas.api.extensions.ExtensionDtype.kind

ExtensionDtype.kind
A character code (one of ‘biufcmMOSUV’), default ‘O’

This should match the NumPy dtype used when the array is converted to an ndarray, which is probably ‘O’ for object if the extension type cannot be represented as a built-in NumPy type.

See also:

numpy.dtype.kind

34.22.4.2 pandas.api.extensions.ExtensionDtype.name

ExtensionDtype.name
A string identifying the data type.

Will be used for display in, e.g. Series.dtype

34.22.4.3 pandas.api.extensions.ExtensionDtype.names

ExtensionDtype.names
Ordered list of field names, or None if there are no fields.

This is for compatibility with NumPy arrays, and may be removed in the future.

34.22.4.4 pandas.api.extensions.ExtensionDtype.type

ExtensionDtype.type
The scalar type for the array, e.g. int

It’s expected ExtensionArray[item] returns an instance of ExtensionDtype.type for scalar item.

Methods

construct_from_string(string)
Attempt to construct this type from a string.

is_dtype(dtype)
Check if we match ‘dtype’.

34.22.4.5 pandas.api.extensions.ExtensionDtype.construct_from_string

classmethod
ExtensionDtype.construct_from_string(string)

Attempt to construct this type from a string.

Parameters
string [str]

Returns

self [instance of ‘cls’]

 Raises  TypeError

If a class cannot be constructed from this ‘string’.

Examples

If the extension dtype can be constructed without any arguments, the following may be an adequate implementation.

```python
>>> @classmethod
... def construct_from_string(cls, string):
...     if string == cls.name:
...         return cls()
...     else:
...         raise TypeError("Cannot construct a '{}/' from "
...                         "'{}/".format(cls, string))
```

34.22.4.6 pandas.api.extensions.ExtensionDtype.is_dtype

classmethod  ExtensionDtype.is_dtype(dtype)

Check if we match ‘dtype’.

Parameters  dtype : object

The object to check.

Returns

 is_dtype  [bool]

Notes

The default implementation is True if
1. cls.construct_from_string(dtype) is an instance of cls.
2. dtype is an object and is an instance of cls
3. dtype has a dtype attribute, and any of the above conditions is true for dtype.dtype.

34.22.5 pandas.api.extensions.ExtensionArray

class  pandas.api.extensions.ExtensionArray

Abstract base class for custom 1-D array types.

pandas will recognize instances of this class as proper arrays with a custom type and will not attempt to coerce them to objects. They may be stored directly inside a DataFrame or Series.

New in version 0.23.0.
Notes

The interface includes the following abstract methods that must be implemented by subclasses:

- `_from_sequence`
- `_from_factorized`
- `__getitem__`
- `__len__`
- `dtype`
- `nbytes`
- `isna`
- `take`
- `copy`
- `_concat_same_type`

An additional method is available to satisfy pandas’ internal, private block API.

- `_formatting_values`

Some methods require casting the ExtensionArray to an ndarray of Python objects with `self.astype(object)`, which may be expensive. When performance is a concern, we highly recommend over-riding the following methods:

- `fillna`
- `unique`
- `factorize` / `_values_for_factorize`
- `argsort` / `_values_for_argsort`

This class does not inherit from `abc.ABCMeta` for performance reasons. Methods and properties required by the interface raise `pandas.errors.AbstractMethodError` and no `register` method is provided for registering virtual subclasses.

ExtensionArrays are limited to 1 dimension.

They may be backed by none, one, or many NumPy arrays. For example, `pandas.Categorical` is an extension array backed by two arrays, one for codes and one for categories. An array of IPv6 address may be backed by a NumPy structured array with two fields, one for the lower 64 bits and one for the upper 64 bits. Or they may be backed by some other storage type, like Python lists. Pandas makes no assumptions on how the data are stored, just that it can be converted to a NumPy array. The ExtensionArray interface does not impose any rules on how this data is stored. However, currently, the backing data cannot be stored in attributes called `.values` or `._values` to ensure full compatibility with pandas internals. But other names as `.data`, `._data`, `._items`, ... can be freely used.

Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dtype</code></td>
<td>An instance of ‘ExtensionDtype’.</td>
</tr>
<tr>
<td><code>nbytes</code></td>
<td>The number of bytes needed to store this object in memory.</td>
</tr>
</tbody>
</table>
Table 191 – continued from previous page

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ndim</td>
<td>Extension Arrays are only allowed to be 1-dimensional.</td>
</tr>
<tr>
<td>shape</td>
<td>Return a tuple of the array dimensions.</td>
</tr>
</tbody>
</table>

### 34.22.5.1 pandas.api.extensions.ExtensionArray.dtype

ExtensionArray.dtype
An instance of ‘ExtensionDtype’.

### 34.22.5.2 pandas.api.extensions.ExtensionArray.nbytes

ExtensionArray.nbytes
The number of bytes needed to store this object in memory.

### 34.22.5.3 pandas.api.extensions.ExtensionArray.ndim

ExtensionArray.ndim
Extension Arrays are only allowed to be 1-dimensional.

### 34.22.5.4 pandas.api.extensions.ExtensionArray.shape

ExtensionArray.shape
Return a tuple of the array dimensions.

### Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>argsort</td>
<td>Return the indices that would sort this array.</td>
</tr>
<tr>
<td>astype</td>
<td>Cast to a NumPy array with ‘dtype’.</td>
</tr>
<tr>
<td>copy</td>
<td>Return a copy of the array.</td>
</tr>
<tr>
<td>factorize</td>
<td>Encode the extension array as an enumerated type.</td>
</tr>
<tr>
<td>fillna</td>
<td>Fill NA/NaN values using the specified method.</td>
</tr>
<tr>
<td>isna</td>
<td>Boolean NumPy array indicating if each value is missing.</td>
</tr>
<tr>
<td>take</td>
<td>Take elements from an array.</td>
</tr>
<tr>
<td>unique</td>
<td>Compute the ExtensionArray of unique values.</td>
</tr>
</tbody>
</table>

### 34.22.5.5 pandas.api.extensions.ExtensionArray.argsort

ExtensionArray.argsort (ascending=True, kind='quicksort', *args, **kwargs)
Return the indices that would sort this array.

Parameters ascending : bool, default True
Whether the indices should result in an ascending or descending sort.

kind : {'quicksort', 'mergesort', 'heapsort'}, optional
Sorting algorithm.

*args, **kwargs:
passed through to `numpy.argsort()`.

**Returns**  
`index_array` : ndarray  
Array of indices that sort `self`.

**See also:**  
`numpy.argsort`  
Sorting implementation used internally.

### 34.22.5.6 pandas.api.extensions.ExtensionArray.astype

`ExtensionArray.astype(dtype, copy=True)`  
Cast to a NumPy array with ‘dtype’.

**Parameters**  
`dtype` : str or dtype  
Typecode or data-type to which the array is cast.

`copy` : bool, default True  
Whether to copy the data, even if not necessary. If False, a copy is made only if the old dtype does not match the new dtype.

**Returns**  
`array` : ndarray  
NumPy ndarray with ‘dtype’ for its dtype.

### 34.22.5.7 pandas.api.extensions.ExtensionArray.copy

`ExtensionArray.copy(deep=False)`  
Return a copy of the array.

**Parameters**  
`deep` : bool, default False  
Also copy the underlying data backing this array.

**Returns**  
`ExtensionArray`

### 34.22.5.8 pandas.api.extensions.ExtensionArray.factorize

`ExtensionArray.factorize(na_sentinel=-1)`  
Encode the extension array as an enumerated type.

**Parameters**  
`na_sentinel` : int, default -1  
Value to use in the `labels` array to indicate missing values.

**Returns**  
`labels` : ndarray  
An integer NumPy array that’s an indexer into the original ExtensionArray.

`uniques` : ExtensionArray  
An ExtensionArray containing the unique values of `self`.

**Note:**  
uniques will not contain an entry for the NA value of the ExtensionArray if there are any missing values present in `self`. 

Chapter 34. API Reference
See also:

`pandas.factorize` Top-level factorize method that dispatches here.

Notes

`pandas.factorize()` offers a `sort` keyword as well.

34.22.5.9 `pandas.api.extensions.ExtensionArray.fillna`

ExtensionArray. `fillna` (value=None, method=None, limit=None)
Fill NA/NaN values using the specified method.

Parameters

- `value`: scalar, array-like
  If a scalar value is passed it is used to fill all missing values. Alternatively, an array-like ‘value’ can be given. It’s expected that the array-like have the same length as ‘self’.
- `method`: {'backfill', 'bfill', 'pad', 'ffill', None}, default None
  Method to use for filling holes in reindexed Series pad / ffill: propagate last valid observation forward to next valid backfill / bfill: use NEXT valid observation to fill gap
- `limit`: int, default None
  If method is specified, this is the maximum number of consecutive NaN values to forward/backward fill. In other words, if there is a gap with more than this number of consecutive NaNs, it will only be partially filled. If method is not specified, this is the maximum number of entries along the entire axis where NaNs will be filled.

Returns

`filled` [ExtensionArray with NA/NaN filled]

34.22.5.10 `pandas.api.extensions.ExtensionArray.isna`

ExtensionArray. `isna`()
Boolean NumPy array indicating if each value is missing.
This should return a 1-D array the same length as ‘self’.

34.22.5.11 `pandas.api.extensions.ExtensionArray.take`

ExtensionArray. `take` (indices, allow_fill=False, fill_value=None)
Take elements from an array.

Parameters

- `indices`: sequence of integers
  Indices to be taken.
- `allow_fill`: bool, default False
  How to handle negative values in `indices`.
• False: negative values in `indices` indicate positional indices from the right (the default). This is similar to `numpy.take()`.

• True: negative values in `indices` indicate missing values. These values are set to `fill_value`. Any other other negative values raise a `ValueError`.

**fill_value**: any, optional

Fill value to use for NA-indices when `allow_fill` is True. This may be None, in which case the default NA value for the type, `self.dtype.na_value`, is used.

For many ExtensionArrays, there will be two representations of `fill_value`: a user-facing “boxed” scalar, and a low-level physical NA value. `fill_value` should be the user-facing version, and the implementation should handle translating that to the physical version for processing the take if necessary.

**Returns**

ExtensionArray

**Raises** IndexError

When the indices are out of bounds for the array.

ValueError

When `indices` contains negative values other than -1 and `allow_fill` is True.

**See also:**

`numpy.take`, `pandas.api.extensions.take`

**Notes**

ExtensionArray.take is called by `Series.__getitem__`, `.loc`, `.iloc`, when `indices` is a sequence of values. Additionally, it’s called by `Series.reindex()`, or any other method that causes realignment, with a `fill_value`.

**Examples**

Here’s an example implementation, which relies on casting the extension array to object dtype. This uses the helper method `pandas.api.extensions.take()`.

```python
def take(self, indices, allow_fill=False, fill_value=None):
    from pandas.core.algorithms import take

    # If the ExtensionArray is backed by an ndarray, then
    # just pass that here instead of coercing to object.
    data = self.astype(object)

    if allow_fill and fill_value is None:
        fill_value = self.dtype.na_value

    # fill_value should always be translated from the scalar
    # type for the array, to the physical storage type for
    # the data, before passing to take.
    result = take(data, indices, fill_value=fill_value,
```

(continues on next page)
allow_fill=allow_fill)

return self._from_sequence(result)

34.22.5.12 pandas.api.extensions.ExtensionArray.unique

ExtensionArray.unique()

Compute the ExtensionArray of unique values.

Returns

uniques [ExtensionArray]

34.22.6 pandas.Index.asi8

Index.asi8 = None

34.22.7 pandas.Index.holds_integer

Index.holds_integer()

34.22.8 pandas.Index.is_type_compatible

Index.is_type_compatible(kind)

34.22.9 pandas.Index.nlevels

Index.nlevels

34.22.10 pandas.Index.sort

Index.sort(*args, **kwargs)

34.22.11 pandas.Panel.agg

Panel.agg(func, *args, **kwargs)

34.22.12 pandas.Panel.aggregate

Panel.aggregate(func, *args, **kwargs)

34.22.13 pandas.Panel.is_copy

Panel.is_copy

34.22. Extensions
34.22.14 pandas.Series.imag

Series.imag

34.22.15 pandas.Series.real

Series.real
This section will focus on downstream applications of pandas.

### 35.1 Storing pandas DataFrame objects in Apache Parquet format

The Apache Parquet format provides key-value metadata at the file and column level, stored in the footer of the Parquet file:

```plaintext
5: optional list<KeyValue> key_value_metadata
```

where `KeyValue` is

```
struct KeyValue {
  1: required string key
  2: optional string value
}
```

So that a pandas.DataFrame can be faithfully reconstructed, we store a pandas metadata key in the FileMetaData with the value stored as:

```
{ 'index_columns': ['__index_level_0__', '__index_level_1__', ...],
  'column_indexes': [<ci0>, <ci1>, ..., <ciN>],
  'columns': [<c0>, <c1>, ...],
  'pandas_version': $VERSION
}
```

Here, `<c0>`/`<ci0>` and so forth are dictionaries containing the metadata for each column. This has JSON form:

```
{ 'name': column_name,
  'pandas_type': pandas_type,
  'numpy_type': numpy_type,
  'metadata': metadata
}
```

`pandas_type` is the logical type of the column, and is one of:

- **Boolean**: 'bool'
- **Integers**: 'int8', 'int16', 'int32', 'int64', 'uint8', 'uint16', 'uint32', 'uint64'
- **Floats**: 'float16', 'float32', 'float64'
- **Date and Time Types**: 'datetime', 'datetimetz', 'timedelta'
- **String**: 'unicode', 'bytes'
• Categorical: 'categorical'
• Other Python objects: 'object'

The `numpy_type` is the physical storage type of the column, which is the result of `str(dtype)` for the underlying NumPy array that holds the data. So for `datetimetz` this is `datetime64[ns]` and for categorical, it may be any of the supported integer categorical types.

The `metadata` field is `None` except for:

• `datetimetz`: `{ 'timezone': zone, 'unit': 'ns' }`, e.g. `{ 'timezone': 'America/New_York', 'unit': 'ns' }`. The 'unit' is optional, and if omitted it is assumed to be nanoseconds.
• `categorical`: `{ 'num_categories': K, 'ordered': is_ordered, 'type': $TYPE }
  – Here 'type' is optional, and can be a nested pandas type specification here (but not categorical)
• `unicode`: `{ 'encoding': encoding }
  – The encoding is optional, and if not present is UTF-8
• `object`: `{ 'encoding': encoding }`. Objects can be serialized and stored in `BYTE_ARRAY` Parquet columns. The encoding can be one of:
  – 'pickle'
  – 'msgpack'
  – 'bson'
  – 'json'
• `timedelta`: `{ 'unit': 'ns' }`. The 'unit' is optional, and if omitted it is assumed to be nanoseconds. This metadata is optional altogether

For types other than these, the 'metadata' key can be omitted. Implementations can assume `None` if the key is not present.

As an example of fully-formed metadata:

```json
{ "index_columns": [ '__index_level_0__' ],
  "column_indexes": [ {
    'name': None,
    'pandas_type': 'string',
    'numpy_type': 'object',
    'metadata': None
  } ],
  "columns": [ {
    'name': 'c0',
    'pandas_type': 'int8',
    'numpy_type': 'int8',
    'metadata': None
  }, {
    'name': 'c1',
    'pandas_type': 'bytes',
    'numpy_type': 'object',
    'metadata': None
  }, {
    'name': 'c2',
    'pandas_type': 'categorical',
    'numpy_type': 'int16',
    'metadata': { 'num_categories': 1000, 'ordered': False }
  }, {
    'name': 'c3',
    'pandas_type': 'datetimetz',
    'numpy_type': 'datetime64[ns]' }
```

(continues on next page)
```json

'metadata': {'timezone': 'America/Los_Angeles'},

'c4':

'pandas_type': 'object',

'numpy_type': 'object',

'metadata': {'encoding': 'pickle'}},

'__index_level_0__':

'pandas_type': 'int64',

'numpy_type': 'int64',

'metadata': None

'pandas_version': '0.20.0'}
```
This section will provide a look into some of pandas internals. It’s primarily intended for developers of pandas itself.

### 36.1 Indexing

In pandas there are a few objects implemented which can serve as valid containers for the axis labels:

- **Index**: the generic “ordered set” object, an ndarray of object dtype assuming nothing about its contents. The labels must be hashable (and likely immutable) and unique. Populates a dict of label to location in Cython to do $O(1)$ lookups.
- **Int64Index**: a version of Index highly optimized for 64-bit integer data, such as time stamps
- **Float64Index**: a version of Index highly optimized for 64-bit float data
- **MultiIndex**: the standard hierarchical index object
- **DatetimeIndex**: An Index object with Timestamp boxed elements (impl are the int64 values)
- **TimedeltaIndex**: An Index object with Timedelta boxed elements (impl are the in64 values)
- **PeriodIndex**: An Index object with Period elements

There are functions that make the creation of a regular index easy:

- **date_range**: fixed frequency date range generated from a time rule or DateOffset. An ndarray of Python datetime objects
- **period_range**: fixed frequency date range generated from a time rule or DateOffset. An ndarray of Period objects, representing Timespans

The motivation for having an Index class in the first place was to enable different implementations of indexing. This means that it’s possible for you, the user, to implement a custom Index subclass that may be better suited to a particular application than the ones provided in pandas.

From an internal implementation point of view, the relevant methods that an Index must define are one or more of the following (depending on how incompatible the new object internals are with the Index functions):

- **get_loc**: returns an “indexer” (an integer, or in some cases a slice object) for a label
- **slice_locs**: returns the “range” to slice between two labels
- **get_indexer**: Computes the indexing vector for reindexing / data alignment purposes. See the source / docstrings for more on this
- **get_indexer_non_unique**: Computes the indexing vector for reindexing / data alignment purposes when the index is non-unique. See the source / docstrings for more on this
- **reindex**: Does any pre-conversion of the input index then calls get_indexer
• union, intersection: computes the union or intersection of two Index objects
• insert: Inserts a new label into an Index, yielding a new object
• delete: Delete a label, yielding a new object
• drop: Deletes a set of labels
• take: Analogous to ndarray.take

36.1.1 MultiIndex

Internally, the MultiIndex consists of a few things: the levels, the integer labels, and the level names:

```python
In [1]: index = pd.MultiIndex.from_product([range(3), ['one', 'two']], names=['first', 'second'])
In [2]: index
Out[2]:
MultiIndex(levels=[[0, 1, 2], ['one', 'two']],
          labels=[[0, 0, 1, 1, 2, 2], [0, 1, 0, 1, 0, 1]],
          names=['first', 'second'])
```

You can probably guess that the labels determine which unique element is identified with that location at each layer of the index. It’s important to note that sortedness is determined solely from the integer labels and does not check (or care) whether the levels themselves are sorted. Fortunately, the constructors from_tuples and from_arrays ensure that this is true, but if you compute the levels and labels yourself, please be careful.

36.1.2 Values

Pandas extends NumPy’s type system with custom types, like Categorical or datetimes with a timezone, so we have multiple notions of “values”. For 1-D containers (Index classes and Series) we have the following convention:

- cls._ndarray_values is always a NumPy ndarray. Ideally, _ndarray_values is cheap to compute. For example, for a Categorical, this returns the codes, not the array of objects.

- cls._values refers is the “best possible” array. This could be an ndarray, ExtensionArray, or in Index subclass (note: we’re in the process of removing the index subclasses here so that it’s always an ndarray or ExtensionArray).

So, for example, Series[category]._values is a Categorical, while Series[category]._ndarray_values is the underlying codes.
36.2 Subclassing pandas Data Structures

This section has been moved to Subclassing pandas Data Structures.
While pandas provides a rich set of methods, containers, and data types, your needs may not be fully satisfied. Pandas offers a few options for extending pandas.

### 37.1 Registering Custom Accessors

Libraries can use the decorators `pandas.api.extensions.register_dataframe_accessor()`, `pandas.api.extensions.register_series_accessor()`, and `pandas.api.extensions.register_index_accessor()`, to add additional “namespaces” to pandas objects. All of these follow a similar convention: you decorate a class, providing the name of attribute to add. The class’s `__init__` method gets the object being decorated. For example:

```python
@pd.api.extensions.register_dataframe_accessor("geo")
class GeoAccessor(object):
    def __init__(self, pandas_obj):
        self._obj = pandas_obj

    @property
def center(self):
        # return the geographic center point of this DataFrame
        lat = self._obj.latitude
        lon = self._obj.longitude
        return (float(lon.mean()), float(lat.mean()))

    def plot(self):
        # plot this array's data on a map, e.g., using Cartopy
        pass
```

Now users can access your methods using the `geo` namespace:

```python
>>> ds = pd.DataFrame({'longitude': np.linspace(0, 10),
...                    'latitude': np.linspace(0, 20)})
>>> ds.geo.center
(5.0, 10.0)
>>> ds.geo.plot()
# plots data on a map
```

This can be a convenient way to extend pandas objects without subclassing them. If you write a custom accessor, make a pull request adding it to our pandas Ecosystem page.
37.2 Extension Types

New in version 0.23.0.

**Warning:** The `pandas.api.extension.ExtensionDtype` and `pandas.api.extension.ExtensionArray` APIs are new and experimental. They may change between versions without warning.

Pandas defines an interface for implementing data types and arrays that extend NumPy’s type system. Pandas itself uses the extension system for some types that aren’t built into NumPy (categorical, period, interval, datetime with timezone).

Libraries can define a custom array and data type. When pandas encounters these objects, they will be handled properly (i.e. not converted to an ndarray of objects). Many methods like `pandas.isna()` will dispatch to the extension type’s implementation.

If you’re building a library that implements the interface, please publicize it on Extension Data Types.

The interface consists of two classes.

### 37.2.1 ExtensionDtype

A `pandas.api.extension.ExtensionDtype` is similar to a `numpy.dtype` object. It describes the data type. Implementors are responsible for a few unique items like the name.

One particularly important item is the `type` property. This should be the class that is the scalar type for your data. For example, if you were writing an extension array for IP Address data, this might be `ipaddress.IPv4Address`.

See the [extension dtype source](https://github.com/pandas-dev/pandas/blob/master/pandas/tests/extension/conftest.py) for interface definition.

### 37.2.2 ExtensionArray

This class provides all the array-like functionality. ExtensionArrays are limited to 1 dimension. An ExtensionArray is linked to an ExtensionDtype via the `dtype` attribute.

Pandas makes no restrictions on how an extension array is created via its `__new__` or `__init__`, and puts no restrictions on how you store your data. We do require that your array be convertible to a NumPy array, even if this is relatively expensive (as it is for `Categorical`).

They may be backed by none, one, or many NumPy arrays. For example, `pandas.Categorical` is an extension array backed by two arrays, one for codes and one for categories. An array of IPv6 addresses may be backed by a NumPy structured array with two fields, one for the lower 64 bits and one for the upper 64 bits. Or they may be backed by some other storage type, like Python lists.

See the [extension array source](https://github.com/pandas-dev/pandas/blob/master/pandas/tests/extension/conftest.py) for the interface definition. The docstrings and comments contain guidance for properly implementing the interface.

We provide a test suite for ensuring that your extension arrays satisfy the expected behavior. To use the test suite, you must provide several pytest fixtures and inherit from the base test class. The required fixtures are found in `https://github.com/pandas-dev/pandas/blob/master/pandas/tests/extension/conftest.py`.

To use a test, subclass it:

```python
from pandas.tests.extension import base
```
Warning: There are some easier alternatives before considering subclassing pandas data structures.

1. Extensible method chains with pipe
2. Use composition. See here.
3. Extending by registering an accessor
4. Extending by extension type

This section describes how to subclass pandas data structures to meet more specific needs. There are two points that need attention:

1. Override constructor properties.
2. Define original properties

Note: You can find a nice example in geopandas project.

37.3.1 Override Constructor Properties

Each data structure has several constructor properties for returning a new data structure as the result of an operation. By overriding these properties, you can retain subclasses through pandas data manipulations.

There are 3 constructor properties to be defined:

- _constructor: Used when a manipulation result has the same dimensions as the original.
- _constructor_sliced: Used when a manipulation result has one lower dimension(s) as the original, such as DataFrame single columns slicing.
- _constructor_expanddim: Used when a manipulation result has one higher dimension as the original, such as Series.to_frame() and DataFrame.to_panel().

Following table shows how pandas data structures define constructor properties by default.

<table>
<thead>
<tr>
<th>Property Attributes</th>
<th>Series</th>
<th>DataFrame</th>
</tr>
</thead>
<tbody>
<tr>
<td>_constructor</td>
<td>Series</td>
<td>DataFrame</td>
</tr>
<tr>
<td>_constructor_sliced</td>
<td>NotImplementedError</td>
<td>Series</td>
</tr>
<tr>
<td>_constructorExpanddim</td>
<td>DataFrame</td>
<td>Panel</td>
</tr>
</tbody>
</table>

Below example shows how to define SubclassedSeries and SubclassedDataFrame overriding constructor properties.
class SubclassedSeries(Series):

    @property
def _constructor(self):
        return SubclassedSeries

    @property
def _constructor_expanddim(self):
        return SubclassedDataFrame

class SubclassedDataFrame(DataFrame):

    @property
def _constructor(self):
        return SubclassedDataFrame

    @property
def _constructor_sliced(self):
        return SubclassedSeries

>>> s = SubclassedSeries([1, 2, 3])
>>> type(s)
<class '__main__.SubclassedSeries'>

>>> to_framed = s.to_frame()
>>> type(to_framed)
<class '__main__.SubclassedDataFrame'>

>>> df = SubclassedDataFrame({'A': [1, 2, 3], 'B': [4, 5, 6], 'C': [7, 8, 9]})
>>> df
     A  B  C
0   1  4  7
1   2  5  8
2   3  6  9

>>> type(df)
<class '__main__.SubclassedDataFrame'>

>>> sliced1 = df[['A', 'B']]  
>>> sliced1
     A  B
0   1  4
1   2  5
2   3  6

>>> type(sliced1)
<class '__main__.SubclassedDataFrame'>

>>> sliced2 = df['A'] 
>>> sliced2
0  1
1  2
2  3
Name: A, dtype: int64

>>> type(sliced2)
<class '__main__.SubclassedSeries'>
37.3.2 Define Original Properties

To let original data structures have additional properties, you should let pandas know what properties are added. pandas maps unknown properties to data names overriding __getattr__. Defining original properties can be done in one of 2 ways:

1. Define _internal_names and _internal_names_set for temporary properties which WILL NOT be passed to manipulation results.

2. Define _metadata for normal properties which will be passed to manipulation results.

Below is an example to define two original properties, “internal_cache” as a temporary property and “added_property” as a normal property

```python
class SubclassedDataFrame2(DataFrame):
    # temporary properties
    _internal_names = pd.DataFrame._internal_names + ['internal_cache']
    _internal_names_set = set(_internal_names)

    # normal properties
    _metadata = ['added_property']

    @property
def _constructor(self):
        return SubclassedDataFrame2
```

```bash
>>> df = SubclassedDataFrame2({'A': [1, 2, 3], 'B': [4, 5, 6], 'C': [7, 8, 9]})
>>> df
   A  B  C
0  1  4  7
1  2  5  8
2  3  6  9

>>> df.internal_cache = 'cached'
>>> df.added_property = 'property'

>>> df.internal_cache
'cached'
>>> df.added_property
'property'

# properties defined in _internal_names is reset after manipulation
>>> df[['A', 'B']].internal_cache
AttributeError: 'SubclassedDataFrame2' object has no attribute 'internal_cache'

# properties defined in _metadata are retained
>>> df[['A', 'B']].added_property
'property'
```
This is the list of changes to pandas between each release. For full details, see the commit logs at http://github.com/pandas-dev/pandas

What is it
pandas is a Python package providing fast, flexible, and expressive data structures designed to make working with “relational” or “labeled” data both easy and intuitive. It aims to be the fundamental high-level building block for doing practical, real world data analysis in Python. Additionally, it has the broader goal of becoming the most powerful and flexible open source data analysis / manipulation tool available in any language.

Where to get it
- Source code: http://github.com/pandas-dev/pandas
- Binary installers on PyPI: https://pypi.org/project/pandas
- Documentation: http://pandas.pydata.org

38.1 pandas 0.23.2

Release date: July 5, 2018
This is a minor bug-fix release in the 0.23.x series and includes some small regression fixes and bug fixes.
See the full whatsnew for a list of all the changes.

38.1.1 Thanks
A total of 17 people contributed to this release. People with a “+” by their names contributed a patch for the first time.
- David Krych
- Jacopo Rota +
- Jeff Reback
- Jeremy Schendel
- Joris Van den Bossche
- Kalyan Gokhale
- Matthew Roeschke
- Michael Odintsov +
- Ming Li
38.2 pandas 0.23.1

Release date: June 12, 2018

This is a minor release from 0.23.0 and includes a number of bug fixes and performance improvements. See the full whatsnew for a list of all the changes.

38.2.1 Thanks

A total of 30 people contributed to this release. People with a “+” by their names contributed a patch for the first time.

- Adam J. Stewart
- Adam Kim +
- Aly Sivji
- Chalmer Lowe +
- Damini Satya +
- Dr. Irv
- Gabe Fernando +
- Giftlin Rajaiah
- Jeff Reback
- Jeremy Schendel +
- Joris Van den Bossche
- Kalyan Gokhale +
- Kevin Sheppard
- Matthew Roeschke
- Max Kanter +
- Ming Li
- Pyry Kovanen +
- Stefano Cianciulli
- Tom Augspurger
38.3 pandas 0.23.0

Release date: May 15, 2018

This is a major release from 0.22.0 and includes a number of API changes, new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- Round-trippable JSON format with ‘table’ orient.
- Instantiation from dicts respects order for Python 3.6+.
- Dependent column arguments for assign.
- Merging / sorting on a combination of columns and index levels.
- Extending Pandas with custom types.
- Excluding unobserved categories from groupby.
- Changes to make output shape of DataFrame.apply consistent.

See the full whatsnew for a list of all the changes.

38.3.1 Thanks

A total of 328 people contributed to this release. People with a “+” by their names contributed a patch for the first time.

- Aaron Critchley
- AbdealiJK +
- Adam Hooper +
- Albert Villanova del Moral
- Alejandro Giacometti +
- Alejandro Hohmann +
- Alex Rychyk
pandas: powerful Python data analysis toolkit, Release 0.23.2

- Alexander Buchkovsky
- Alexander Lenail +
- Alexander Michael Schade
- Aly Sivji +
- Andreas Költringer +
- Andrew
- Andrew Bui +
- András Novoszáth +
- Andy Craze +
- Andy R. Terrel
- Anh Le +
- Anil Kumar Pallekonda +
- Antoine Pitrou +
- Antonio Linde +
- Antonio Molina +
- Antonio Quinonez +
- Armin Varshokar +
- Artem Bogachev +
- Avi Sen +
- Azeez Oluwafemi +
- Ben Auffarth +
- Bernhard Thiel +
- Bhavesh Poddar +
- BielStela +
- Blair +
- Bob Haffner
- Brett Naul +
- Brock Mendel
- Bryce Guinta +
- Carlos Eduardo Moreira dos Santos +
- Carlos García Márquez +
- Carol Willing
- Cheuk Ting Ho +
- Chitrannk Dixit +
- Chris
- Chris Burr +
• Chris Catalfo +
• Chris Mazzullo
• Christian Chwala +
• Cihan Ceyhan +
• Clemens Brunner
• Colin +
• Cornelius Riemenschneider
• Crystal Gong +
• DaanVanHauwermeiren
• Dan Dixey +
• Daniel Frank +
• Daniel Garrido +
• Daniel Sakuma +
• DataOmbudsman +
• Dave Hirschfeld
• Dave Lewis +
• David Adrián Cañones Castellano +
• David Arcos +
• David C Hall +
• David Fischer
• David Hoese +
• David Lutz +
• David Polo +
• David Stansby
• Dennis Kamau +
• Dillon Niederhut
• Dimitri +
• Dr. Irv
• Dror Atariah
• Eric Chea +
• Eric Kisslinger
• Eric O. LEBIGOT (EOL) +
• FAN-GOD +
• Fabian Retkowski +
• Fer Sar +
• Gabriel de Maeztu +
• Gianpaolo Macario +
• Giftlin Rajaiah
• Gilberto Olimpio +
• Gina +
• Gjelt +
• Graham Inggs +
• Grant Roch
• Grant Smith +
• Grzegorz Konefau +
• Guilherme Beltramini
• HagaiHargil +
• Hamish Pitkeathly +
• Hammad Mashkoor +
• Hannah Ferchland +
• Hans
• Haochen Wu +
• Hissashi Rocha +
• Iain Barr +
• Ibrahim Sharaf ElDen +
• Ignasi Fosch +
• Igor Conrado Alves de Lima +
• Igor Shelvinskyi +
• Imanflow +
• Ingolf Becker
• Israel Saeta Pérez
• Iva Koevksa +
• Jakub Nowacki +
• Jan F-F +
• Jan Koch +
• Jan Werkmann
• Janelle Zoutkamp +
• Jason Bandlow +
• Jaume Bonet +
• Jay Alammar +
• Jeff Reback
• JennaVergeynst

2428 Chapter 38. Release Notes
• Jimmy Woo +
• Jing Qiang Goh +
• Joachim Wagner +
• Joan Martín Miralles +
• Joel Nothman
• Joeun Park +
• John Cant +
• Johnny Metz +
• Jon Mease
• Jonas Schulze +
• Jongwony +
• Jordi Contestí +
• Joris Van den Bossche
• José F. R. Fonseca +
• Jovix +
• Julio Martinez +
• Jörg Döpfert
• KOBAYASHI Ittoku +
• Kate Surta +
• Kenneth +
• Kevin Kuhl
• Kevin Sheppard
• Krzysztof Chomski
• Ksenia +
• Ksenia Bobrova +
• Kunal Gosar +
• Kurtis Kerstein +
• Kyle Barron +
• Laksh Arora +
• Laurens Geffert +
• Leif Walsh
• Liam Marshall +
• Liam3851 +
• Licht Takeuchi
• Liudmila +
• Ludovico Russo +
Mabel Villalba +
Manan Pal Singh +
Manraj Singh
Marc +
Marc Garcia
Marco Hemken +
Maria del Mar Bibiloni +
Mario Corchero +
Mark Woodbridge +
Martin Journois +
Mason Gallo +
Matias Heikkilä +
Matt Braymer-Hayes
Matt Kirk +
Matt Maybeno +
Matthew Kirk +
Matthew Rocklin +
Matthew Roeschke
Matthias Bussonnier +
Max Mikhaylov +
Maxim Veksler +
Maximilian Roos
Maximiliano Greco +
Michael Penkov
Michael Röttger +
Michael Selik +
Michael Waskom
Mie~~~
Mike Kutzma +
Ming Li +
Mitar +
Mitch Negus +
Montana Low +
Moritz Münst +
Mortada Mehyar
Myles Braithwaite +
• Nate Yoder
• Nicholas Ursa +
• Nick Chmura
• Nikos Karagiannakis +
• Nipun Sadvilkar +
• Nis Martensen +
• Noah +
• Noémi Éltető +
• Olivier Bilodeau +
• Ondrej Kokes +
• Onno Eberhard +
• Paul Ganssle +
• Paul Mannino +
• Paul Reidy
• Paulo Roberto de Oliveira Castro +
• Pepe Flores +
• Peter Hoffmann
• Phil Ngo +
• Pietro Battiston
• Pranav Suri +
• Priyanka Ojha +
• Pulkit Maloo +
• README Bot +
• Ray Bell +
• Riccardo Magliocchetti +
• Ridhwan Luthra +
• Robert Meyer
• Robin
• Robin Kiplang’at +
• Rohan Pandit +
• Rok Mihevc +
• Rouz Azari
• Ryszard T. Kaleta +
• Sam Cohan
• Sam Foo
• Samir Musali +
• Samuel Sinayoko +
• Sangwoong Yoon
• SarahJessica +
• Sharad Vijalaparum +
• Shubham Chaudhary +
• SiYoungOh +
• Sietse Brouwer
• Simone Basso +
• Stefania Delprete +
• Stefano Cianciulli +
• Stephen Childs +
• StephenVoland +
• Stijn Van Hoey +
• Sven
• Talitha Pumar +
• Tarbo Fukazawa +
• Ted Petrou +
• Thomas A Caswell
• Tim Hoffmann +
• Tim Swast
• Tom Augspurger
• Tommy +
• Tulio Casagrande +
• Tushar Gupta +
• Tushar Mittal +
• Upkar Lidder +
• Victor Villas +
• Vince W +
• Vinicius Figueiredo +
• Vipin Kumar +
• WBare
• Wenhuan +
• Wes Turner
• William Ayd
• Wilson Lin +
• Xbar
• Yaroslav Halchenko
• Yee Mey
• Yeongseon Choe +
• Yian +
• Yimeng Zhang
• ZhuBaohe +
• Zihao Zhao +
• adatasetaday +
• akielbowicz +
• akosel +
• alinde1 +
• amuta +
• bolkedebruin
• cbertinato
• cgohlke
• charlie0389 +
• chris-b1
• csfarkas +
• dajcs +
• deflatSOCO +
• derestle-htwg
• discort
• dmanikowski-reef +
• donK23 +
• elrubio +
• fivemok +
• fjiod
• fjetter +
• froessler +
• gabrielclow
• gfyoung
• ghasemnaddaf
• h-vetinari +
• himanshu awasthi +
• ignamv +
• jayfoad +
• jazzmuesli +
• jbrockmendel
• jen w +
• jjames34 +
• joaoavf +
• joders +
• jschendel
• juan huguet +
• l736x +
• luzpaz +
• mdeboc +
• miguelmorin +
• miker985
• miquelcamprodon +
• orereta +
• ottiP +
• peterpanmj +
• rafarui +
• raph-m +
• readyready15728 +
• rmihael +
• samghelms +
• scriptomation +
• sfoo +
• stefansimik +
• stonebig
• tmnhat2001 +
• tomneep +
• topper-123
• tv3141 +
• verakai +
• xpvpc +
• zhanghui +
38.4 pandas 0.22.0

**Release date:** December 29, 2017

This is a major release from 0.21.1 and includes a single, API-breaking change. We recommend that all users upgrade to this version after carefully reading the release note.

The only changes are:

- The sum of an empty or all-NA Series is now 0
- The product of an empty or all-NA Series is now 1
- We’ve added a `min_count` parameter to `.sum()` and `.prod()` controlling the minimum number of valid values for the result to be valid. If fewer than `min_count` non-NA values are present, the result is NA. The default is 0. To return NaN, the 0.21 behavior, use `min_count=1`.

See the v0.22.0 Whatsnew overview for further explanation of all the places in the library this affects.

38.5 pandas 0.21.1

**Release date:** December 12, 2017

This is a minor bug-fix release in the 0.21.x series and includes some small regression fixes, bug fixes and performance improvements. We recommend that all users upgrade to this version.

Highlights include:

- Temporarily restore matplotlib datetime plotting functionality. This should resolve issues for users who relied implicitly on pandas to plot datetimes with matplotlib. See [here](#).
- Improvements to the Parquet IO functions introduced in 0.21.0. See [here](#).

See the v0.21.1 Whatsnew overview for an extensive list of all the changes for 0.21.1.

38.5.1 Thanks

A total of 46 people contributed to this release. People with a “+” by their names contributed a patch for the first time.

38.5.1.1 Contributors

- Aaron Critchley +
- Alex Rychyk
- Alexander Buchkovsky +
- Alexander Michael Schade +
- Chris Mazzullo
- Cornelius Riemenschneider +
- Dave Hirschfeld +
- David Fischer +
- David Stansby +
- Dror Atariah +
• Eric Kisslinger +
• Hans +
• Ingolf Becker +
• Jan Werkmann +
• Jeff Reback
• Joris Van den Bossche
• Jörg Döpfert +
• Kevin Kuhl +
• Krzysztof Chomski +
• Leif Walsh
• Licht Takeuchi
• Manraj Singh +
• Matt Braymer-Hayes +
• Michael Waskom +
• Mie~~~ +
• Peter Hoffmann +
• Robert Meyer +
• Sam Cohan +
• Sietse Brouwer +
• Sven +
• Tim Swast
• Tom Augspurger
• Wes Turner
• William Ayd +
• Yee Mey +
• bolkedebruin +
• cgohlke
• derestle-htwg +
• fjiod +
• gabrielclow +
• gfyounge
• ghasemnaddaf +
• jbrockmendel
• jschendel
• miker985 +
• topper-123
38.6 pandas 0.21.0

**Release date:** October 27, 2017

This is a major release from 0.20.3 and includes a number of API changes, deprecations, new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- Integration with Apache Parquet, including a new top-level `read_parquet()` function and `DataFrame.to_parquet()` method, see [here](#).
- New user-facing `pandas.api.types.CategoricalDtype` for specifying categoricals independent of the data, see [here](#).
- The behavior of `sum` and `prod` on all-NaN Series/DataFrames is now consistent and no longer depends on whether `bottleneck` is installed, and `sum` and `prod` on empty Series now return NaN instead of 0, see [here](#).
- Compatibility fixes for pypy, see [here](#).
- Additions to the `drop`, `reindex` and `rename` API to make them more consistent, see [here](#).
- Addition of the new methods `DataFrame.infer_objects` (see [here](#)) and `GroupBy.pipe` (see [here](#)).
- Indexing with a list of labels, where one or more of the labels is missing, is deprecated and will raise a `KeyError` in a future version, see [here](#).

See the [v0.21.0 Whatsnew](#) overview for an extensive list of all enhancements and bugs that have been fixed in 0.21.0

38.6.1 Thanks

A total of 206 people contributed to this release. People with a “+” by their names contributed a patch for the first time.

38.6.1.1 Contributors

- 3553x +
- Aaron Barber
- Adam Gleave +
- Adam Smith +
- AdamShamlan +
- Adrian Liaw +
- Alan Velasco +
- Alan Yee +
- Alex B +
- Alex Lubbock +
- Alex Marchenko +
- Alex Rychyk +
- Amol K +
pandas: powerful Python data analysis toolkit, Release 0.23.2

• Andreas Winkler
• Andrew +
• Andrew
• André Jonasson +
• Becky Sweger
• Berkay +
• Bob Haffner +
• Bran Yang
• Brian Tu +
• Brock Mendel +
• Carol Willing +
• Carter Green +
• Chankey Pathak +
• Chris
• Chris Billington
• Chris Filo Gorgolewski +
• Chris Kerr
• Chris M +
• Chris Mazzullo +
• Christian Prinoth
• Christian Stade-Schuldt
• Christoph Moehl +
• DSM
• Daniel Chen +
• Daniel Grady
• Daniel Himmelstein
• Dave Willmer
• David Cook
• David Gwynne
• David Read +
• Dillon Niederhut +
• Douglas Rudd
• Eric Stein +
• Eric Wieser +
• Erik Fredriksen
• Florian Wilhelm +
• Floris Kint +
• Forbidden Donut
• Gabe F +
• Giftlin +
• Giftlin Rajaiah +
• Giulio Pepe +
• Guilherme Beltramini
• Guillem Borrell +
• Hanmin Qin +
• Hendrik Makait +
• Hugues Valois
• Hussain Tamboli +
• Iva Miholic +
• Jan Novotný +
• Jan Rudolph
• Jean Helie +
• Jean-Baptiste Schiratti +
• Jean-Mathieu Deschenes
• Jeff Knupp +
• Jeff Reback
• Jeff Tratner
• JennaVergeynst
• JimStearns206
• Joel Nothman
• John W. O’Brien
• Jon Crall +
• Jon Mease
• Jonathan J. Helmus +
• Joris Van den Bossche
• JosephWagner
• Juarez Bochi
• Julian Kuhlmann +
• Karel De Brabandere
• Kassandra Keeton +
• Keiron Pizzey +
• Keith Webber
• Kernc
• Kevin Sheppard
• Kirk Hansen +
• Licht Takeuchi +
• Lucas Kushner +
• Mahdi Ben Jelloul +
• Makarov Andrey +
• Malgorzata Turzanska +
• Marc Garcia +
• Margaret Sy +
• MarsGuy +
• Matt Bark +
• Matthew Roeschke
• Matti Picus
• Mehmet Ali “Mali” Akmanalp
• Michael Gasvoda +
• Michael Penkov +
• Milo +
• Morgan Stuart +
• Morgan243 +
• Nathan Ford +
• Nick Eubank
• Nick Garvey +
• Oleg Shteynbuk +
• P-Tillmann +
• Pankaj Pandey
• Patrick Luo
• Patrick O’Melveny
• Paul Reidy +
• Paula +
• Peter Quackenbush
• Peter Yanovich +
• Phillip Cloud
• Pierre Haessig
• Pietro Battiston
• Pradyumna Reddy Chinthala
• Prasanjit Prakash
• RobinFiveWords
• Ryan Hendrickson
• Sam Foo
• Sangwoong Yoon +
• Simon Gibbons +
• SimonBaron
• Steven Cutting +
• Sudeep +
• Sylvia +
• T N +
• Telt
• Thomas A Caswell
• Tim Swast +
• Tom Augspurger
• Tong SHEN
• Tuan +
• Utkarsh Upadhyay +
• Vincent La +
• Vivek +
• WANG Aiyong
• WBare
• Wes McKinney
• XF +
• Yi Liu +
• Yosuke Nakabayashi +
• aaron315 +
• abarber4gh +
• aerlund +
• agustín méndez +
• andymaheshw +
• ante328 +
• aviolo +
• bpraggastis
• cbertinato +
• cclauss +
• chernrick
• chris-b1
• dkamm +
• dwkenefick
• economy
• faic +
• fding253 +
• gfyong
• guygoldberg +
• hhuuggoo +
• huashuai +
• ian
• iulia +
• jaredsnyder
• jbrockmendel +
• jdeschenes
• jebob +
• jschendel +
• keitakurita
• kernc +
• kiwirob +
• kjford
• linebp
• lloydkirk
• louispotok +
• majiang +
• manikbhandari +
• matthiashuschle +
• mattip
• maxwasserman +
• mjlove12 +
• nmartensen +
• pandas-docs-bot +
• parchd-1 +
• philipphanemann +
• rdk1024 +
• reidy-p +
• ri938
• ruiann +
• rvernica +
• s-weigand +
• scotthavard92 +
• skwbc +
• step4me +
• tobycheese +
• topper-123 +
• tsdlovell
• ysau +
• zzgao +

38.7 pandas 0.20.0 / 0.20.1

Release date: May 5, 2017

This is a major release from 0.19.2 and includes a number of API changes, deprecations, new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

• New .agg() API for Series/DataFrame similar to the groupby-rolling-resample API’s, see here
• Integration with the feather-format, including a new top-level pd.read_feather() and DataFrame.to_feather() method, see here.
• The .ix indexer has been deprecated, see here
• Panel has been deprecated, see here
• Addition of an IntervalIndex and Interval scalar type, see here
• Improved user API when grouping by index levels in .groupby(), see here
• Improved support for UInt64 dtypes, see here
• A new orient for JSON serialization, orient='table', that uses the Table Schema spec and that gives the possibility for a more interactive repr in the Jupyter Notebook, see here
• Experimental support for exporting styled DataFrames (DataFrame.style) to Excel, see here
• Window binary corr/cov operations now return a MultiIndexed DataFrame rather than a Panel, as Panel is now deprecated, see here
• Support for S3 handling now uses s3fs, see here
• Google BigQuery support now uses the pandas-gbq library, see here
pandas: powerful Python data analysis toolkit, Release 0.23.2

See the v0.20.1 Whatsnew overview for an extensive list of all enhancements and bugs that have been fixed in 0.20.1.

Note: This is a combined release for 0.20.0 and 0.20.1. Version 0.20.1 contains one additional change for backwards-compatibility with downstream projects using pandas’ utils routines. (GH16250)

38.7.1 Thanks

- abaldenko
- Adam J. Stewart
- Adrian
- adrian-stepien
- Ajay Saxena
- Akash Tandon
- Albert Villanova del Moral
- Aleksey Bilogur
- alexandercbooth
- Alexis Mignon
- Amol Kahat
- Andreas Winkler
- Andrew Kittredge
- Anthonios Partheniou
- Arco Bast
- Ashish Singal
- atbd
- bastewart
- Baurzhan Muftakhidinov
- Ben Kandel
- Ben Thayer
- Ben Welsh
- Bill Chambers
- bmagnusson
- Brandon M. Burroughs
- Brian
- Brian McFee
- carlosdanielcsantos
- Carlos Souza
- chaimdemulder

Chapter 38. Release Notes
• Chris
• chris-b1
• Chris Ham
• Christopher C. Aycock
• Christoph Gohlke
• Christoph Paulik
• Chris Warth
• Clemens Brunner
• DaanVanHauwermeiren
• Daniel Himmelstein
• Dave Willmer
• David Cook
• David Gwynne
• David Hoffman
• David Krych
• dickreuter
• Diego Fernandez
• Dimitris Spathis
• discort
• Dmitry L
• Dody Suria Wijaya
• Dominik Stanczak
• Dr-Irv
• Dr. Irv
• dr-leo
• D.S. McNeil
• dubourg
• dwkenefick
• Elliott Sales de Andrade
• Ennemoser Christoph
• Francesc Alted
• Fumito Hamamura
• funnycrab
• gfyoun
• Giacomo Ferroni
• goldenbull

38.7. pandas 0.20.0 / 0.20.1
• Julien Marrec
• Jun Kim
• Justin Solinsky
• Kacawi
• Kamal Kamalaldin
• Kerby Shedden
• Kernc
• Keshav Ramaswamy
• Kevin Sheppard
• Kyle Kelley
• Larry Ren
• Leon Yin
• linebp
• Line Pedersen
• Lorenzo Cestaro
• Luca Scarabello
• Lukasz
• Mahmoud Lababidi
• manu
• manuels
• Mark Mandel
• Matthew Brett
• Matthew Roeschke
• mattip
• Matti Picus
• Matt Roeschke
• maxalbert
• Maximilian Roos
• mcoedawc
• Michael Charlton
• Michael Felt
• Michael Lamparski
• Michiel Stock
• Mikolaj Chwalisz
• Min RK
• Miroslav Šedivý
• Mykola Golubyev
• Nate Yoder
• Nathalie Rud
• Nicholas Ver Halen
• Nick Chmura
• Nolan Nichols
• nuffe
• Pankaj Pandey
• paul-mannino
• Pawel Kordek
• pbreach
• Pete Huang
• Peter
• Peter Csizsek
• Petio Petrov
• Phil Ruffwind
• Pietro Battiston
• Piotr Chromiec
• Prasanjit Prakash
• Robert Bradshaw
• Rob Forgione
• Robin
• Rodolfo Fernandez
• Roger Thomas
• Rouz Azari
• Sahil Dua
• sakkemo
• Sam Foo
• Sami Salonen
• Sarah Bird
• Sarma Tangirala
• scis19fr
• Scott Sanderson
• Sebastian Bank
• Sebastian Gsänger
• Sébastien de Menten
38.8 pandas 0.19.2

Release date: December 24, 2016

This is a minor bug-fix release in the 0.19.x series and includes some small regression fixes, bug fixes and performance improvements.

Highlights include:
• Compatibility with Python 3.6
• Added a Pandas Cheat Sheet. (GH13202).

See the v0.19.2 Whatsnew page for an overview of all bugs that have been fixed in 0.19.2.

38.8.1 Thanks

• Ajay Saxena
• Ben Kandel
• Chris
• Chris Ham
• Christopher C. Aycock
• Daniel Himmelstein
• Dave Willmer
• Dr-Irv
• gfyounge
• hesham shabana
• Jeff Carey
• Jeff Reback
• Joe Jevnik
• Joris Van den Bossche
• Julian Santander
• Kerby Shedden
• Keshav Ramaswamy
• Kevin Sheppard
• Luca Scarabello
• Matti Picus
• Matt Roeschke
• Maximilian Roos
• Mykola Golubyev
• Nate Yoder
• Nicholas Ver Halen
• Pawel Kordek
• Pietro Battiston
• Rodolfo Fernandez
• sinhrks
• Tara Adiseshan
• Tom Augspurger
38.9 pandas 0.19.1

Release date: November 3, 2016

This is a minor bug-fix release from 0.19.0 and includes some small regression fixes, bug fixes and performance improvements.

See the v0.19.1 Whatsnew page for an overview of all bugs that have been fixed in 0.19.1.

38.9.1 Thanks

- Adam Chainz
- Anthonios Partheniou
- Arash Rouhani
- Ben Kandel
- Brandon M. Burroughs
- Chris
- chris-b1
- Chris Warth
- David Krych
- dubourg
- gfyoung
- Iván Vallés Pérez
- Jeff Reback
- Joe Jevnik
- Jon M. Mease
- Joris Van den Bossche
- Josh Owen
- Keshav Ramaswamy
- Larry Ren
- mattrijk
- Michael Felt
- paul-mannino
- Piotr Chromiec
- Robert Bradshaw
- Sinhrks
38.10 pandas 0.19.0

Release date: October 2, 2016

This is a major release from 0.18.1 and includes number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- `merge_asof()` for asof-style time-series joining, see here
- `.rolling()` is now time-series aware, see here
- `read_csv()` now supports parsing Categorical data, see here
- A function `union_categorical()` has been added for combining categoricals, see here
- `PeriodIndex` now has its own `period` dtype, and changed to be more consistent with other `Index` classes. See here
- Sparse data structures gained enhanced support of `int` and `bool` dtypes, see here
- Comparison operations with `Series` no longer ignores the index, see here for an overview of the API changes.
- Introduction of a pandas development API for utility functions, see here.
- Deprecation of `Panel4D` and `PanelND`. We recommend to represent these types of n-dimensional data with the `xarray` package.
- Removal of the previously deprecated modules `pandas.io.data`, `pandas.io.wb`, `pandas.tools.rplot`.

See the v0.19.0 Whatsnew overview for an extensive list of all enhancements and bugs that have been fixed in 0.19.0.

38.10.1 Thanks

- adneu
- Adrien Emery
- agraboso
- Alex Alekseyev
- Alex Vig
- Allen Riddell
- Amol
- Amol Agrawal
- Andy R. Terrel
- Anthonios Partheniou
- babakkeyvani
- Ben Kandel
• Bob Baxley
• Brett Rosen
• c123w
• Camilo Cota
• Chris
• chris-b1
• Chris Grinolds
• Christian Hudon
• Christopher C. Aycock
• Chris Warth
• cmazzullo
• conquistador1492
• cr3
• Daniel Siladji
• Douglas McNeil
• Drewrey Lupton
• dsm054
• Eduardo Blancas Reyes
• Elliot Marsden
• Evan Wright
• Felix Marczinowski
• Francis T. O’Donovan
• Gábor Lipták
• Geraint Duck
• gfyoung
• Giacomo Ferroni
• Grant Roch
• Haleemur Ali
• harshul1610
• Hassan Shamim
• iamsimha
• Iulius Curt
• Ivan Nazarov
• jackieleng
• Jeff Reback
• Jeffrey Gerard
• Jenn Olsen
• Jim Crist
• Joe Jevnik
• John Evans
• John Freeman
• John Liekezer
• Johnny Gill
• John W. O’Brien
• John Zwinick
• Jordan Erenrich
• Joris Van den Bossche
• Josh Howes
• Jozef Brandys
• Kamil Sindi
• Ka Wo Chen
• Kerby Shedden
• Kerne
• Kevin Sheppard
• Matthieu Brucher
• Maximilian Roos
• Michael Scherer
• Mike Graham
• Mortada Mehyar
• mpuelles
• Muhammad Haseeb Tariq
• Nate George
• Neil Parley
• Nicolas Bonnotte
• OXPHOS
• Pan Deng / Zora
• Paul
• Pauli Virtanen
• Paul Mestemaker
• Pawel Kordek
• Pietro Battiston
• pijucha
• Piotr Jucha
• priyankjain
• Ravi Kumar Nimmi
• Robert Gieseke
• Robert Kern
• Roger Thomas
• Roy Keyes
• Russell Smith
• Sahil Dua
• Sanjiv Lobo
• Sašo Stanovnik
• Shawn Heide
• sinhrks
• Sinhrks
• Stephen Kappel
• Steve Choi
• Stewart Henderson
• Sudarshan Konge
• Thomas A Caswell
• Tom Augspurger
• Tom Bird
• Uwe Hoffmann
• wcwagner
• WillAyd
• Xiang Zhang
• Yadunandan
• Yaroslav Halchenko
• YG-Riku
• Yuichiro Kaneko
• yui-knk
• zhangjinjie
• znmean
• Yan Facai
38.11 pandas 0.18.1

Release date: (May 3, 2016)

This is a minor release from 0.18.0 and includes a large number of bug fixes along with several new features, enhancements, and performance improvements.

Highlights include:

- `.groupby(...)` has been enhanced to provide convenient syntax when working with `.rolling(..)`, `.expanding(..)` and `.resample(..)` per group, see here
- `pd.to_datetime()` has gained the ability to assemble dates from a DataFrame, see here
- Method chaining improvements, see here.
- Custom business hour offset, see here.
- Many bug fixes in the handling of sparse, see here
- Expanded the Tutorials section with a feature on modern pandas, courtesy of @TomAugbsburger. (GH13045).

See the v0.18.1 Whatsnew overview for an extensive list of all enhancements and bugs that have been fixed in 0.18.1.

38.11.1 Thanks

- Andrew Fiore-Gartland
- Bastiaan
- Benoît Vinot
- Brandon Rhodes
- DaCoEx
- Drew Fustin
- Ernesto Freitas
- Filip Ter
- Gregory Livschitz
- Gábor Lipták
- Hassan Kibirige
- Ibis Lin
- Israel Saeta Pérez
- Jason Wolosonovich
- Jeff Reback
- Joe Jevnik
- Joris Van den Bossche
- Joshua Storck
- Ka Wo Chen
- Kerby Shedden
- Kieran O’Mahony
• Leif Walsh
• Mahmoud Lababidi
• Maoyuan Liu
• Mark Roth
• Matt Wittmann
• MaxU
• Maximilian Roos
• Michael Droettboom
• Nick Eubank
• Nicolas Bonnotte
• OXPHOS
• Pauli Virtanen
• Peter Waller
• Pietro Battiston
• Prabhjot Singh
• Robin Wilson
• Roger Thomas
• Sebastian Bank
• Stephen Hoover
• Tim Hopper
• Tom Augspurger
• WANG Aiyong
• Wes Turner
• Winand
• Xbar
• Yan Facai
• adneu
• ajenkins-cargometrics
• behzad nouri
• chinskiy
• gfyoun
• jeps-journal
• jonaslb
• kotefa
• nileracecrew
• onesandzeroes
This is a major release from 0.17.1 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- Moving and expanding window functions are now methods on Series and DataFrame, similar to `.groupby`, see [here](#).
- Adding support for a `RangeIndex` as a specialized form of the `Int64Index` for memory savings, see [here](#).
- API breaking change to the `.resample` method to make it more `.groupby` like, see [here](#).
- Removal of support for positional indexing with floats, which was deprecated since 0.14.0. This will now raise a `TypeError`, see [here](#).
- The `.to_xarray()` function has been added for compatibility with the `xarray` package, see [here](#).
- The `read_sas` function has been enhanced to read `sas7bdat` files, see [here](#).
- Addition of the `str.extractall()` method, and API changes to the `str.extract()` method and `str.cat()` method.
- `pd.test()` top-level nose test runner is available (GH4327).

See the [v0.18.0 Whatsnew](#) overview for an extensive list of all enhancements and bugs that have been fixed in 0.18.0.

### 38.12.1 Thanks

- ARF
- Alex Alekseyev
- Andrew McPherson
- Andrew Rosenfeld
- Anthonios Partheniou
- Anton I. Sipos
- Ben
- Ben North
- Bran Yang
- Chris
- Chris Carroux
- Christopher C. Aycock
- Christopher Scanlin
• Cody
• Da Wang
• Daniel Grady
• Dorozhko Anton
• Dr-Irv
• Erik M. Bray
• Evan Wright
• Francis T. O’Donovan
• Frank Cleary
• Gianluca Rossi
• Graham Jeffries
• Guillaume Horel
• Henry Hammond
• Isaac Schwabacher
• Jean-Mathieu Deschenes
• Jeff Reback
• Joe Jevnik
• John Freeman
• John Fremlin
• Jonas Hoersch
• Joris Van den Bossche
• Joris Vankerschaver
• Justin Lecher
• Justin Lin
• Ka Wo Chen
• Keming Zhang
• Kerby Shedden
• Kyle
• Marco Farrugia
• MasonGallo
• MattRijk
• Matthew Lurie
• Maximilian Roos
• Mayank Asthana
• Mortada Mehyar
• Moussa Taifi
• Navreet Gill
• Nicolas Bonnotte
• Paul Reiners
• Philip Gura
• Pietro Battiston
• RahulHP
• Randy Carnevale
• Rinoc Johnson
• Rishipuri
• Sangmin Park
• Scott E Lasley
• Sereger13
• Shannon Wang
• Skipper Seabold
• Thierry Moisan
• Thomas A Caswell
• Toby Dylan Hocking
• Tom Augspurger
• Travis
• Trent Hauck
• Tux1
• Varun
• Wes McKinney
• Will Thompson
• Yoav Ram
• Yoong Kang Lim
• Yoshiki Vázquez Baeza
• Young Joong Kim
• Younggun Kim
• Yuval Langer
• alex argunov
• behzad nouri
• boombard
• brian-pantano
• chromy
• daniel
38.13 pandas 0.17.1

**Release date:** (November 21, 2015)

This is a minor release from 0.17.0 and includes a large number of bug fixes along with several new features, enhancements, and performance improvements.

Highlights include:

- Support for Conditional HTML Formatting, see [here](#)
- Releasing the GIL on the csv reader & other ops, see [here](#)
- Regression in `DataFrame.drop_duplicates` from 0.16.2, causing incorrect results on integer values (GH11376)

See the v0.17.1 **Whatsnew** overview for an extensive list of all enhancements and bugs that have been fixed in 0.17.1.

### 38.13.1 Thanks

- Aleksandr Drozd
- Alex Chase
- Anthonios Partheniou
- BrenBarn
- Brian J. McGuirk
- Chris
- Christian Berendt
- Christian Perez
• Cody Piersall
• Data & Code Expert Experimenting with Code on Data
• DrIrv
• Evan Wright
• Guillaume Gay
• Hamed Saljooghinejad
• Iblis Lin
• Jake VanderPlas
• Jan Schulz
• Jean-Mathieu Deschenes
• Jeff Reback
• Jimmy Callin
• Joris Van den Bossche
• K.-Michael Aye
• Ka Wo Chen
• Loïc Séguin-C
• Luo Yicheng
• Magnus Jöud
• Manuel Leonhardt
• Matthew Gilbert
• Maximilian Roos
• Michael
• Nicholas Stahl
• Nicolas Bonnotte
• Pastafarianist
• Petra Chong
• Phil Schaf
• Philipp A
• Rob deCarvalho
• Roman Khomenko
• Rémy Léone
• Sebastian Bank
• Thierry Moisan
• Tom Augspurger
• Tux1
• Varun
38.14 pandas 0.17.0

Release date: (October 9, 2015)

This is a major release from 0.16.2 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes. We recommend that all users upgrade to this version.

Highlights include:

- Release the Global Interpreter Lock (GIL) on some cython operations, see here
- Plotting methods are now available as attributes of the .plot accessor, see here
- The sorting API has been revamped to remove some long-time inconsistencies, see here
- Support for a datetime64[ns] with timezones as a first-class dtype, see here
- The default for to_datetime will now be to raise when presented with unparsable formats, previously this would return the original input. Also, date parse functions now return consistent results. See here
- The default for dropna in HDFStore has changed to False, to store by default all rows even if they are all NaN, see here
- Datetime accessor (dt) now supports Series.dt.strftime to generate formatted strings for datetime-likes, and Series.dt.total_seconds to generate each duration of the timedelta in seconds. See here
- Period and PeriodIndex can handle multiplied freq like 3D, which corresponding to 3 days span. See here
- Development installed versions of pandas will now have PEP440 compliant version strings (GH9518)
- Development support for benchmarking with the Air Speed Velocity library (GH8316)
• Support for reading SAS xport files, see here
• Documentation comparing SAS to pandas, see here
• Removal of the automatic TimeSeries broadcasting, deprecated since 0.8.0, see here
• Display format with plain text can optionally align with Unicode East Asian Width, see here
• Compatibility with Python 3.5 (GH11097)
• Compatibility with matplotlib 1.5.0 (GH11111)

See the v0.17.0 Whatsnew overview for an extensive list of all enhancements and bugs that have been fixed in 0.17.0.

### 38.14.1 Thanks

• Alex Rothberg
• Andrea Bedini
• Andrew Rosenfeld
• Andy Li
• Anthonios Partheniou
• Artemy Kolchinsky
• Bernard Willers
• Charlie Clark
• Chris
• Chris Whelan
• Christoph Gohlke
• Christopher Whelan
• Clark Fitzgerald
• Clearfield Christopher
• Dan Ringwalt
• Daniel Ni
• Data & Code Expert Experimenting with Code on Data
• David Cottrell
• David John Gagne
• David Kelly
• ETF
• Eduardo Schettino
• Egor
• Egor Panfilov
• Evan Wright
• Frank Pinter
• Gabriel Araujo
• Garrett-R
• Gianluca Rossi
• Guillaume Gay
• Guillaume Poulin
• Harsh Nisar
• Ian Henriksen
• Ian Hoegen
• Jaidev Deshpande
• Jan Rudolph
• Jan Schulz
• Jason Swails
• Jeff Reback
• Jonas Buyl
• Joris Van den Bossche
• Joris Vankerschaver
• Josh Levy-Kramer
• Julien Danjou
• Ka Wo Chen
• Karrie Kehoe
• Kelsey Jordahl
• Kerby Shedden
• Kevin Sheppard
• Lars Buitinck
• Leif Johnson
• Luis Ortiz
• Mac
• Matt Gambogi
• Matt Savoie
• Matthew Gilbert
• Maximilian Roos
• Michelangelo D’Agostino
• Mortada Mehyar
• Nick Eubank
• Nipun Batra
• Ondřej Čertik
• Phillip Cloud
pandas: powerful Python data analysis toolkit, Release 0.23.2

- Pratap Vardhan
- Rafal Skolasinski
- Richard Lewis
- Rinoc Johnson
- Rob Levy
- Robert Gieseke
- Safia Abdalla
- Samuel Denny
- Saumitra Shahapure
- Sebastian Pölsterl
- Sebastian Rubbert
- Sheppard, Kevin
- Sinhrks
- Siu Kwan Lam
- Skipper Seabold
- Spencer Carruciu
- Stephan Hoyer
- Stephen Hoover
- Stephen Pascoe
- Terry Santegoeds
- Thomas Grainger
- Tjerk Santegoeds
- Tom Augspurger
- Vincent Davis
- Winterflower
- Yaroslav Halchenko
- Yuan Tang (Terry)
- agijsberts
- ajcr
- behzad nouri
- cel4
- cyrusmaher
- davidovitch
- ganego
- jreback
- juricast

Chapter 38. Release Notes
• larvian
• maximilianr
• msund
• rekcahpassyla
• robertzk
• scls19fr
• seth-p
• sinhrks
• springcoil
• terrytangyuan
• tzinckgraf

38.15 pandas 0.16.2

**Release date:** (June 12, 2015)

This is a minor release from 0.16.1 and includes a large number of bug fixes along with several new features, enhancements, and performance improvements.

Highlights include:

• A new `pipe` method, see [here](#)
• Documentation on how to use `numba` with `pandas`, see [here](#)

See the v0.16.2 *Whatsnew* overview for an extensive list of all enhancements and bugs that have been fixed in 0.16.2.

38.15.1 Thanks

• Andrew Rosenfeld
• Artemy Kolchinsky
• Bernard Willers
• Christer van der Meeren
• Christian Hudon
• Constantine Glen Evans
• Daniel Julius Lasiman
• Evan Wright
• Francesco Brundu
• Gaëtan de Menten
• Jake VanderPlas
• James Hiebert
• Jeff Reback
38.16 pandas 0.16.1

Release date: (May 11, 2015)

This is a minor release from 0.16.0 and includes a large number of bug fixes along with several new features, enhancements, and performance improvements. A small number of API changes were necessary to fix existing bugs.

See the v0.16.1 Whatsnew overview for an extensive list of all API changes, enhancements and bugs that have been fixed in 0.16.1.

38.16.1 Thanks

- Alfonso MHC
- Andy Hayden
- Artemy Kolchinsky
- Chris Gilmer
- Chris Grinolds
- Dan Birken
- David BROCHART
- David Hirschfeld
• David Stephens
• Dr. Leo
• Evan Wright
• Frans van Dunné
• Hatem Nassrat
• Henning Sperr
• Hugo Herter
• Jan Schulz
• Jeff Blackburne
• Jeff Reback
• Jim Crist
• Jonas Abernot
• Joris Van den Bossche
• Kerby Shedden
• Leo Razoumov
• Manuel Riel
• Mortada Mehyar
• Nick Burns
• Nick Eubank
• Olivier Grisel
• Phillip Cloud
• Pietro Battiston
• Roy Hyunjin Han
• Sam Zhang
• Scott Sanderson
• Stephan Hoyer
• Tiago Antao
• Tom Ajamian
• Tom Augspurger
• Tomaz Berisa
• Vikram Shigur
• Vladimir Filimonov
• William Hogman
• Yasin A
• Younggun Kim
• behzad nouri
38.17 pandas 0.16.0

Release date: (March 22, 2015)

This is a major release from 0.15.2 and includes a number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes.

Highlights include:

- DataFrame.assign method, see here
- Series.to_coo/from_coo methods to interact with scipy.sparse, see here
- Backwards incompatible change to Timedelta to conform the .seconds attribute with datetime.timedelta, see here
- Changes to the .loc slicing API to conform with the behavior of .ix see here
- Changes to the default for ordering in the Categorical constructor, see here
- The pandas.tools.rplot, pandas.sandbox.qtpandas and pandas.rpy modules are deprecated. We refer users to external packages like seaborn, pandas-qt and rpy2 for similar or equivalent functionality, see here

See the v0.16.0 Whatsnew overview or the issue tracker on GitHub for an extensive list of all API changes, enhancements and bugs that have been fixed in 0.16.0.

38.17.1 Thanks

- Aaron Toth
- Alan Du
- Alessandro Amici
- Artemy Kolchinsky
- Ashwini Chaudhary
- Ben Schiller
- Bill Letson
- Brandon Bradley
- Chau Hoang
- Chris Reynolds
- Chris Whelan
- Christer van der Meer
- David Cottrell
- David Stephens
- Ehsan Azarnasab
- Garrett-R
- Guillaume Gay
- Jake Torcasso
- Jason Sexauer
- Jeff Reback
- John McNamara
- Joris Van den Bossche
- Joschka zur Jacobsmühlen
- Juarez Bochi
- Junya Hayashi
- K.-Michael Aye
- Kerby Shedden
- Kevin Sheppard
- Kieran O’Mahony
- Kodi Arfer
- Matti Airas
- Min RK
- Mortada Mehyar
- Robert
- Scott E Lasley
- Scott Lasley
- Sergio Pascual
- Skipper Seabold
- Stephan Hoyer
- Thomas Grainger
- Tom Augspurger
Release date: (December 12, 2014)

This is a minor release from 0.15.1 and includes a large number of bug fixes along with several new features, enhancements, and performance improvements. A small number of API changes were necessary to fix existing bugs.

See the v0.15.2 Whatsnew overview for an extensive list of all API changes, enhancements and bugs that have been fixed in 0.15.2.

38.18.1 Thanks

• Aaron Staple
• Angelos Evripiotis
• Artemy Kolchinsky
• Benoit Pointet
• Brian Jacobowski
• Charalampos Papaloizou
• Chris Warth
• David Stephens
pandas: powerful Python data analysis toolkit, Release 0.23.2

- sinhrks
- unutbu
- wavedatalab
- Åsmund Hjulstad

38.19 pandas 0.15.1

**Release date:** (November 9, 2014)

This is a minor release from 0.15.0 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes.

See the [v0.15.1 Whatsnew](#) overview for an extensive list of all API changes, enhancements and bugs that have been fixed in 0.15.1.

38.19.1 Thanks

- Aaron Staple
- Andrew Rosenfeld
- Anton I. Sipos
- Artemy Kolchinsky
- Bill Letson
- Dave Hughes
- David Stephens
- Guillaume Horel
- Jeff Reback
- Joris Van den Bossche
- Kevin Sheppard
- Nick Stahl
- Sanghee Kim
- Stephan Hoyer
- TomAugspurger
- WANG Aiyong
- behzad nouri
- immerrr
- jnmclarty
- jreback
- pallav-fdsi
- unutbu
38.20 pandas 0.15.0

Release date: (October 18, 2014)

This is a major release from 0.14.1 and includes a number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes.

Highlights include:

- Drop support for NumPy < 1.7.0 (GH7711)
- The Categorical type was integrated as a first-class pandas type, see here
- New scalar type Timedelta, and a new index type TimedeltaIndex, see here
- New DataFrame default display for df.info() to include memory usage, see Memory Usage
- New datetimelike properties accessor .dt for Series, see Datetimelike Properties
- Split indexing documentation into Indexing and Selecting Data and MultiIndex / Advanced Indexing
- Split out string methods documentation into Working with Text Data
- read_csv will now by default ignore blank lines when parsing, see here
- API change in using Indexes in set operations, see here
- Internal refactoring of the Index class to no longer sub-class ndarray, see Internal Refactoring
- dropping support for PyTables less than version 3.0.0, and numexpr less than version 2.1 (GH7990)

See the v0.15.0 Whatsnew overview or the issue tracker on GitHub for an extensive list of all API changes, enhancements and bugs that have been fixed in 0.15.0.

38.20.1 Thanks

- Aaron Schumacher
- Adam Greenhall
- Andy Hayden
- Anthony O’Brien
- Artemy Kolchinsky
- behzad nouri
- Benedikt Sauer
- benjamin
- Benjamin Thyreau
- Ben Schiller
- bjonen
- BorisVerk
- Chris Reynolds
- Chris Stoafer
- Dav Clark
- dlovell
pandas: powerful Python data analysis toolkit, Release 0.23.2

- DSM
- dsm054
- FragLegs
- German Gomez-Herrero
- Hsiaoming Yang
- Huan Li
- hunterowens
- Hyungtae Kim
- immerrr
- Isaac Slavitt
- ischwabacher
- Jacob Schaeer
- Jacob Wasserman
- Jan Schulz
- Jeff Tratner
- Jesse Farnham
- jmorris0x0
- jnmclarty
- Joe Bradish
- Joerg Rittinger
- John W. O’Brien
- Joris Van den Bossche
- jreback
- Kevin Sheppard
- klonuo
- Kyle Meyer
- lexual
- Max Chang
- mcjcode
- Michael Mueller
- Michael W Schatzow
- Mike Kelly
- Mortada Mehyar
- mtrbean
- Nathan Sanders
- Nathan Typanski
38.21  pandas 0.14.1

Release date:  (July 11, 2014)

This is a minor release from 0.14.0 and includes a small number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes.

Highlights include:

- New methods `select_dtypes()` to select columns based on the dtype and `sem()` to calculate the standard error of the mean.
- Support for dateutil timezones (see docs).
• Support for ignoring full line comments in the `read_csv()` text parser.
• New documentation section on *Options and Settings*.
• Lots of bug fixes.

See the v0.14.1 *Whatsnew* overview or the issue tracker on GitHub for an extensive list of all API changes, enhancements and bugs that have been fixed in 0.14.1.

### 38.21.1 Thanks

• Andrew Rosenfeld
• Andy Hayden
• Benjamin Adams
• Benjamin M. Gross
• Brian Quistorff
• Brian Wignall
• bwignall
• clham
• Daniel Waeb
• David Bew
• David Stephens
• DSM
• dsm054
• helger
• immerrr
• Jacob Schaer
• jaimefrio
• Jan Schulz
• John David Reaver
• John W. O’Brien
• Joris Van den Bossche
• jreback
• Julien Danjou
• Kevin Sheppard
• K.-Michael Aye
• Kyle Meyer
• lexual
• Matthew Brett
• Matt Wittmann
38.22 pandas 0.14.0

Release date: (May 31, 2014)
This is a major release from 0.13.1 and includes a number of API changes, several new features, enhancements, and performance improvements along with a large number of bug fixes.

Highlights include:

• Officially support Python 3.4
• SQL interfaces updated to use sqlalchemy, see here.
• Display interface changes, see here
• MultiIndexing using Slicers, see here.
• Ability to join a singly-indexed DataFrame with a multi-indexed DataFrame, see here
• More consistency in groupby results and more flexible groupby specifications, see here
• Holiday calendars are now supported in CustomBusinessDay, see here
• Several improvements in plotting functions, including: hexbin, area and pie plots, see here.
• Performance doc section on I/O operations, see here

See the v0.14.0 Whatsnew overview or the issue tracker on GitHub for an extensive list of all API changes, enhancements and bugs that have been fixed in 0.14.0.
38.22.1 Thanks

- Acanthostega
- Adam Marcus
- agijsberts
- akittredge
- Alex Gaudio
- Alex Rothberg
- AllenDowney
- Andrew Rosenfeld
- Andy Hayden
- ankostis
- anomrake
- Antoine Mazières
- antron-d
- bashtage
- Benedikt Sauer
- benjamin
- Brad Buran
- bwignall
- cgohlke
- chebee7i
- Christopher Whelan
- Clark Fitzgerald
- clham
- Dale Jung
- Dan Allan
- Dan Birken
- danielballan
- Daniel Waeber
- David Jung
- David Stephens
- Douglas McNeil
- DSM
- Garrett Drapala
- Gouthaman Balaraman
- Guillaume Poulin
• hshimizu77
• hugo
• immerrr
• ischwabacher
• Jacob Howard
• Jacob Schaer
• jaimefrio
• Jason Sexauer
• Jeff Reback
• Jeffrey Starr
• Jeff Tratner
• John David Reaver
• John McNamara
• John W. O’Brien
• Jonathan Chambers
• Joris Van den Bossche
• jreback
• jsexauer
• Julia Evans
• Júlio
• Katie Atkinson
• kdiether
• Kelsey Jordahl
• Kevin Sheppard
• K.-Michael Aye
• Matthias Kuhn
• Matt Wittmann
• Max Grender-Jones
• Michael E. Gruen
• michaelws
• mikebailey
• Mike Kelly
• Nipun Batra
• Noah Spies
• ojdo
• onesandzeroes
38.23 pandas 0.13.1

Release date: (February 3, 2014)

38.23.1 New Features

- Added `date_format` and `datetime_format` attribute to `ExcelWriter`. (GH4133)

38.23.2 API Changes

- `Series.sort` will raise a `ValueError` (rather than a `TypeError`) on sorting an object that is a view of another (GH5856, GH5853)
- `Raise/Warn SettingWithCopyError` (according to the option `chained_assignment` in more cases, when detecting chained assignment, related (GH5938, GH6025)
• DataFrame.head(0) returns self instead of empty frame (GH5846)
• autocorrelation_plot now accepts **kwargs. (GH5623)
• convert_objects now accepts a convert_timedelta='coerce' argument to allow forced dtype conversion of timedeltas (GH5458, issue: 5689)
• Add -NaN and -nan to the default set of NA values (GH5952). See NA Values.
• NDFrame now has an equals method. (GH5283)
• DataFrame.apply will use the reduce argument to determine whether a Series or a DataFrame should be returned when the DataFrame is empty (GH6007).

38.23.3 Experimental Features

38.23.4 Improvements to existing features

• perf improvements in Series datetime/timedelta binary operations (GH5801)
• option_context context manager now available as top-level API (GH5752)
• df.info() view now display dtype info per column (GH5682)
• df.info() now honors option max_info_rows, disable null counts for large frames (GH5974)
• perf improvements in DataFrame count/dropna for axis=1
• Series.str.contains now has a regex=False keyword which can be faster for plain (non-regex) string patterns. (GH5879)
• support dtypes property on Series/Panel/Panel4D
• extend Panel.apply to allow arbitrary functions (rather than only ufuncs) (GH1148) allow multiple axes to be used to operate on slabs of a Panel
• The ArrayFormatter for datetime and timedelta64 now intelligently limit precision based on the values in the array (GH3401)
• pd.show_versions() is now available for convenience when reporting issues.
• perf improvements to Series.str.extract (GH5944)
• perf improvements in dtypes/ftypes methods (GH5968)
• perf improvements in indexing with object dtypes (GH5968)
• improved dtype inference for timedelta like passed to constructors (GH5458, GH5689)
• escape special characters when writing to latex (:issue: 5374)
• perf improvements in DataFrame.apply (GH6013)
• pd.read_csv and pd.to_datetime learned a new infer_datetime_format keyword which greatly improves parsing perf in many cases. Thanks to @lexical for suggesting and @danbirken for rapidly implementing. (GH5490, issue: 6021)
• add ability to recognize ‘%p’ format code (am/pm) to date parsers when the specific format is supplied (GH5361)
• Fix performance regression in JSON IO (GH5765)
• performance regression in Index construction from Series (GH6150)
38.23.5 Bug Fixes

- Bug in `io.wb.get_countries` not including all countries (GH6008)
- Bug in Series replace with timestamp dict (GH5797)
- `read_csv/read_table` now respects the `prefix` kwarg (GH5732).
- Bug in selection with missing values via `.ix` from a duplicate indexed DataFrame failing (GH5835)
- Fix issue of boolean comparison on empty DataFrames (GH5808)
- Bug in `isnull` handling `NaT` in an object array (GH5443)
- Bug in `to_datetime` when passed a `np.nan` or integer datelike and a format string (GH5863)
- Bug in `groupby` dtype conversion with datetimelike (GH5869)
- Regression in handling of empty Series as indexers to Series (GH5877)
- Bug in internal caching, related to (GH5727)
- Testing bug in reading JSON/msgpack from a non-filepath on windows under py3 (GH5874)
- Bug when assigning to `.ix[tuple(...)]` (GH5896)
- Bug in fully reindexing a Panel (GH5905)
- Bug in `idxmin/max` with object dtypes (GH5914)
- Bug in `BusinessDay` when adding n days to a date not on offset when n>5 and n%5==0 (GH5890)
- Bug in assigning to chained series with a series via ix (GH5928)
- Bug in creating an empty DataFrame, copying, then assigning (GH5932)
- Bug in `DataFrame.tail` with empty frame (GH5846)
- Bug in propagating metadata on `resample` (GH5862)
- Fixed string-representation of `NaT` to be “NaT” (GH5708)
- Fixed string-representation for `Timestamp` to show nanoseconds if present (GH5912)
- `pd.match` not returning passed sentinel
- `Panel.to_frame()` no longer fails when `major_axis` is a `MultiIndex` (GH5402).
- Bug in `pd.read_msgpack` with inferring a `DateTimeIndex` frequency incorrectly (GH5947)
- Fixed `to_datetime` for array with both Tz-aware datetimes and `NaT`'s (GH5961)
- Bug in rolling skew/kurtosis when passed a Series with bad data (GH5749)
- Bug in `scipy.interpolate` methods with a datetime index (GH5975)
- Bug in `NaT` comparison if a mixed datetime/np.datetime64 with `NaT` were passed (GH5968)
- Fixed bug with `pd.concat` losing dtype information if all inputs are empty (GH5742)
- Recent changes in IPython cause warnings to be emitted when using previous versions of pandas in QTConsole, now fixed. If you’re using an older version and need to suppress the warnings, see (GH5922).
- Bug in merging `timedelta` dtypes (GH5695)
- Bug in `plotting.scatter_matrix` function. Wrong alignment among diagonal and off-diagonal plots, see (GH5497).
- Regression in Series with a multi-index via ix (GH6018)
• Bug in Series.xs with a multi-index (GH6018)
• Bug in Series construction of mixed type with datelike and an integer (which should result in object type and not automatic conversion) (GH6028)
• Possible segfault when chained indexing with an object array under NumPy 1.7.1 (GH6026, GH6056)
• Bug in setting using fancy indexing a single element with a non-scalar (e.g. a list), (GH6043)
• to_sql did not respect if_exists (GH4110 GH4304)
• Regression in .get(0) indexing from 0.12 (GH5652)
• Subtle iloc indexing bug, surfaced in (GH6059)
• Bug with insert of strings into DatetimeIndex (GH5818)
• Fixed unicode bug in to_html/HTML repr (GH6098)
• Fixed missing arg validation in get_options_data (GH6105)
• Bug in assignment with duplicate columns in a frame where the locations are a slice (e.g. next to each other) (GH6120)
• Bug in propagating _ref_locs during construction of a DataFrame with dups index/columns (GH6121)
• Bug in DataFrame.apply when using mixed datelike reductions (GH6125)
• Bug in DataFrame.append when appending a row with different columns (GH6129)
• Bug in DataFrame construction with recarray and non-ns datetime dtype (GH6140)
• Bug in .loc setitem indexing with a datafarme on rhs, multiple item setting, and a datetimelike (GH6152)
• Fixed a bug in query/eval during lexicographic string comparisons (GH6155).
• Fixed a bug in query where the index of a single-element Series was being thrown away (GH6148).
• Bug in HDFStore on appending a dataframe with multi-indexed columns to an existing table (GH6167)
• Consistency with dtypes in setting an empty DataFrame (GH6171)
• Bug in selecting on a multi-index HDFStore even in the presence of under specified column spec (GH6169)
• Bug in nanops.var with ddof=1 and 1 elements would sometimes return inf rather than nan on some platforms (GH6136)
• Bug in Series and DataFrame bar plots ignoring the use_index keyword (GH6209)
• Bug in groupby with mixed str/int under python3 fixed; argsort was failing (GH6212)

38.24 pandas 0.13.0

Release date: January 3, 2014

38.24.1 New Features

• plot(kind='kde') now accepts the optional parameters bw_method and ind, passed to scipy.stats.gaussian_kde() (for scipy >= 0.11.0) to set the bandwidth, and to gkde.evaluate() to specify the indices at which it is evaluated, respectively. See scipy docs. (GH4298)
• Added isin method to DataFrame (GH4211)
• df.to_clipboard() learned a new excel keyword that let’s you paste df data directly into excel (enabled by default). (GH5070).

• Clipboard functionality now works with PySide (GH4282)

• New extract string method returns regex matches more conveniently (GH4685)

• Auto-detect field widths in read_fwf when unspecified (GH4488)

• to_csv() now outputs datetime objects according to a specified format string via the date_format keyword (GH4313)

• Added LastWeekOfMonth DateOffset (GH4637)

• Added cumcount groupby method (GH4646)

• Added FY5253, and FY5253Quarter DateOffsets (GH4511)

• Added mode() method to Series and DataFrame to get the statistical mode(s) of a column/series. (GH5367)

### 38.24.2 Experimental Features

• The new eval() function implements expression evaluation using numexpr behind the scenes. This results in large speedups for complicated expressions involving large DataFrames/Series.

• DataFrame has a new eval() that evaluates an expression in the context of the DataFrame; allows inline expression assignment

• A query() method has been added that allows you to select elements of a DataFrame using a natural query syntax nearly identical to Python syntax.

• pd.eval and friends now evaluate operations involving datetime64 objects in Python space because numexpr cannot handle NaT values (GH4897).

• Add msgpack support via pd.read_msgpack() and pd.to_msgpack() / df.to_msgpack() for serialization of arbitrary pandas (and python objects) in a lightweight portable binary format (GH686, GH5506)

• Added PySide support for the qtpandas DataFrameModel and DataFrameWidget.

• Added pandas.io.gbq for reading from (and writing to) Google BigQuery into a DataFrame. (GH4140)

### 38.24.3 Improvements to existing features

• read_html now raises a URLLError instead of catching and raising a ValueError (GH4303, GH4305)

• read_excel now supports an integer in its sheetname argument giving the index of the sheet to read in (GH4301).

• get_dummies works with NaN (GH4446)

• Added a test for read_clipboard() and to_clipboard() (GH4282)

• Added bins argument to value_counts (GH3945), also sort and ascending, now available in Series method as well as top-level function.

• Text parser now treats anything that reads like inf (“inf”, “Inf”, “-Inf”, “iNf”, etc.) to infinity. (GH4220, GH4219), affecting read_table, read_csv, etc.

• Added a more informative error message when plot arguments contain overlapping color and style arguments (GH4402)

• Significant table writing performance improvements in HDFStore
• JSON date serialization now performed in low-level C code.
• JSON support for encoding datetime.time
• Expanded JSON docs, more info about orient options and the use of the numpy param when decoding.
• Add drop_level argument to xs (GH4180)
• Can now resample a DataFrame with ohlc (GH2320)
• Index.copy() and MultiIndex.copy() now accept keyword arguments to change attributes (i.e., names, levels, labels) (GH4039)
• Add rename and set_names methods to Index as well as set_names, set_levels, set_labels to MultiIndex. (GH4039) with improved validation for all (GH4039, GH4794)
• A Series of dtype timedelta64[ns] can now be divided/multiplied by an integer series (GH4521)
• A Series of dtype timedelta64[ns] can now be divided by another timedelta64[ns] object to yield a float64 dtyped Series. This is frequency conversion; astyping is also supported.
• Timedelta64 support fillna/ffill/bfill with an integer interpreted as seconds, or a timedelta (GH3371)
• Box numeric ops on timedelta Series (GH4984)
• Datetime64 support ffill/bfill
• Performance improvements with __getitem__ on DataFrames with when the key is a column
• Support for using a DateTimeIndex/PeriodsIndex directly in a datelike calculation e.g. s-s.index (GH4629)
• Better/cleaned up exceptions in core/common, io/excel and core/format (GH4721, GH3954), as well as cleaned up test cases in tests/test_frame, tests/test_multilevel (GH4732).
• Performance improvement of timeseries plotting with PeriodIndex and added test to vbench (GH4705 and GH4722)
• Add axis and level keywords to where, so that the other argument can now be an alignable pandas object.
• to_datetime with a format of ‘%Y%m%d’ now parses much faster
• It’s now easier to hook new Excel writers into pandas (just subclass ExcelWriter and register your engine). You can specify an engine in to_excel or in ExcelWriter. You can also specify which writers you want to use by default with config options io.excel.xlsx.writer and io.excel.xls.writer. (GH4745, GH4750)
• Panel.to_excel() now accepts keyword arguments that will be passed to its DataFrame's to_excel() methods. (GH4750)
• Added XlsxWriter as an optional ExcelWriter engine. This is about 5x faster than the default openpyxl xlsx writer and is equivalent in speed to the xlwt xlsx writer module. (GH4542)
• allow DataFrame constructor to accept more list-like objects, e.g. list of collections.Sequence and array.Array objects (GH3783, GH4297, GH4851), thanks @lgautier
• DataFrame constructor now accepts a NumPy masked record array (GH3478), thanks @nothman
• __getitem__ with tuple key (e.g., [:, 2]) on Series without MultiIndex raises ValueError (GH4759, GH4837)
• read_json now raises a (more informative) ValueError when the dict contains a bad key and orient='split' (GH4730, GH4838)
• read_stata now accepts Stata 13 format (GH4291)

• ExcelWriter and ExcelFile can be used as contextmanagers. (GH3441, GH4933)

• pandas is now tested with two different versions of statsmodels (0.4.3 and 0.5.0) (GH4981).

• Better string representations of MultiIndex (including ability to roundtrip via repr). (GH3347, GH4935)

• Both ExcelFile and read_excel to accept an xld.Book for the io (formerly path_or_buf) argument; this requires engine to be set. (GH4961).

• concat now gives a more informative error message when passed objects that cannot be concatenated (GH4608).

• Add halflife option to exponentially weighted moving functions (PR GH4998)

• to_dict now takes records as a possible outtype. Returns an array of column-keyed dictionaries. (GH4936)

• tz_localize can infer a fall daylight savings transition based on the structure of unlocalized data (GH4230)

• DatetimeIndex is now in the API documentation

• Improve support for converting R datasets to pandas objects (more informative index for timeseries and numeric, support for factors, dist, and high-dimensional arrays).

• read_html() now supports the parse_dates, tupleize_cols and thousands parameters (GH4770).

• json_normalize() is a new method to allow you to create a flat table from semi-structured JSON data. See the docs (GH1067)

• DataFrame.from_records() will now accept generators (GH4910)

• DataFrame.interpolate() and Series.interpolate() have been expanded to include interpolation methods from scipy. (GH4434, GH1892)

• Series now supports a to_frame method to convert it to a single-column DataFrame (GH5164)

• DatetimeIndex (and date_range) can now be constructed in a left- or right-open fashion using the closed parameter (GH4579)

• Python csv parser now supports usecols (GH4335)

• Added support for Google Analytics v3 API segment IDs that also supports v2 IDs. (GH5271)

• NDFrame.drop() now accepts names as well as integers for the axis argument. (GH5354)

• Added short docstrings to a few methods that were missing them + fixed the docstrings for Panel flex methods. (GH5336)

• NDFrame.drop(), NDFrame.dropna(), and .drop_duplicates() all accept inplace as a keyword argument; however, this only means that the wrapper is updated inplace, a copy is still made internally. (GH1960, GH5247, GH5628, and related GH2325 [still not closed])

• Fixed bug in tools.plotting.andrews_curves so that lines are drawn grouped by color as expected.

• read_excel() now tries to convert integral floats (like 1.0) to int by default. (GH5394)

• Excel writers now have a default option merge_cells into excel() to merge cells in MultiIndex and Hierarchical Rows. Note: using this option it is no longer possible to round trip Excel files with merged MultiIndex and Hierarchical Rows. Set the merge_cells to False to restore the previous behaviour. (GH5254)

• The FRED DataReader now accepts multiple series (issue`3413`)

• StataWriter adjusts variable names to Stata’s limitations (GH5709)
38.24.4 API Changes

- `DataFrame.reindex()` and forward/backward filling now raises `ValueError` if either index is not monotonic (GH4483, GH4484).

- *pandas* now is Python 2/3 compatible without the need for 2to3 thanks to @jtratner. As a result, *pandas* now uses iterators more extensively. This also led to the introduction of substantive parts of the Benjamin Peterson’s *six* library into *compat*. (GH4384, GH4375, GH4372)

- *pandas.util.compat* and *pandas.util.py3compat* have been merged into *pandas.compat*. *pandas.compat* now includes many functions allowing 2/3 compatibility. It contains both list and iterator versions of range, filter, map and zip, plus other necessary elements for Python 3 compatibility. `lmap`, `lzip`, `lrange` and `lfilter` all produce lists instead of iterators, for compatibility with *numpy*, *subscripting* and *pandas constructors*. (GH4384, GH4375, GH4372)

- deprecated `iterkv`, which will be removed in a future release (was just an alias of `iteritems` used to get around `2to3`’s changes). (GH4384, GH4375, GH4372)

- `Series.get` with negative indexers now returns the same as `[]` (GH4390)

- allow `ix/loc` for `Series/DataFrame/Panel` to set on any axis even when the single-key is not currently contained in the index for that axis (GH2578, GH5226, GH5632, GH5720, GH5744, GH5756)

- Default export for `to_clipboard` is now csv with a sep of `t` for compat (GH3368)

- `at` now will enlarge the object in place (and return the same) (GH2578)

- `DataFrame.plot` will scatter plot x versus y by passing `kind='scatter'` (GH2215)

- **HDFStore**

  - `append_to_multiple` automatically synchronizes writing rows to multiple tables and adds a `dropna` kwarg (GH4698)

  - handle a passed `Series` in table format (GH4330)

  - added an `is_open` property to indicate if the underlying file handle is_open; a closed store will now report ‘CLOSED’ when viewing the store (rather than raising an error) (GH4409)

  - a close of a `HDFStore` now will close that instance of the `HDFStore` but will only close the actual file if the ref count (by PyTables) w.r.t. all of the open handles are 0. Essentially you have a local instance of `HDFStore` referenced by a variable. Once you close it, it will report closed. Other references (to the same file) will continue to operate until they themselves are closed. Performing an action on a closed file will raise `ClosedFileError`

  - removed the `__quiet` attribute, replace by a `DuplicateWarning` if retrieving duplicate rows from a table (GH4367)

  - removed the `warn` argument from `open`. Instead a `PossibleDataLossError` exception will be raised if you try to use `mode='w'` with an `OPEN` file handle (GH4367)

  - allow a passed locations array or mask as a `where` condition (GH4467)

  - add the keyword `dropna=True` to `append` to change whether ALL nan rows are not written to the store (default is `True`, ALL nan rows are NOT written), also settable via the option `io.hdf.dropna_table` (GH4625)

  - the `format` keyword now replaces the `table` keyword; allowed values are `fixed(f)|table(t)` the `Storer` format has been renamed to `Fixed`

  - a column multi-index will be recreated properly (GH4710); raise on trying to use a multi-index with `data_columns` on the same axis

  - `select_as_coordinates` will now return an `Int64Index` of the resultant selection set
- support timedelta64[ns] as a serialization type (GH3577)
- store datetime.date objects as ordinals rather than timetuples to avoid timezone issues (GH2852), thanks @tavistmorph and @numpand
- numexpr 2.2.2 fixes incompatibility in PyTables 2.4 (GH4908)
- flush now accepts an fsync parameter, which defaults to False (GH5364)
- unicode indices not supported on table formats (GH5386)
- pass thru store creation arguments; can be used to support in-memory stores

• JSON
- added date_unit parameter to specify resolution of timestamps. Options are seconds, milliseconds, microseconds and nanoseconds. (GH4362, GH4498).
- added default_handler parameter to allow a callable to be passed which will be responsible for handling otherwise unserializable objects. (GH5138)

• Index and MultiIndex changes (GH4039):
  - Setting levels and labels directly on MultiIndex is now deprecated. Instead, you can use the set_levels() and set_labels() methods.
  - levels, labels and names properties no longer return lists, but instead return containers that do not allow setting of items (‘mostly immutable’)
  - levels, labels and names are validated upon setting and are either copied or shallow-copied.
  - inplace setting of levels or labels now correctly invalidates the cached properties. (GH5238).
  - __deepcopy__ now returns a shallow copy (currently: a view) of the data - allowing metadata changes.
  - MultiIndex.astype() now only allows np.object_-like dtypes and now returns a MultiIndex rather than an Index. (GH4039)
  - Added is_ method to Index that allows fast equality comparison of views (similar to np. may_share_memory but no false positives, and changes on levels and labels setting on MultiIndex). (GH4859, GH4909)
  - Aliased __iadd__ to __add__. (GH4996)

  - Added is_ method to Index that allows fast equality comparison of views (similar to np. may_share_memory but no false positives, and changes on levels and labels setting on MultiIndex). (GH4859, GH4909)

• Infer and downcast dtype if downcast='infer' is passed to fillna/ffill/bfill (GH4604)
• __nonzero__ for all NDFrame objects, will now raise a ValueError, this reverts back to (GH1073, GH4633) behavior. Add .bool() method to NDFrame objects to facilitate evaluating of single-element boolean Series
• DataFrame.update() no longer raises a DataConflictError, it now will raise a ValueError instead (if necessary) (GH4732)
• Series.isin() and DataFrame.isin() now raise a TypeError when passed a string (GH4763). Pass a list of one element (containing the string) instead.
• Remove undocumented/unused kind keyword argument from read_excel, and ExcelFile. (GH4713, GH4712)
• The method argument of NDFrame.replace() is valid again, so that a a list can be passed to to_replace (GH4743).
• provide automatic dtype conversions on _reduce operations (GH3371)
• exclude non-numerics if mixed types with datelike in _reduce operations (GH3371)
• default for tupleize_cols is now False for both to_csv and read_csv. Fair warning in 0.12
  (GH3604)
• moved timedeltas support to pandas.tseries.timedeltas.py; add timedeltas string parsing, add top-level
to_timedelta function
• NDFrame now is compatible with Python’s toplevel abs() function (GH4821).
• raise a TypeError on invalid comparison ops on Series/DataFrame (e.g. integer/datetime) (GH4968)
• added a new index type, Float64Index. This will be automatically created when passing floating values
  in index creation. This enables a pure label-based slicing paradigm that makes [], ix, loc for scalar index-
ing and slicing work exactly the same. Indexing on other index types are preserved (and positional fallback
  for [], ix), with the exception, that floating point slicing on indexes on non Float64Index will raise a
  TypeError, e.g. Series(range(5))[3.5:4.5] (GH263, issue:5375)
• Make Categorical repr nicer (GH4368)
• Remove deprecated Factor (GH3650)
• Remove deprecated set_printoptions/reset_printoptions (issue:3046)
• Remove deprecated _verbose_info (GH3215)
• Begin removing methods that don’t make sense on GroupBy objects (GH4887).
• Remove deprecated read_clipboard/to_clipboard/ExcelFile/ExcelWriter from pandas.
io.parsers (GH3717)
• All non-Index NDFrames (Series, DataFrame, Panel, Panel4D, SparsePanel, etc.), now support the
  entire set of arithmetic operators and arithmetic flex methods (add, sub, mul, etc.). SparsePanel does not
  support pow or mod with non-scalars. (GH3765)
• Arithmetic func factories are now passed real names (suitable for using with super) (GH5240)
• Provide NumPy compatibility with 1.7 for a calling convention like np.prod(pandas_object) as NumPy
  call with additional keyword args (GH4435)
• Provide __dir__ method (and local context) for tab completion / remove ipython completers code (GH4501)
• Support non-unique axes in a Panel via indexing operations (GH4960)
• .truncate will raise a ValueError if invalid before and after dates are given (GH5242)
• Timestamp now supports now/today/utcnow class methods (GH5339)
• default for display.max_seq_len is now 100 rather then None. This activates truncated display (‘…’) of long
  sequences in various places. (GH3391)
• All division with NDFrame - likes is now truedivision, regardless of the future import. You can use // and
  floordiv to do integer division.

```python
In [3]: arr = np.array([1, 2, 3, 4])
In [4]: arr2 = np.array([5, 3, 2, 1])

In [5]: arr / arr2
Out[5]: array([0, 0, 1, 4])

In [6]: pd.Series(arr) / pd.Series(arr2) # no future import required
Out[6]:
```

(continues on next page)
• raise/warn SettingWithCopyError/Warning exception/warning when setting of a copy thru chained assignment is detected, settable via option mode.chained_assignment

• test the list of NA values in the csv parser. add N/A, #NA as independent default na values (GH5521)

• The refactoring involving “Series” deriving from NDFrame breaks rpy2<=2.3.8. an Issue has been opened against rpy2 and a workaround is detailed in GH5698. Thanks @JanSchulz.

• Series.argmin and Series.argmax are now aliased to Series.idxmin and Series.idxmax. These return the index of the min or max element respectively. Prior to 0.13.0 these would return the position of the min / max element (GH6214)

### 38.24.5 Internal Refactoring

In 0.13.0 there is a major refactor primarily to subclass Series from NDFrame, which is the base class currently for DataFrame and Panel, to unify methods and behaviors. Series formerly subclassed directly from ndarray. (GH4080, GH3862, GH816) See Internal Refactoring

• Refactor of series.py/frame.py/panel.py to move common code to generic.py

• added _setup_axes to created generic NDFrame structures

• moved methods
  - from_axes, _wrap_array, axes, ix, loc, iloc, shape, empty, swapaxes, transpose, pop
  - __iter__, keys, __contains__, __len__, __neg__, __invert__
  - convert_objects, as_blocks, as_matrix, values
  - __getstate__, __setstate__ (compat remains in frame/panel)
  - __getattr__, __setattr__
  - _indexed_same, reindex_like, align, where, mask
  - fillna, replace (Series replace is now consistent with DataFrame)
  - filter (also added axis argument to selectively filter on a different axis)
  - reindex, reindex_axis, take
  - truncate (moved to become part of NDFrame)
  - isnull/notnull now available on NDFrame objects

• These are API changes which make Panel more consistent with DataFrame

• swapaxes on a Panel with the same axes specified now return a copy

• support attribute access for setting

• filter supports same API as original DataFrame filter

• fillna refactored to core/generic.py, while > 3ndim is NotImplemented
• Series now inherits from NDFrame rather than directly from ndarray. There are several minor changes that affect the API.

• NumPy functions that do not support the array interface will now return ndarrays rather than series, e.g. np.diff, np.ones_like, np.where

• Series(0.5) would previously return the scalar 0.5, this is no longer supported

• TimeSeries is now an alias for Series. the property is_time_series can be used to distinguish (if desired)

• Refactor of Sparse objects to use BlockManager

• Created a new block type in internals, SparseBlock, which can hold multi-dtypes and is non-consolidatable. SparseSeries and SparseDataFrame now inherit more methods from their hierarchy (Series/DataFrame), and no longer inherit from SparseArray (which instead is the object of the SparseBlock)

• Sparse suite now supports integration with non-sparse data. Non-float sparse data is supportable (partially implemented)

• Operations on sparse structures within DataFrames should preserve sparseness, merging type operations will convert to dense (and back to sparse), so might be somewhat inefficient

• enable setitem on SparseSeries for boolean/integer/slices

• SparsePanels implementation is unchanged (e.g. not using BlockManager, needs work)

• added ftypes method to Series/DataFrame, similar to dtypes, but indicates if the underlying is sparse/dense (as well as the dtype)

• All NDFrame objects now have a _prop_attributes, which can be used to indicate various values to propagate to a new object from an existing (e.g. name in Series will follow more automatically now)

• Internal type checking is now done via a suite of generated classes, allowing isinstance(value, klass) without having to directly import the klass, courtesy of @jtratner

• Bug in Series update where the parent frame is not updating its cache based on changes (GH4080, GH5216) or types (GH3217), fillna (GH3386)

• Indexing with dtype conversions fixed (GH4463, GH4204)

• Refactor Series.reindex to core/generic.py (GH4604, GH4618), allow method= in reindexing on a Series to work

• Series.copy no longer accepts the order parameter and is now consistent with NDFrame copy

• Refactor rename methods to core/generic.py; fixes Series.rename for (GH4605), and adds rename with the same signature for Panel

• Series (for index) / Panel (for items) now as attribute access to its elements (GH1903)

• Refactor clip methods to core/generic.py (GH4798)

• Refactor of _get_numeric_data/_get_bool_data to core/generic.py, allowing Series/Panel functionality

• Refactor of Series arithmetic with time-like objects (datetime/timedelta/time etc.) into a separate, cleaned up wrapper class. (GH4613)

• Complex compat for Series with ndarray. (GH4819)

• Removed unnecessary rwproperty from codebase in favor of builtin property. (GH4843)

• Refactor object level numeric methods (mean/sum/min/max…) from object level modules to core/generic.py (GH4435).
• Refactor cum objects to core/generic.py (GH4435), note that these have a more numpy-like function signature.

• *read_html()* now uses *TextParser* to parse HTML data from bs4/lxml (GH4770).

• Removed the *keep_internal* keyword parameter in pandas/core/groupby.py because it wasn’t being used (GH5102).

• Base DateOffsets are no longer all instantiated on importing pandas, instead they are generated and cached on the fly. The internal representation and handling of DateOffsets has also been clarified. (GH5189, related GH5004)

• MultiIndex constructor now validates that passed levels and labels are compatible. (GH5213, GH5214)

• Unity *dropna* for Series/DataFrame signature (GH5250), tests from GH5234, courtesy of @rockg

• Rewrite assert_almost_equal() in cython for performance (GH4398)

• Added an internal _update_inplace method to facilitate updating NDFrame wrappers on inplace ops (only is for convenience of caller, doesn’t actually prevent copies). (GH5247)

### 38.24.6 Bug Fixes

- **HDFStore**
  - raising an invalid *TypeError* rather than *ValueError* when appending with a different block ordering (GH4096)
  - *read_hdf* was not respecting as passed mode (GH4504)
  - appending a 0-len table will work correctly (GH4273)
  - *to_hdf* was raising when passing both arguments *append* and *table* (GH4584)
  - reading from a store with duplicate columns across dtypes would raise (GH4767)
  - Fixed a bug where *ValueError* wasn’t correctly raised when column names weren’t strings (GH4956)
  - A zero length series written in Fixed format not deserializing properly. (GH4708)
  - Fixed decoding perf issue on pyt3 (GH5441)
  - Validate levels in a multi-index before storing (GH5527)
  - Correctly handle *data_columns* with a Panel (GH5717)

- Fixed bug in tslib.tz_convert(vals, tz1, tz2): it could raise IndexError exception while trying to access trans[pos + 1] (GH4496)

- The *by* argument now works correctly with the *layout* argument (GH4102, GH4014) in *.*.hist plotting methods

- Fixed bug in PeriodIndex.map where using *str* would return the str representation of the index (GH4136)

- Fixed test failure *test_time_series_plot_color_with_empty_kwargs* when using custom matplotlib default colors (GH4345)

- Fix running of stata IO tests. Now uses temporary files to write (GH4353)

- Fixed an issue where *DataFrame.sum* was slower than *DataFrame.mean* for integer valued frames (GH4365)

- *read_html* tests now work with Python 2.6 (GH4351)

- Fixed bug where network testing was throwing *NameError* because a local variable was undefined (GH4381)
• In `to_json`, raise if a passed `orient` would cause loss of data because of a duplicate index (GH4359)
• In `to_json`, fix date handling so milliseconds are the default timestamp as the docstring says (GH4362).
• `as_index` is no longer ignored when doing groupby apply (GH4648, GH3417)
• JSON NaT handling fixed, NaTs are now serialized to `null` (GH4498)
• Fixed JSON handling of escapable characters in JSON object keys (GH4593)
• Fixed passing `keep_default_na=False` when `na_values=None` (GH4318)
• Fixed bug with `values` raising an error on a DataFrame with duplicate columns and mixed dtypes, surfaced in (GH4377)
• Fixed bug with duplicate columns and type conversion in `read_json` when `orient='split'` (GH4377)
• Fixed JSON bug where locales with decimal separators other than `.` threw exceptions when encoding / decoding certain values. (GH4918)
• Fix `.iat` indexing with a `PeriodIndex` (GH4390)
• Fixed an issue where `PeriodIndex` joining with self was returning a new instance rather than the same instance (GH4379); also adds a test for this for the other index types
• Fixed a bug with all the dtypes being converted to object when using the CSV cparser with the usecols parameter (GH3192)
• Fix an issue in merging blocks where the resulting DataFrame had partially set `_ref_locs` (GH4403)
• Fixed an issue where hist subplots were being overwritten when they were called using the top level matplotlib API (GH4408)
• Fixed a bug where calling `Series.astype(str)` would truncate the string (GH4405, GH4437)
• Fixed a py3 compat issue where bytes were being repr'd as tuples (GH4455)
• Fixed Panel attribute naming conflict if item is named ‘a’ (GH3440)
• Fixed an issue where duplicate indexes were raising when plotting (GH4486)
• Fixed an issue where cumsum and cumprod didn’t work with bool dtypes (GH4170, GH4440)
• Fixed Panel slicing issued in `xs` that was returning an incorrect dimmed object (GH4016)
• Fix resampling bug where custom reduce function not used if only one group (GH3849, GH4494)
• Fixed Panel assignment with a transposed frame (GH3830)
• Raise on set indexing with a Panel and a Panel as a value which needs alignment (GH3777)
• frozenset objects now raise in the `Series` constructor (GH4482, GH4480)
• Fixed issue with sorting a duplicate multi-index that has multiple dtypes (GH4516)
• Fixed bug in `DataFrame.set_values` which was causing name attributes to be lost when expanding the index. (GH3742, GH4039)
• Fixed issue where individual `names`, `levels` and `labels` could be set on `MultiIndex` without validation (GH3714, GH4039)
• Fixed (GH3334) in `pivot_table`. Margins did not compute if values is the index.
• Fix bug in having a rhs of `np.timedelta64` or `np.offsets.DateOffset` when operating with date-times (GH4532)
• Fix arithmetic with `series/datetimeindex` and `np.timedelta64` not working the same (GH4134) and buggy timedelta in NumPy 1.6 (GH4135)
- Fix bug in `pd.read_clipboard` on windows with PY3 (GH4561); not decoding properly
- `tslib.get_period_field()` and `tslib.get_period_field_arr()` now raise if code argument out of range (GH4519, GH4520)
- Fix boolean indexing on an empty series loses index names (GH4235), infer_dtype works with empty arrays.
- Fix reindexing with multiple axes; if an axes match was not replacing the current axes, leading to a possible lazy frequency inference issue (GH3317)
- Fixed issue where `DataFrame.apply` was reraising exceptions incorrectly (causing the original stack trace to be truncated).
- Fix selection with `ix/loc` and non_unique selectors (GH4619)
- Fix assignment with `iloc/loc` involving a dtype change in an existing column (GH4312, GH5702) have internal `setitem_with_indexer in core/indexing to use Block.setitem`
- Fixed bug where thousands operator was not handled correctly for floating point numbers in `csv_import` (GH4322)
- Fix an issue with `CacheableOffset` not properly being used by many `DateOffset`; this prevented the `DateOffset` from being cached (GH4609)
- Fix boolean comparison with a `DataFrame` on the lhs, and a list/tuple on the rhs (GH4576)
- Fix error/dtype conversion with `setitem` of `None` on `Series/DataFrame` (GH4667)
- Fix decoding based on a passed in non-default encoding in `pd.read_stata` (GH4626)
- Fix `DataFrame.from_records` with a plain-vanilla `ndarray`. (GH4727)
- Fix some inconsistencies with `Index.rename` and `MultiIndex.rename`, etc. (GH4718, GH4628)
- Bug in using `iloc/loc` with a cross-sectional and duplicate indices (GH4726)
- Bug with using `QUOTE_NONE` with `to_csv` causing Exception. (GH4328)
- Bug with `Series` indexing not raising an error when the right-hand-side has an incorrect length (GH2702)
- Bug in multi-indexing with a partial string selection as one part of a `MultiIndex` (GH4758)
- Bug with reindexing on the index with a non-unique index will now raise `ValueError` (GH4746)
- Bug in setting with `loc/ix` a single indexer with a multi-index axis and a NumPy array, related to (GH3777)
- Bug in concatenation with duplicate columns across dtypes not merging with axis=0 (GH4771, GH4975)
- Bug in `iloc` with a slice index failing (GH4771)
- Incorrect error message with no colspecs or width in `read_fwf`. (GH4774)
- Fix bugs in indexing in a `Series` with a duplicate index (GH4548, GH4550)
- Fixed bug with reading compressed files with `read_fwf` in Python 3. (GH3963)
- Fixed an issue with a duplicate index and assignment with a dtype change (GH4686)
- Fixed an issue related to ticklocs/ticklabels with log scale bar plots across different versions of matplotlib (GH4789)
- Suppressed DeprecationWarning associated with internal calls issued by `repr()` (GH4391)
- Fixed an issue with a duplicate index and duplicate selector with `.loc` (GH4825)
• Fixed an issue with DataFrame.sort_index where, when sorting by a single column and passing a list for ascending, the argument for ascending was being interpreted as True (GH4839, GH4846)

• Fixed Panel.tshift not working. Added freq support to Panel.shift (GH4853)

• Fix an issue in TextFileReader w/ Python engine (i.e. PythonParser) with thousands != “,” (GH4596)

• Bug in getitem with a duplicate index when using where (GH4879)

• Fix Type inference code coerces float column into datetime (GH4601)

• Fixed _ensure_numeric does not check for complex numbers (GH4902)

• Fixed a bug in Series.hist where two figures were being created when the by argument was passed (GH4112, GH4113).

• Fixed a bug in convert_objects for > 2 ndims (GH4937)

• Fixed a bug in DataFrame/Panel cache insertion and subsequent indexing (GH4939, GH5424)

• Fixed string methods for FrozenNDArray and FrozenList (GH4929)

• Fixed a bug with setting invalid or out-of-range values in indexing enlargement scenarios (GH4940)

• Tests for fillna on empty Series (GH4346), thanks @immerrr

• Fixed copy() to shallow copy axes/indices as well and thereby keep separate metadata. (GH4202, GH4830)

• Fixed skiprows option in Python parser for read_csv (GH4382)

• Fixed bug preventing cut from working with np.inf levels without explicitly passing labels (GH3415)

• Fixed wrong check for overlapping in DatetimeIndex.union (GH4564)

• Fixed conflict between thousands separator and date parser in csv_parser (GH4678)

• Fix appending when dtypes are not the same (error showing mixing float/np.datetime64) (GH4993)

• Fix repr for DateOffset. No longer show duplicate entries in kwds. Removed unused offset fields. (GH4638)

• Fixed wrong index name during read_csv if using usecols. Applies to c parser only. (GH4201)

• Timestamp objects can now appear in the left hand side of a comparison operation with a Series or DataFrame object (GH4982).

• Fix a bug when indexing with np.nan via iloc/loc (GH5016)

• Fixed a bug where low memory c parser could create different types in different chunks of the same file. Now coerces to numerical type or raises warning. (GH3866)

• Fix a bug where reshaping a Series to its own shape raised TypeError (GH4554) and other reshaping issues.

• Bug in setting with ix/loc and a mixed int/string index (GH4544)

• Make sure series-series boolean comparisons are label based (GH4947)

• Bug in multi-level indexing with a Timestamp partial indexer (GH4294)

• Tests/fix for multi-index construction of an all-nan frame (GH4078)

• Fixed a bug where read_html() wasn’t correctly inferring values of tables with commas (GH5029)

• Fixed a bug where read_html() wasn’t providing a stable ordering of returned tables (GH4770, GH5029).

• Fixed a bug where read_html() was incorrectly parsing when passed index_col=0 (GH5066).

• Fixed a bug where read_html() was incorrectly inferring the type of headers (GH5048).

• Fixed a bug where DatetimeIndex joins with PeriodIndex caused a stack overflow (GH3899).
- Fixed a bug where `groupby` objects didn’t allow plots (GH5102).
- Fixed a bug where `groupby` objects weren’t tab-completing column names (GH5102).
- Fixed a bug where `groupby.plot()` and friends were duplicating figures multiple times (GH5102).
- Provide automatic conversion of `object` dtypes on fillna, related (GH5103)
- Fixed a bug where default options were being overwritten in the option parser cleaning (GH5121).
- Treat a list/ndarray identically for `iloc` indexing with list-like (GH5006)
- Fix `MultiIndex.get_level_values()` with missing values (GH5074)
- Fix bound checking for `Timestamp()` with datetime64 input (GH4065)
- Fix a bug where `TestReadHtml` wasn’t calling the correct `read_html()` function (GH5150).
- Fix a bug with `NDFrame.replace()` which made replacement appear as though it was (incorrectly) using regular expressions (GH5143).
- Fix better error message for `to_datetime` (GH4928)
- Made sure different locales are tested on travis-ci (GH4918). Also adds a couple of utilities for getting locales and setting locales with a context manager.
- Fixed segfault on `isnull(MultiIndex)` (now raises an error instead) (GH5123, GH5125)
- Allow duplicate indices when performing operations that align (GH5185, GH5639)
- Compound dtypes in a constructor raise `NotImplementedError` (GH5191)
- Bug in comparing duplicate frames (GH4421) related
- Bug in describe on duplicate frames
- Bug in `to_datetime` with a format and `coerce=True` not raising (GH5195)
- Bug in `loc` setting with multiple indexers and a rhs of a Series that needs broadcasting (GH5206)
- Fixed bug where inplace setting of levels or labels on `MultiIndex` would not clear cached `values` property and therefore return wrong values. (GH5215)
- Fixed bug where filtering a grouped DataFrame or Series did not maintain the original ordering (GH4621).
- Fixed `Period` with a business date freq to always roll-forward if on a non-business date. (GH5203)
- Fixed bug in Excel writers where frames with duplicate column names weren’t written correctly. (GH5235)
- Fixed issue with `drop` and a non-unique index on Series (GH5248)
- Fixed seg fault in C parser caused by passing more names than columns in the file. (GH5156)
- Fix `Series.isin` with date/time-like dtypes (GH5021)
- C and Python Parser can now handle the more common multi-index column format which doesn’t have a row for index names (GH4702)
- Bug when trying to use an out-of-bounds date as an object dtype (GH5312)
- Bug when trying to display an embedded PandasObject (GH5324)
- Allows operating of Timestamps to return a datetime if the result is out-of-bounds related (GH5312)
- Fix return value/type signature of `initObjToJSON()` to be compatible with numpy’s `import_array()` (GH5334, GH5326)
- Bug when renaming then set_index on a DataFrame (GH5344)
• Test suite no longer leaves around temporary files when testing graphics. (GH5347) (thanks for catching this @yarikoptic!)
• Fixed html tests on win32. (GH4580)
• Make sure that head/tail are iloc based, (GH5370)
• Fixed bug for PeriodIndex string representation if there are 1 or 2 elements. (GH5372)
• The GroupBy methods transform and filter can be used on Series and DataFrames that have repeated (non-unique) indices. (GH4620)
• Fix empty series not printing name in repr (GH4651)
• Make tests create temp files in temp directory by default. (GH5419)
• pd.to_timedelta of a scalar returns a scalar (GH5410)
• pd.to_timedelta accepts NaN and NaT, returning NaT instead of raising (GH5437)
• performance improvements in isnull on larger size pandas objects
• Fixed various setitem with 1d ndarray that does not have a matching length to the indexer (GH5508)
• Bug in getitem with a multi-index and iloc (GH5528)
• Bug in delitem on a Series (GH5542)
• Bug fix in apply when using custom function and objects are not mutated (GH5545)
• Bug in selecting from a non-unique index with loc (GH5553)
• Bug in groupby returning non-consistent types when user function returns a None, (GH5592)
• Work around regression in numpy 1.7.0 which erroneously raises IndexError from ndarray.item (GH5666)
• Bug in repeated indexing of object with resultant non-unique index (GH5678)
• Bug in fillna with Series and a passed series/dict (GH5703)
• Bug in groupby transform with a datetime-like grouper (GH5712)
• Bug in multi-index selection in PY3 when using certain keys (GH5725)
• Row-wise concat of differing dtypes failing in certain cases (GH5754)

38.25 pandas 0.12.0

Release date: 2013-07-24

38.25.1 New Features

• pd.read_html() can now parse HTML strings, files or urls and returns a list of DataFrame s courtesy of @cpcloud. (GH3477, GH3605, GH3606)
• Support for reading Amazon S3 files. (GH3504)
• Added module for reading and writing JSON strings/files: pandas.io.json includes to_json DataFrame/Series method, and a read_json top-level reader various issues (GH1226, GH3804, GH3876, GH3867, GH1305)
• Added module for reading and writing Stata files: pandas.io.stata (GH1512) includes to_stata DataFrame method, and a read_stata top-level reader
• Added support for writing in `to_csv` and reading in `read_csv`, multi-index columns. The header option in `read_csv` now accepts a list of the rows from which to read the index. Added the option, `tupleize_cols` to provide compatibility for the pre 0.12 behavior of writing and reading multi-index columns via a list of tuples. The default in 0.12 is to write lists of tuples and not interpret list of tuples as a multi-index column. Note: The default value will change in 0.12 to make the default to write and read multi-index columns in the new format. (GH3571, GH1651, GH3141)

• Add iterator to `Series.str` (GH3638)

• `pd.set_option()` now allows N option, value pairs (GH3667).

• Added keyword parameters for different types of `scatter_matrix` subplots

• A `filter` method on grouped Series or DataFrames returns a subset of the original (GH3680, GH919)

• Access to historical Google Finance data in pandas.io.data (GH3814)

• DataFrame plotting methods can sample column colors from a Matplotlib colormap via the `colormap` keyword. (GH3860)

### 38.25.2 Improvements to existing features

• Fixed various issues with internal pprinting code, the repr() for various objects including TimeStamp and Index now produces valid Python code strings and can be used to recreate the object, (GH3038, GH3379, GH3251, GH3460)

• `convert_objects` now accepts a `copy` parameter (defaults to True)

• `HDFStore`
  – will retain index attributes (freq,tz,name) on recreation (GH3499,issue:4098)
  – will warn with a `AttributeConflictWarning` if you are attempting to append an index with a different frequency than the existing, or attempting to append an index with a different name than the existing
  – support datelike columns with a timezone as `data_columns` (GH2852)
  – table writing performance improvements.
  – support python3 (via PyTables 3.0.0) (GH3750)

• Add modulo operator to Series, DataFrame

• Add `date` method to DatetimeIndex

• Add `dropna` argument to `pivot_table` (issue: 3820)

• Simplified the API and added a describe method to Categorical

• `melt` now accepts the optional parameters `var_name` and `value_name` to specify custom column names of the returned DataFrame (GH3649), thanks @hoechenberger. If `var_name` is not specified and `dataframe.columns.name` is not None, then this will be used as the `var_name` (GH4144). Also support for MultiIndex columns.

• clipboard functions use pyperclip (no dependencies on Windows, alternative dependencies offered for Linux) (GH3837).

• Plotting functions now raise a `TypeError` before trying to plot anything if the associated objects have a dtype of object (GH1818, GH3572, GH3911, GH3912), but they will try to convert object arrays to numeric arrays if possible so that you can still plot, for example, an object array with floats. This happens before any drawing takes place which eliminates any spurious plots from showing up.

• Added Faq section on repr display options, to help users customize their setup.
• where operations that result in block splitting are much faster (GH3733)
• Series and DataFrame hist methods now take a figsize argument (GH3834)
• DatetimeIndexes no longer try to convert mixed-integer indexes during join operations (GH3877)
• Add unit keyword to Timestamp and to_datetime to enable passing of integers or floats that are in an epoch unit of D, s, ms, us, ns, thanks @mtkini (GH3969) (e.g. unix timestamps or epoch s, with fractional seconds allowed) (GH3540)
• DataFrame corr method (spearman) is now cythonized.
• Improved network test decorator to catch IOError (and therefore URLError as well). Added with_connectivity_check decorator to allow explicitly checking a website as a proxy for seeing if there is network connectivity. Plus, new optional_args decorator factory for decorators. (GH3910, GH3914)
• read_csv will now throw a more informative error message when a file contains no columns, e.g., all newline characters
• Added layout keyword to DataFrame.hist() for more customizable layout (GH4050)
• Timestamp.min and Timestamp.max now represent valid Timestamp instances instead of the default datetime.min and datetime.max (respectively), thanks @SleepingPills
• read_html now raises when no tables are found and BeautifulSoup==4.2.0 is detected (GH4214)

38.25.3 API Changes

• HDFStore
  – When removing an object, remove(key) raises KeyError if the key is not a valid store object.
  – raise a TypeError on passing where or columns to select with a Storer; these are invalid parameters at this time (GH4189)
  – can now specify an encoding option to append/put to enable alternate encodings (GH3750)
  – enable support for iterator/chunksize with read_hdf
• The repr() for (Multi)Index now obeys display.max_seq_items rather then NumPy threshold print options. (GH3426, GH3466)
• Added mangle_dupe_cols option to read_table/csv, allowing users to control legacy behaviour re dupe cols (A, A.1, A.2 vs A, A ) (GH3468) Note: The default value will change in 0.12 to the “no mangle” behaviour. If your code relies on this behaviour, explicitly specify mangle_dupe_cols=True in your calls.
• Do not allow astypes on datetime64[ns] except to object, and timedelta64[ns] to object/int (GH3425)
• The behavior of datetime64 dtypes has changed with respect to certain so-called reduction operations (GH3726). The following operations now raise a TypeError when performed on a Series and return an empty Series when performed on a DataFrame similar to performing these operations on, for example, a DataFrame of slice objects: - sum, prod, mean, std, var, skew, kurt, corr, and cov
• Do not allow datetimelike/timedeltalike creation except with valid types (e.g. cannot pass datetime64[ms]) (GH3423)
• Add squeeze keyword to groupby to allow reduction from DataFrame -> Series if groups are unique. Regression from 0.10.1, partial revert on (GH2893) with (GH3596)
• Raise on iloc when boolean indexing with a label based indexer mask e.g. a boolean Series, even with integer labels, will raise. Since iloc is purely positional based, the labels on the Series are not alignable (GH3631)
pandas: powerful Python data analysis toolkit, Release 0.23.2

- The `raise_on_error` option to plotting methods is obviated by GH3572, so it is removed. Plots now always raise when data cannot be plotted or the object being plotted has a dtype of `object`.

- `DataFrame.interpolate()` is now deprecated. Please use `DataFrame.fillna()` and `DataFrame.replace()` instead (GH3582, GH3675, GH3676).

- the method and axis arguments of `DataFrame.replace()` are deprecated

- `DataFrame.replace`'s `infer_types` parameter is removed and now performs conversion by default. (GH3907)

- Deprecated display.height, display.width is now only a formatting option does not control triggering of summary, similar to < 0.11.0.

- Add the keyword `allow_duplicates` to `DataFrame.insert` to allow a duplicate column to be inserted if `True`, default is `False` (same as prior to 0.12) (GH3679)

- io API changes
  - added pandas.io.api for i/o imports
  - removed Excel support to pandas.io.excel
  - added top-level `pd.read_sql` and `to_sql` DataFrame methods
  - removed clipboard support to pandas.io.clipboard
  - replace top-level and instance methods `save` and `load` with top-level `read_pickle` and `to_pickle`

- the method and axis arguments of `DataFrame.replace()` are deprecated

- set FutureWarning to require `data_source`, and to replace `year/month` with expiry date in pandas.io options. This is in preparation to add options data from Google (GH3822)

- the method and axis arguments of `DataFrame.replace()` are deprecated

- Implement `__nonzero__` for NDFrame objects (GH3691, GH3696)

- `as_matrix` with mixed signed and unsigned dtypes will result in 2 x the lcd of the unsigned as an int, maxing with `int64`, to avoid precision issues (GH3733)

- `na_values` in a list provided to `read_csv/read_excel` will match string and numeric versions e.g. `na_values=['99']` will match 99 whether the column ends up being int, float, or string (GH3611)

- `read_html` now defaults to `None` when reading, and falls back on `bs4 + html5lib` when lxml fails to parse. a list of parsers to try until success is also valid

- more consistency in the `to_datetime` return types (give string/array of string inputs) (GH3888)

- The internal pandas class hierarchy has changed (slightly). The previous `PandasObject` now is called `PandasContainer` and a new `PandasObject` has become the baseclass for `PandasContainer` as well as `Index`, `Categorical`, `GroupBy`, `SparseList`, and `SparseArray` (+ their base classes). Currently, `PandasObject` provides string methods (from `StringMixin`). (GH4090, GH4092)

- New `StringMixin` that, given a `__unicode__` method, gets Python 2 and Python 3 compatible string methods (`__str__`, `__bytes__`, and `__repr__`). Plus string safety throughout. Now employed in many places throughout the pandas library. (GH4090, GH4092)

38.25.4 Experimental Features

- Added experimental `CustomBusinessDay` class to support `DateOffsets` with custom holiday calendars and custom weekmasks. (GH2301)
38.25.5 Bug Fixes

- Fixed an esoteric excel reading bug. xlrd>=0.9.0 now required for excel support. Should provide python3 support (for reading) which has been lacking. (GH3164)
- Disallow Series constructor called with MultiIndex which caused segfault (GH4187)
- Allow unioning of date ranges sharing a timezone (GH3491)
- Fix to_csv issue when having a large number of rows and NaT in some columns (GH3437)
- .loc was not raising when passed an integer list (GH3449)
- Unordered time series selection was misbehaving when using label slicing (GH3448)
- Fix sorting in a frame with a list of columns which contains datetime64[ns] dtypes (GH3461)
- DataFrames fetched via FRED now handle ‘.’ as a NaN. (GH3469)
- Fix regression in a DataFrame apply with axis=1, objects were not being converted back to base dtypes correctly (GH3480)
- Fix issue when storing uint dtypes in an HDFStore. (GH3493)
- Non-unique index support clarified (GH3468)
  - Addressed handling of dupe columns in df.to_csv new and old (GH3454, GH3457)
  - Fix assigning a new index to a duplicate index in a DataFrame would fail (GH3468)
  - Fix construction of a DataFrame with a duplicate index
  - ref_locs support to allow duplicative indices across dtypes, allows iget support to always find the index (even across dtypes) (GH2194)
  - applymap on a DataFrame with a non-unique index now works (removed warning) (GH2786), and fix (GH3230)
  - Fix to_csv to handle non-unique columns (GH3495)
  - Duplicate indexes with getitem will return items in the correct order (GH3455, GH3457) and handle missing elements like unique indices (GH3561)
  - Duplicate indexes with and empty DataFrame.from_records will return a correct frame (GH3562)
  - Concat to produce a non-unique columns when duplicates are across dtypes is fixed (GH3602)
  - Non-unique indexing with a slice via loc and friends fixed (GH3659)
  - Allow insert/delete to non-unique columns (GH3679)
  - Extend reindex to correctly deal with non-unique indices (GH3679)
  - DataFrame.itertuples() now works with frames with duplicate column names (GH3873)
  - Bug in non-unique indexing via iloc (GH4017); added takeable argument to reindex for location-based taking
  - Allow non-unique indexing in series via .ix/.loc and __getitem__ (GH4246)
  - Fixed non-unique indexing memory allocation issue with .ix/.loc (GH4280)
- Fixed bug in groupby with empty series referencing a variable before assignment. (GH3510)
- Allow index name to be used in groupby for non MultiIndex (GH4014)
- Fixed bug in mixed-frame assignment with aligned series (GH3492)
• Fixed bug in selecting month/quarter/year from a series would not select the time element on the last day (GH3546)
• Fixed a couple of MultiIndex rendering bugs in df.to_html() (GH3547, GH3553)
• Properly convert np.datetime64 objects in a Series (GH3416)
• Raise a TypeError on invalid datetime/timedelta operations e.g. add datetimes, multiple timedelta x datetime
• Fix .diff on datelike and timedelta operations (GH3100)
• combine_first not returning the same dtype in cases where it can (GH3552)
• Fixed bug with Panel.transpose argument aliases (GH3556)
• Fixed platform bug in PeriodIndex.take (GH3579)
• Fixed bug in incorrect conversion of datetime64[ns] in combine_first (GH3593)
• Fixed bug in reset_index with NaN in a multi-index (GH3586)
• fillna methods now raise a TypeError when the value parameter is a list or tuple.
• Fixed bug where a time-series was being selected in preference to an actual column name in a frame (GH3594)
• Make secondary_y work properly for bar plots (GH3598)
• Fix modulo and integer division on Series,DataFrames to act similarly to float dtypes to return np.nan or np.inf as appropriate (GH3590)
• Fix incorrect dtype on groupby with as_index=False (GH3610)
• Fix read_csv/read_excel to correctly encode identical na_values, e.g. na_values=[-999.0,-999] was failing (GH3611)
• Disable HTML output in qtconsole again. (GH3657)
• Reworked the new repr display logic, which users found confusing. (GH3663)
• Fix indexing issue in ndim >= 3 with iloc (GH3617)
• Correctly parse date columns with embedded (nan/NaT) into datetime64[ns] dtype in read_csv when parse_dates is specified (GH3062)
• Fix not consolidating before to_csv (GH3624)
• Fix alignment issue when setitem in a DataFrame with a piece of a DataFrame (GH3626) or a mixed DataFrame and a Series (GH3668)
• Fix plotting of unordered DatetimeIndex (GH3601)
• sql.write_frame failing when writing a single column to sqlite (GH3628), thanks to @stonebig
• Fix pivoting with nan in the index (GH3558)
• Fix running of bs4 tests when it is not installed (GH3605)
• Fix parsing of html table (GH3606)
• read_html() now only allows a single backend: html5lib (GH3616)
• convert_objects with convert_dates='coerce' was parsing some single-letter strings into today’s date
• DataFrame.from_records did not accept empty recarrays (GH3682)
• DataFrame.to_csv will succeed with the deprecated option nanRep. @tdsmith
• DataFrame.to_html and DataFrame.to_latex now accept a path for their first argument (GH3702)
• Fix file tokenization error with `r` delimiter and quoted fields (GH3453)
• Groupby transform with item-by-item not upcasting correctly (GH3740)
• Incorrectly read a HDFStore multi-index Frame with a column specification (GH3748)
• `read_html` now correctly skips tests (GH3741)
• PandasObjects raise TypeError when trying to hash (GH3882)
• Fix incorrect arguments passed to concat that are not list-like (e.g. `concat(df1,df2)`) (GH3481)
• Correctly parse when passed the `dtype=str` (or other variable-len string dtypes) in `read_csv` (GH3795)
• Fix index name not propagating when using `loc/ix` (GH3880)
• Fix groupby when applying a custom function resulting in a returned DataFrame was not converting dtypes (GH3911)
• Fixed a bug where `DataFrame.replace` with a compiled regular expression in the `to_replace` argument wasn’t working (GH3907)
• Fixed `__truediv__` in Python 2.7 with `numexpr` installed to actually do true division when dividing two integer arrays with at least 10000 cells total (GH3764)
• Indexing with a string with seconds resolution not selecting from a time index (GH3925)
• `csv` parsers would loop infinitely if `iterator=True` but no `chunksize` was specified (GH3967), Python parser failing with `chunksize=1`
• Fix index name not propagating when using `shift`
• Fixed `dropna=False` being ignored with multi-index stack (GH3997)
• Fixed flattening of columns when renaming MultiIndex columns DataFrame (GH4004)
• Fix `Series.clip` for datetime series. NA/NaN threshold values will now throw `ValueError` (GH3996)
• Fixed insertion issue into DataFrame, after rename (GH4032)
• Fixed testing issue where too many sockets where open thus leading to a connection reset issue (GH3982, GH3985, GH4028, GH4054)
• Fixed failing tests in `test_yahoo, test_google` where symbols were not retrieved but were being accessed (GH3982, GH3985, GH4028, GH4054)
• `Series.hist` will now take the figure from the current environment if one is not passed
• Fixed bug where a 1xN DataFrame would barf on a 1xN mask (GH4071)
• Fixed running of `tox` under python3 where the pickle import was getting rewritten in an incompatible way (GH4062, GH4063)
• Fixed bug where sharex and sharey were not being passed to `grouped_hist` (GH4089)
• Fix bug where `HDFStore` will fail to append because of a different block ordering on-disk (GH4096)
• Better error messages on inserting incompatible columns to a frame (GH4107)
• Fixed bug in `DataFrame.replace` where a nested dict wasn’t being iterated over when `regex=False` (GH4115)
• Fixed bug in `convert_objects(convert_numeric=True)` where a mixed numeric and object `Series/Frame` was not converting properly (GH4119)
• Fixed bugs in multi-index selection with column multi-index and duplicates (GH4145, GH4146)
• Fixed bug in the parsing of microseconds when using the `format` argument in `to_datetime` (GH4152)
- Fixed bug in `PandasAutoDateLocator` where `invert_xaxis` triggered incorrectly. (GH3990)
- Fixed bug in `Series.where` where broadcasting a single element input vector to the length of the series resulted in multiplying the value inside the input. (GH4192)
- Fixed bug in plotting that wasn’t raising on invalid colormap for matplotlib 1.1.1. (GH4215)
- Fixed the legend displaying in `DataFrame.plot(kind='kde')`. (GH4216)
- Fixed bug where Index slices weren’t carrying the name attribute. (GH4226)
- Fixed bug in initializing `DateTimeIndex` with an array of strings in a certain time zone. (GH4229)
- Fixed bug where `html5lib` wasn’t being properly skipped. (GH4265)
- Fixed bug where `get_data_famafrench` wasn’t using the correct file edges. (GH4281)

### 38.26 pandas 0.11.0

**Release date:** 2013-04-22

#### 38.26.1 New Features

- New documentation section, 10 Minutes to Pandas
- New documentation section, Cookbook
- Allow mixed dtypes (e.g. `float32/float64/int32/int16/int8`) to coexist in DataFrames and propagate in operations
- Add function to `pandas.io.data` for retrieving stock index components from Yahoo! finance. (GH2795)
- Support slicing with time objects. (GH2681)
- Added `.iloc` attribute, to support strict integer based indexing, analogous to `.ix`. (GH2922)
- Added `.loc` attribute, to support strict label based indexing, analogous to `.ix`. (GH3053)
- Added `.iat` attribute, to support fast scalar access via integers (replaces `iget_value/iset_value`).
- Added `.at` attribute, to support fast scalar access via labels (replaces `get_value/set_value`).
- Moved functionality from `irow,icol,iget_value/iset_value` to `.iloc` indexer (via `_ixs` methods in each object).
- Added support for expression evaluation using the `numexpr` library.
- Added `convert=boolean` to take routines to translate negative indices to positive, defaults to True.
- Added `to_series()` method to indices, to facilitate the creation of indexers. (GH3275)

#### 38.26.2 Improvements to existing features

- Improved performance of `df.to_csv()` by up to 10x in some cases. (GH3059)
- Added `blocks` attribute to DataFrames, to return a dict of dtypes to homogeneously dtyped DataFrames.
- Added keyword `convert_numeric` to `convert_objects()` to try to convert object dtypes to numeric types (default is False).
• convert_dates in convert_objects can now be coerce which will return a datetime64[ns] dtype with non-convertibles set as NaT; will preserve an all-nan object (e.g., strings), default is True (to perform soft-conversion)

• Series print output now includes the dtype by default

• Optimize internal reindexing routines (GH2819, GH2867)

• describe_option() now reports the default and current value of options.

• Add format option to pandas.to_datetime with faster conversion of strings that can be parsed with datetime.strptime

• Add axes property to Series for compatibility

• Add xs function to Series for compatibility

• Allow setitem in a frame where only mixed numerics are present (e.g., int and float), (GH3037)

• HDFStore
  – Provide dotted attribute access to get from stores (e.g., store.df == store['df'])
  – New keywords iterator=boolean, and chunksize=number_in_a_chunk are provided to support iteration on select and select_as_multiple (GH3076)
  – support read_hdf/to_hdf API similar to read_csv/to_csv (GH3222)

• Add squeeze method to possibly remove length 1 dimensions from an object.

```
In [1]: p = pd.Panel(np.random.randn(3,4,4),items=['ItemA','ItemB','ItemC'],
                 ...: major_axis=pd.date_range('20010102',periods=4),
                 ...: minor_axis=['A','B','C','D'])
...:

In [2]: p
Out[2]:
<class 'pandas.core.panel.Panel'>
Dimensions: 3 (items) x 4 (major_axis) x 4 (minor_axis)
Items axis: ItemA to ItemC
Major_axis axis: 2001-01-02 00:00:00 to 2001-01-05 00:00:00
Minor_axis axis: A to D

In [3]: p.reindex(items=['ItemA']).squeeze()

   A    B    C    D
2001-01-02 0.469112 -0.282863 -1.509059 -1.135632
2001-01-03 1.212112 -0.173215 0.119209 -1.044236
2001-01-04 -0.861849 -2.104569 -0.494929 1.071804
2001-01-05 0.721555 -0.706771 -1.039575 0.271860

In [4]: p.reindex(items=['ItemA'],minor=['B']).squeeze()

   2001-01-02 -0.282863
2001-01-03 -0.173215
2001-01-04 -2.104569
2001-01-05 -0.706771
Freq: D, Name: B, dtype: float64
```

• Improvement to Yahoo API access in pd.io.data.Options (GH2758)
• added option `display.max_seq_items` to control the number of elements printed per sequence pprinting it. (GH2979)

• added option `display.chop_threshold` to control display of small numerical values. (GH2739)

• added option `display.max_info_rows` to prevent verbose_info from being calculated for frames above 1M rows (configurable). (GH2807, GH2918)

• value_counts() now accepts a "normalize" argument, for normalized histograms. (GH2710).

• DataFrame.from_records now accepts not only dicts but any instance of the collections.Mapping ABC.

• Allow selection semantics via a string with a datelike index to work in both Series and DataFrames (GH3070)

```python
In [5]: idx = pd.date_range("2001-10-1", periods=5, freq='M')
In [6]: ts = pd.Series(np.random.rand(len(idx)),index=idx)
In [7]: ts['2001']
Out[7]:
          2001-10-31  0.838796
            2001-11-30  0.897333
            2001-12-31  0.732592
Freq: M, dtype: float64
In [8]: df = pd.DataFrame(dict(A = ts))
In [9]: df['2001']
Out[9]:
       A
2001-10-31  0.838796
2001-11-30  0.897333
2001-12-31  0.732592
```

• added option `display.mpl_style` providing a sleeker visual style for plots. Based on https://gist.github.com/huyng/816622 (GH3075).

• Improved performance across several core functions by taking memory ordering of arrays into account. Courtesy of @stephenwlin (GH3130)

• Improved performance of groupby transform method (GH2121)

• Handle "ragged" CSV files missing trailing delimiters in rows with missing fields when also providing explicit list of column names (so the parser knows how many columns to expect in the result) (GH2981)

• On a mixed DataFrame, allow setting with indexers with ndarray/DataFrame on rhs (GH3216)

• Treat boolean values as integers (values 1 and 0) for numeric operations. (GH2641)

• Add `time` method to DatetimeIndex (GH3180)

• Return NA when using Series.str[...] for values that are not long enough (GH3223)

• Display cursor coordinate information in time-series plots (GH1670)

• to_html() now accepts an optional “escape” argument to control reserved HTML character escaping (enabled by default) and escapes `, in addition to `< and `>`. (GH2919)

### 38.26.3 API Changes

• Do not automatically upcast numeric specified dtypes to `int64` or `float64` (GH622 and GH797)
- DataFrame construction of lists and scalars, with no dtype present, will result in casting to int64 or float64, regardless of platform. This is not an apparent change in the API, but noting it.
- Guarantee that convert_objects() for Series/DataFrame always returns a copy
- Groupby operations will respect dtypes for numeric float operations (float32/float64); other types will be operated on, and will try to cast back to the input dtype (e.g. if an int is passed, as long as the output doesn’t have nans, then an int will be returned)
- backfill/pad/take/diff/ohlc will now support float32/int16/int8 operations
- Block types will upcast as needed in where/masking operations (GH2793)
- Series now automatically will try to set the correct dtype based on passed datetimelike objects (datetime/Timestamp)
  - timedelta64 are returned in appropriate cases (e.g. Series - Series, when both are datetime64)
  - mixed datetimes and objects (GH2751) in a constructor will be cast correctly
  - astype on datetimes to object are now handled (as well as NaT conversions to np.nan)
  - all timedelta like objects will be correctly assigned to timedelta64 with mixed NaN and/or NaT allowed
- Arguments to DataFrame.clip were inconsistent to NumPy and Series clipping (GH2747)
- util.testing.assert_frame_equal now checks the column and index names (GH2964)
- Constructors will now return a more informative ValueError on failures when invalid shapes are passed
- Don’t suppress TypeError in GroupBy.agg (GH3238)
- Methods return None when inplace=True (GH1893)
- HDFStore
  - added the method select_column to select a single column from a table as a Series.
  - deprecated the unique method, can be replicated by select_column(key,column).unique()
  - min_itemsize parameter will now automatically create data_columns for passed keys
- Downcast on pivot if possible (GH3283), adds argument downcast to fillna
- Introduced options display.height/width for explicitly specifying terminal height/width in characters. Deprecated display.line_width, now replaced by display.width. These defaults are in effect for scripts as well, so unless disabled, previously very wide output will now be output as “expand_repr” style wrapped output.
- Various defaults for options (including display.max_rows) have been revised, after a brief survey concluded they were wrong for everyone. Now at w=80,h=60.
- HTML repr output in IPython qtconsole is once again controlled by the option display.notebook_repr_html, and on by default.

### 38.26.4 Bug Fixes

- Fix seg fault on empty data frame when fillna with pad or backfill (GH2778)
- Single element ndarrays of datetimelike objects are handled (e.g. np.array(datetime(2001,1,1,0,0))), w/o dtype being passed
- 0-dim ndarrays with a passed dtype are handled correctly (e.g. np.array(0.,dtype='float32'))
- Fix some boolean indexing inconsistencies in Series.__getitem__/__setitem__ (GH2776)
• Fix issues with DataFrame and Series constructor with integers that overflow `int64` and some mixed typed type lists (GH2845)
• HDFStore
  – Fix weird PyTables error when using too many selectors in a where also correctly filter on any number of values in a Term expression (so not using numexpr filtering, but isin filtering)
  – Internally, change all variables to be private-like (now have leading underscore)
  – Fixes for query parsing to correctly interpret boolean and != (GH2849, GH2973)
  – Fixes for pathological case on SparseSeries with 0-len array and compression (GH2931)
  – Fixes bug with writing rows if part of a block was all-nan (GH3012)
  – Exceptions are now ValueError or TypeError as needed
  – A table will now raise if min_itemsize contains fields which are not queryables
• Bug showing up in applymap where some object type columns are converted (GH2909) had an incorrect default in convert_objects
• TimeDeltas
  – Series ops with a Timestamp on the rhs was throwing an exception (GH2898) added tests for Series ops with datetimes, timedeltas, Timestamps, and datelike Series on both lhs and rhs
  – Fixed subtle timedelta64 inference issue on py3 & NumPy 1.7.0 (GH3094)
  – Fixed some formatting issues on timedelta when negative
  – Support null checking on timedelta64, representing (and formatting) with NaT
  – Support setitem with np.nan value, converts to NaT
  – Support min/max ops in a Dataframe (abs not working, nor do we error on non-supported ops)
  – Support idxmin/idxmax/abs/max/min in a Series (GH2989, GH2982)
• Bug on in-place putmasking on an integer series that needs to be converted to float (GH2746)
• Bug in argsort of datetime64[ns] Series with NaT (GH2967)
• Bug in value_counts of datetime64[ns] Series (GH3002)
• Fixed printing of NaT in an index
• Bug in idxmin/idxmax of datetime64[ns] Series with NaT (GH2982)
• Bug in icol, take with negative indicies was producing incorrect return values (see GH2922, GH2892), also check for out-of-bounds indices (GH3029)
• Bug in DataFrame column insertion when the column creation fails, existing frame is left in an irrecoverable state (GH3010)
• Bug in DataFrame update, combine_first where non-specified values could cause dtype changes (GH3016, GH3041)
• Bug in groupby with first/last where dtypes could change (GH3041, GH2763)
• Formatting of an index that has nan was inconsistent or wrong (would fill from other values), (GH2850)
• Unstack of a frame with no nans would always cause dtype upcasting (GH2929)
• Fix scalar datetime.datetime parsing bug in read_csv (GH3071)
• Fixed slow printing of large Dataframes, due to inefficient dtype reporting (GH2807)
• Fixed a segfault when using a function as grouper in groupby (GH3035)
• Fix pretty-printing of infinite data structures (closes GH2978)
• Fixed exception when plotting timeseries bearing a timezone (closes GH2877)
• str.contains ignored na argument (GH2806)
• Substitute warning for segfault when grouping with categorical grouper of mismatched length (GH3011)
• Fix exception in SparseSeries.density (GH2083)
• Fix upsampling bug with closed='left' and daily to daily data (GH3020)
• Fixed missing tick bars on scatter_matrix plot (GH3063)
• Fixed bug in Timestamp(d,tz=foo) when d is date() rather then datetime() (GH2993)
• series.plot(kind='bar') now respects pylab color schem (GH3115)
• Fixed bug in reshape if not passed correct input, now raises TypeError (GH2719)
• Fixed a bug where Series ctor did not respect ordering if OrderedDict passed in (GH3282)
• Fix NameError issue on RESO_US (GH2787)
• Allow selection in an unordered timeseries to work similarly to an ordered timeseries (GH2437).
• Fix implemented .xs when called with axes=1 and a level parameter (GH2903)
• Timestamp now supports the class method fromordinal similar to datetimes (GH3042)
• Fix issue with indexing a series with a boolean key and specifying a 1-len list on the rhs (GH2745) or a list on the rhs (GH3235)
• Fixed bug in groupby apply when kernel generate list of arrays having unequal len (GH1738)
• fixed handling of rolling_corr with center=True which could produce corr>1 (GH3155)
• Fixed issues where indices can be passed as ‘index/column’ in addition to 0/1 for the axis parameter
• PeriodIndex.tolist now boxes to Period (GH3178)
• PeriodIndex.get_loc KeyError now reports Period instead of ordinal (GH3179)
• df.to_records bug when handling MultiIndex (GH3189)
• Fix Series.__getitem__ segfault when index less than -length (GH3168)
• Fix bug when using Timestamp as a date parser (GH2932)
• Fix bug creating date range from Timestamp with time zone and passing same time zone (GH2926)
• Add comparison operators to Period object (GH2781)
• Fix bug when concatenating two Series into a DataFrame when they have the same name (GH2797)
• Fix automatic color cycling when plotting consecutive timeseries without color arguments (GH2816)
• fixed bug in the pickling of PeriodIndex (GH2891)
• Upcast/split blocks when needed in a mixed DataFrame when setitem with an indexer (GH3126)
• Invoking df.applymap on a dataframe with dupe cols now raises a ValueError (GH2786)
• Apply with invalid returned indices raise correct Exception (GH2808)
• Fixed a bug in plotting log-scale bar plots (GH3247)
• df.plot() grid on/off now obeys the mpl default style, just like series.plot(). (GH3233)
• Fixed a bug in the legend of plotting.andrews_curves() (GH3278)
• Produce a series on apply if we only generate a singular series and have a simple index (GH2893)
• Fix Python ASCII file parsing when integer falls outside of floating point spacing (GH3258)
• fixed pretty printing of sets (GH3294)
• Panel() and Panel.from_dict() now respects ordering when give OrderedDict (GH3303)
• DataFrame where with a datetimelike incorrectly selecting (GH3311)
• Ensure index casts work even in Int64Index
• Fix set_index segfault when passing MultiIndex (GH3308)
• Ensure pickles created in py2 can be read in py3
• Insert ellipsis in MultiIndex summary repr (GH3348)
• Groupby will handle mutation among an input groups columns (and fallback to non-fast apply) (GH3380)
• Eliminated unicode errors on FreeBSD when using MPL GTK backend (GH3360)
• Period.strftime should return unicode strings always (GH3363)
• Respect passed read_* chunksize in get_chunk function (GH3406)

38.27 pandas 0.10.1

Release date: 2013-01-22

38.27.1 New Features

• Add data interface to World Bank WDI pandas.io.wb (GH2592)

38.27.2 API Changes

• Restored inplace=True behavior returning self (same object) with deprecation warning until 0.11 (GH1893)
• HDFStore
  – refactored HDFStore to deal with non-table stores as objects, will allow future enhancements
  – removed keyword compression from put (replaced by keyword complib to be consistent across library)
  – warn PerformanceWarning if you are attempting to store types that will be pickled by PyTables

38.27.3 Improvements to existing features

• HDFStore
  – enables storing of multi-index dataframes (closes GH1277)
  – support data column indexing and selection, via data_columns keyword in append
  – support write chunking to reduce memory footprint, via chunksize keyword to append
  – support automagic indexing via index keyword to append
pandas: powerful Python data analysis toolkit, Release 0.23.2

- support `expectedrows` keyword in append to inform PyTables about the expected table size
- support `start` and `stop` keywords in select to limit the row selection space
- added `get_store` context manager to automatically import with pandas
- added column filtering via `columns` keyword in select
- added methods `append_to_multiple/select_as_multiple/select_as_coordinates` to do multiple-table append/selection
- added support for `datetime64` in columns
- added method `unique` to select the unique values in an indexable or data column
- added method `copy` to copy an existing store (and possibly upgrade)
- show the shape of the data on disk for non-table stores when printing the store
- added ability to read PyTables flavor tables (allows compatibility to other HDF5 systems)

- Add `logx` option to DataFrame/Series.plot (GH2327, GH2565)
- Support reading gzipped data from file-like object
- `pivot_table` `aggfunc` can be anything used in GroupBy.aggregate (GH2643)
- Implement DataFrame merges in case where set cardinalities might overflow 64-bit integer (GH2690)
- Raise exception in C file parser if integer dtype specified and have NA values. (GH2631)
- Attempt to parse ISO8601 format dates when parse_dates=True in read_csv for major performance boost in such cases (GH2698)
- Add methods `neg` and `inv` to Series
- Implement `kind` option in ExcelFile to indicate whether it’s an XLS or XLSX file (GH2613)
- Documented a fast-path in pd.read_csv when parsing iso8601 datetime strings yielding as much as a 20x speedup. (GH5993)

38.27.4 Bug Fixes

- Fix read_csv/read_table multithreading issues (GH2608)
- HDFStore
  - correctly handle `nan` elements in string columns; serialize via the `nan_rep` keyword to append
  - raise correctly on non-implemented column types (unicode/date)
  - handle correctly `Term` passed types (e.g. `index<1000`, when index is `Int64`), (closes GH512)
  - handle Timestamp correctly in data_columns (closes GH2637)
  - contains correctly matches on non-natural names
  - correctly store `float32` dtypes in tables (if not other float types in the same table)
- Fix DataFrame.info bug with UTF8-encoded columns. (GH2576)
- Fix DatetimeIndex handling of FixedOffset tz (GH2604)
- More robust detection of being in IPython session for wide DataFrame console formatting (GH2585)
- Fix platform issues with `file:///` in unit test (GH2564)
- Fix bug and possible segfault when grouping by hierarchical level that contains NA values (GH2616)
• Ensure that MultiIndex tuples can be constructed with NAs (GH2616)
• Fix int64 overflow issue when unstacking MultiIndex with many levels (GH2616)
• Exclude non-numeric data from DataFrame.quantile by default (GH2625)
• Fix a Cython C int64 boxing issue causing read_csv to return incorrect results (GH2599)
• Fix groupby summing performance issue on boolean data (GH2692)
• Don’t bork Series containing datetime64 values with to_datetime (GH2699)
• Fix DataFrame.from_records corner case when passed columns, index column, but empty record list (GH2633)
• Fix C parser-tokenizer bug with trailing fields. (GH2668)
• Don’t exclude non-numeric data from GroupBy.max/min (GH2700)
• Don’t lose time zone when calling DatetimeIndex.drop (GH2621)
• Fix setitem on a Series with a boolean key and a non-scalar as value (GH2686)
• Box datetime64 values in Series.apply/map (GH2627, GH2689)
• Upconvert datetime + datetime64 values when concatenating frames (GH2624)
• Raise a more helpful error message in merge operations when one DataFrame has duplicate columns (GH2649)
• Fix partial date parsing issue occurring only when code is run at EOM (GH2618)
• Prevent MemoryError when using counting sort in sortlevel with high-cardinality MultiIndex objects (GH2684)
• Fix Period resampling bug when all values fall into a single bin (GH2070)
• Fix buggy interaction with usecols argument in read_csv when there is an implicit first index column (GH2654)
• Fix bug in Index.summary() where string format methods were being called incorrectly. (GH3869)

38.28 pandas 0.10.0

Release date: 2012-12-17

38.28.1 New Features

• Brand new high-performance delimited file parsing engine written in C and Cython. 50% or better performance in many standard use cases with a fraction as much memory usage. (GH407, GH821)
• Many new file parser (read_csv, read_table) features:
  – Support for on-the-fly gzip or bz2 decompression (compression option)
  – Ability to get back numpy.recarray instead of DataFrame (as_recarray=True)
  – dtype option: explicit column dtypes
  – usecols option: specify list of columns to be read from a file. Good for reading very wide files with many irrelevant columns (GH1216 GH926, GH2465)
  – Enhanced unicode decoding support via encoding option
  – skipinitialspace dialect option
  – Can specify strings to be recognized as True (true_values) or False (false_values)
- High-performance `delim_whitespace` option for whitespace-delimited files; a preferred alternative to the ‘s+’ regular expression delimiter
- Option to skip “bad” lines (wrong number of fields) that would otherwise have caused an error in the past (`error_bad_lines` and `warn_bad_lines` options)
- Substantially improved performance in the parsing of integers with thousands markers and lines with comments
- Easy of European (and other) decimal formats (`decimal` option) (GH584, GH2466)
- Custom line terminators (e.g. `lineterminator=’~’`) (GH2457)
- Handling of no trailing commas in CSV files (GH2333)
- Ability to handle fractional seconds in date_converters (GH2209)
- `read_csv` allow scalar arg to `na_values` (GH1944)
- Explicit column dtype specification in `read_`* functions (GH1858)
- Easier CSV dialect specification (GH1743)
- Improve parser performance when handling special characters (GH1204)

• Google Analytics API integration with easy oauth2 workflow (GH2283)
• Add error handling to Series.str.encode/decode (GH2276)
• Add where and mask to Series (GH2337)
• Grouped histogram via `by` keyword in Series/DataFrame.hist (GH2186)
• Support optional `min_periods` keyword in `corr` and `cov` for both Series and DataFrame (GH2002)
• Add duplicated and drop_duplicates functions to Series (GH1923)
• Add docs for HDFStore table format
• ‘density’ property in SparseSeries (GH2384)
• Add `ffill` and `bfill` convenience functions for forward- and backfilling time series data (GH2284)
• New option configuration system and functions `set_option`, `get_option`, `describe_option`, and `reset_option`. Deprecate `set_printoptions` and `reset_printoptions` (GH2393). You can also access options as attributes via `pandas.options.X`.
• Wide DataFrames can be viewed more easily in the console with new `expand_frame_repr` and `line_width` configuration options. This is on by default now (GH2436)
• Scikits.timeseries-like moving window functions via `rolling_window` (GH1270)

### 38.28.2 Experimental Features

- Add support for Panel4D, a named 4 Dimensional structure
- Add support for ndpanel factory functions, to create custom, domain-specific N-Dimensional containers

### 38.28.3 API Changes

- The default binning/labeling behavior for `resample` has been changed to `closed=’left’, label=’left’` for daily and lower frequencies. This had been a large source of confusion for users. See “what’s new” page for more on this. (GH2410)
pandas: powerful Python data analysis toolkit, Release 0.23.2

- Methods with `inplace` option now return None instead of the calling (modified) object (GH1893)
- The special case DataFrame - TimeSeries doing column-by-column broadcasting has been deprecated. Users should explicitly do e.g. `df.sub(ts, axis=0)` instead. This is a legacy hack and can lead to subtle bugs.
- `inf/-inf` are no longer considered as NA by `isnull/notnull`. To be clear, this is legacy cruft from early pandas. This behavior can be globally re-enabled using the new option `mode.use_inf_as_null` (GH2050, GH1919)
- `pandas.merge` will now default to `sort=False`. For many use cases sorting the join keys is not necessary, and doing it by default is wasteful
- Specify `header=0` explicitly to replace existing column names in file in `read_*` functions.
- Default column names for header-less parsed files (yielded by `read_csv`, etc.) are now the integers 0, 1, ..., A new argument `prefix` has been added; to get the v0.9.x behavior specify `prefix='X'` (GH2034). This API change was made to make the default column names more consistent with the DataFrame constructor’s default column names when none are specified.
- DataFrame selection using a boolean frame now preserves input shape
- If function passed to `Series.apply` yields a Series, result will be a DataFrame (GH2316)
- Values like YES/NO/yes/no will not be considered as boolean by default any longer in the file parsers. This can be customized using the new `true_values` and `false_values` options (GH2360)
- `obj.fillna()` is no longer valid; make `method='pad'` no longer the default option, to be more explicit about what kind of filling to perform. Add `ffill/bfill` convenience functions per above (GH2284)
- `HDFStore.keys()` now returns an absolute path-name for each key
- `to_string()` now always returns a unicode string. (GH2224)
- File parsers will not handle NA sentinel values arising from passed converter functions

38.28.4 Improvements to existing features

- Add `nrows` option to `DataFrame.from_records` for iterators (GH1794)
- Unstack/reshape algorithm rewrite to avoid high memory use in cases where the number of observed key-tuples is much smaller than the total possible number that could occur (GH2278). Also improves performance in most cases.
- Support duplicate columns in `DataFrame.from_records` (GH2179)
- Add `normalize` option to `Series/DataFrame.asfreq` (GH2137)
- SparseSeries and SparseDataFrame construction from empty and scalar values now no longer create dense ndarrays unnecessarily (GH2322)
- `HDFStore` now supports hierarchical keys (GH2397)
- Support multiple query selection formats for `HDFStore` tables (GH1996)
- Support `del store['df']` syntax to delete HDFStores
- Add multi-dtype support for `HDFStore` tables
- `min_itemsize` parameter can be specified in `HDFStore table` creation
- Indexing support in `HDFStore` tables (GH698)
- Add `line_terminator` option to `DataFrame.to_csv` (GH2383)
- added implementation of `str(x)/unicode(x)/bytes(x)` to major pandas data structures, which should do the right thing on both py2.x and py3.x. (GH2224)
• Reduce groupby.apply overhead substantially by low-level manipulation of internal NumPy arrays in DataFrames (GH535)
• Implement value_vars in melt and add melt to pandas namespace (GH2412)
• Added boolean comparison operators to Panel
• Enable Series.str.strip/lstrip/rstrip methods to take an argument (GH2411)
• The DataFrame ctor now respects column ordering when given an OrderedDict (GH2455)
• Assigning DatetimeIndex to Series changes the class to TimeSeries (GH2139)
• Improve performance of .value_counts method on non-integer data (GH2480)
• get_level_values method for MultiIndex return Index instead of ndarray (GH2449)
• convert_to_r_dataframe conversion for datetime values (GH2351)
• Allow DataFrame.to_csv to represent inf and nan differently (GH2026)
• Add min_i argument to nancorr to specify minimum required observations (GH2002)
• Add inplace option to sortlevel / sort functions on DataFrame (GH1873)
• Enable DataFrame to accept scalar constructor values like Series (GH1856)
• DataFrame.from_records now takes optional size parameter (GH1794)
• include iris dataset (GH1709)
• No datetime64 DataFrame column conversion of datetime.datetime with tzinfo (GH1581)
• Micro-optimizations in DataFrame for tracking state of internal consolidation (GH217)
• Format parameter in DataFrame.to_csv (GH1525)
• Partial string slicing for DatetimeIndex for daily and higher frequencies (GH2306)
• Implement col_space parameter in to_html and to_string in DataFrame (GH1000)
• Override Series.tolist and box datetime64 types (GH2447)
• Optimize unstack memory usage by compressing indices (GH2278)
• Fix HTML repr in IPython qtconsole if opening window is small (GH2275)
• Escape more special characters in console output (GH2492)
• df.select now invokes bool on the result of crit(x) (GH2487)

38.28.5 Bug Fixes

• Fix major performance regression in DataFrame.iteritems (GH2273)
• Fixes bug when negative period passed to Series/DataFrame.diff (GH2266)
• Escape tabs in console output to avoid alignment issues (GH2038)
• Properly box datetime64 values when retrieving cross-section from mixed-dtype DataFrame (GH2272)
• Fix concatenation bug leading to GH2057, GH2257
• Fix regression in Index console formatting (GH2319)
• Box Period data when assigning PeriodIndex to frame column (GH2243, GH2281)
• Raise exception on calling reset_index on Series with inplace=True (GH2277)
• Enable setting multiple columns in DataFrame with hierarchical columns (GH2295)
• Respect dtype=object in DataFrame constructor (GH2291)
• Fix DatetimeIndex.join bug with tz-aware indexes and how='outer' (GH2317)
• pop(...) and del works with DataFrame with duplicate columns (GH2349)
• Treat empty strings as NA in date parsing (rather than let dateutil do something weird) (GH2263)
• Prevent uint64 -> int64 overflows (GH2355)
• Enable joins between MultiIndex and regular Index (GH2024)
• Fix time zone metadata issue when unioning non-overlapping DatetimeIndex objects (GH2367)
• Raise/handle int64 overflows in parsers (GH2247)
• Deleting of consecutive rows in HDFStore tables is much faster than before
• Appending on a HDFStore would fail if the table was not first created via put
• Use col_space argument as minimum column width in DataFrame.to_html (GH2328)
• Fix tz-aware DatetimeIndex.to_period (GH2232)
• Fix DataFrame row indexing case with MultiIndex (GH2314)
• Fix to_excel exporting issues with Timestamp objects in index (GH2294)
• Fixes assigning scalars and array to hierarchical column chunk (GH1803)
• Fixed a UnicodeDecodeError with series tidy_repr (GH2225)
• Fixed issued with duplicate keys in an index (GH2347, GH2380)
• Fixed issues re: Hash randomization, default on starting w/ py3.3 (GH2331)
• Fixed issue with missing attributes after loading a pickled dataframe (GH2431)
• Fix Timestamp formatting with tzoffset time zone in dateutil 2.1 (GH2443)
• Fix GroupBy.apply issue when using BinGrouper to do ts binning (GH2300)
• Fix issues resulting from datetime.datetime columns being converted to datetime64 when calling DataFrame.apply. (GH2374)
• Raise exception when calling to_panel on non uniquely-indexed frame (GH2441)
• Improved detection of console encoding on IPython zmq frontends (GH2458)
• Preserve time zone when .append-ing two time series (GH2260)
• Box timestamps when calling reset_index on time-zone-aware index rather than creating a tz-less datetime64 column (GH2262)
• Enable searching non-string columns in DataFrame.filter(like=...) (GH2467)
• Fixed issue with losing nanosecond precision upon conversion to DatetimeIndex (GH2252)
• Handle timezones in Datetime.normalize (GH2338)
• Fix test case where dtype specification with endianness causes failures on big endian machines (GH2318)
• Fix plotting bug where upsampling causes data to appear shifted in time (GH2448)
• Fix read_csv failure for UTF-16 with BOM and skiprows (GH2298)
• read_csv with names arg not implicitly setting header=None (GH2459)
• Unrecognized compression mode causes segfault in read_csv (GH2474)
• In read_csv, header=0 and passed names should discard first row (GH2269)
• Correctly route to stdout/stderr in read_table (GH2071)
• Fix exception when Timestamp.to_datetime is called on a Timestamp with tzoffset (GH2471)
• Fixed unintentional conversion of datetime64 to long in groupby.first() (GH2133)
• Union of empty DataFrames now return empty with concatenated index (GH2307)
• DataFrame.sort_index raises more helpful exception if sorting by column with duplicates (GH2488)
• DataFrame.to_string formatters can be list, too (GH2520)
• DataFrame.combine_first will always result in the union of the index and columns, even if one DataFrame is length-zero (GH2525)
• Fix several DataFrame.icol/irow with duplicate indices issues (GH2228, GH2259)
• Use Series names for column names when using concat with axis=1 (GH2489)
• Raise Exception if start, end, periods all passed to date_range (GH2538)
• Fix Panel resampling issue (GH2537)

38.29 pandas 0.9.1

Release date: 2012-11-14

38.29.1 New Features

• Can specify multiple sort orders in DataFrame/Series.sort/sort_index (GH928)
• New top and bottom options for handling NAs in rank (GH1508, GH2159)
• Add where and mask functions to DataFrame (GH2109, GH2151)
• Add at_time and between_time functions to DataFrame (GH2149)
• Add flexible pow and rpow methods to DataFrame (GH2190)

38.29.2 API Changes

• Upsampling period index “spans” intervals. Example: annual periods upsampled to monthly will span all months in each year
• Period.end_time will yield timestamp at last nanosecond in the interval (GH2124, GH2125, GH1764)
• File parsers no longer coerce to float or bool for columns that have custom converters specified (GH2184)

38.29.3 Improvements to existing features

• Time rule inference for week-of-month (e.g. WOM-2FRI) rules (GH2140)
• Improve performance of datetime + business day offset with large number of offset periods
• Improve HTML display of DataFrame objects with hierarchical columns
• Enable referencing of Excel columns by their column names (GH1936)
DataFrame.dot can accept ndarrays (GH2042)
Support negative periods in Panel.shift (GH2164)
Make .drop(...) work with non-unique indexes (GH2101)
Improve performance of Series/DataFrame.diff (re: GH2087)
Support unary ~ (__invert__) in DataFrame (GH2110)
Turn off pandas-style tick locators and formatters (GH2205)
DataFrame[DataFrame] uses DataFrame.where to compute masked frame (GH2230)

38.29.4 Bug Fixes

Fix some duplicate-column DataFrame constructor issues (GH2079)
Fix bar plot color cycle issues (GH2082)
Fix off-center grid for stacked bar plots (GH2157)
Fix plotting bug if inferred frequency is offset with N > 1 (GH2126)
Implement comparisons on date offsets with fixed delta (GH2078)
Handle inf/-inf correctly in read_* parser functions (GH2041)
Fix matplotlib unicode interaction bug
Make WLS r-squared match statsmodels 0.5.0 fixed value
Fix zero-trimming DataFrame formatting bug
Correctly compute/box datetime64 min/max values from Series.min/max (GH2083)
Fix unstacking edge case with unrepresented groups (GH2100)
Fix Series.str failures when using pipe pattern ‘|’ (GH2119)
Fix pretty-printing of dict entries in Series, DataFrame (GH2144)
Cast other datetime64 values to nanoseconds in DataFrame ctor (GH2095)
Alias Timestamp.astimezone to tz_convert, so will yield Timestamp (GH2060)
Fix timedelta64 formatting from Series (GH2165, GH2146)
Handle None values gracefully in dict passed to Panel constructor (GH2075)
Box datetime64 values as Timestamp objects in Series/DataFrame.iget (GH2148)
Fix Timestamp indexing bug in DatetimeIndex.insert (GH2155)
Use index name(s) (if any) in DataFrame.to_records (GH2161)
Don’t lose index names in Panel.to_frame/DataFrame.to_panel (GH2163)
Work around length-0 boolean indexing NumPy bug (GH2096)
Fix partial integer indexing bug in DataFrame.xs (GH2107)
Fix variety of cut/qcut string-bin formatting bugs (GH1978, GH1979)
Raise Exception when xs view not possible of MultiIndex’d DataFrame (GH2117)
Fix groupby(...).first() issue with datetime64 (GH2133)
Better floating point error robustness in some rolling_* functions (GH2114, GH2527)
- Fix ewma NA handling in the middle of Series (GH2128)
- Fix numerical precision issues in diff with integer data (GH2087)
- Fix bug in MultiIndex.__getitem__ with NA values (GH2008)
- Fix DataFrame.from_records dict-arg bug when passing columns (GH2179)
- Fix Series and DataFrame.diff for integer dtypes (GH2087, GH2174)
- Fix bug when taking intersection of DatetimeIndex with empty index (GH2129)
- Pass through timezone information when calling DataFrame.align (GH2127)
- Properly sort when joining on datetime64 values (GH2196)
- Fix indexing bug in which False/True were being coerced to 0/1 (GH2199)
- Many unicode formatting fixes (GH2201)
- Fix improper MultiIndex conversion issue when assigning e.g. DataFrame.index (GH2200)
- Fix conversion of mixed-type DataFrame to ndarray with dup columns (GH2236)
- Fix duplicate columns issue (GH2218, GH2219)
- Fix SparseSeries.__pow__ issue with NA input (GH2220)
- Fix icol with integer sequence failure (GH2228)
- Fixed resampling tz-aware time series issue (GH2245)
- SparseDataFrame.icol was not returning SparseSeries (GH2227, GH2229)
- Enable ExcelWriter to handle PeriodIndex (GH2240)
- Fix issue constructing DataFrame from empty Series with name (GH2234)
- Use console-width detection in interactive sessions only (GH1610)
- Fix parallel_coordinates legend bug with mpl 1.2.0 (GH2237)
- Make tz_localize work in corner case of empty Series (GH2248)

38.30 pandas 0.9.0

Release date: 10/7/2012

38.30.1 New Features

- Add str.encode and str.decode to Series (GH1706)
- Add to_latex method to DataFrame (GH1735)
- Add convenient expanding window equivalents of all rolling_* ops (GH1785)
- Add Options class to pandas.io.data for fetching options data from Yahoo! Finance (GH1748, GH1739)
- Recognize and convert more boolean values in file parsing (Yes, No, TRUE, FALSE, variants thereof) (GH1691, GH1295)
38.30.2 Improvements to existing features

- Proper handling of NA values in merge operations (GH1990)
- Add flags option for re.compile in some Series.str methods (GH1659)
- Parsing of UTC date strings in read_* functions (GH1693)
- Handle generator input to Series (GH1679)
- Add na_action='ignore' to Series.map to quietly propagate NAs (GH1661)
- Add args/kwds options to Series.apply (GH1829)
- Add inplace option to Series/DataFrame.reset_index (GH1797)
- Add level parameter to Series.reset_index
- Add quoting option for DataFrame.to_csv (GH1902)
- Indicate long column value truncation in DataFrame output with ... (GH1854)
- DataFrame.dot will not do data alignment, and also work with Series (GH1915)
- Add na option for missing data handling in some vectorized string methods (GH1689)
- If index_label=False in DataFrame.to_csv, do not print fields/commas in the text output. Results in easier importing into R (GH1583)
- Can pass tuple/list of axes to DataFrame.dropna to simplify repeated calls (dropping both columns and rows) (GH924)
- Improve DataFrame.to_html output for hierarchically-indexed rows (do not repeat levels) (GH1929)
- TimeSeries.between_time can now select times across midnight (GH1871)
- Enable skip footer parameter in ExcelFile.parse (GH1843)

38.30.3 API Changes

- Change default header names in read_* functions to more Pythonic X0, X1, etc. instead of X.1, X.2. (GH2000)
- Deprecated day_of_year API removed from PeriodIndex, use dayofyear (GH1723)
- Don’t modify NumPy suppress printoption at import time
- The internal HDF5 data arrangement for DataFrames has been transposed. Legacy files will still be readable by HDFStore (GH1834, GH1824)
- Legacy cruft removed: pandas.stats.misc.quantileTS
- Use ISO8601 format for Period repr: monthly, daily, and on down (GH1776)
- Empty DataFrame columns are now created as object dtype. This will prevent a class of TypeErrors that was occurring in code where the dtype of a column would depend on the presence of data or not (e.g. a SQL query having results) (GH1783)
- Setting parts of DataFrame/Panel using ix now aligns input Series/DataFrame (GH1630)
- first and last methods in GroupBy no longer drop non-numeric columns (GH1809)
- Resolved inconsistencies in specifying custom NA values in text parser. na_values of type dict no longer override default NAs unless keep_default_na is set to false explicitly (GH1657)
- Enable skipfooter parameter in text parsers as an alias for skip footer
38.30.4 Bug Fixes

- Perform arithmetic column-by-column in mixed-type DataFrame to avoid type upcasting issues. Caused downstream DataFrame.diff bug (GH1896)
- Fix matplotlib auto-color assignment when no custom spectrum passed. Also respect passed color keyword argument (GH1711)
- Fix resampling logical error with closed='left' (GH1726)
- Fix critical DatetimeIndex.union bugs (GH1730, GH1719, GH1745, GH1702, GH1753)
- Fix critical DatetimeIndex.intersection bug with unanchored offsets (GH1708)
- Fix MM-YYYY time series indexing case (GH1672)
- Fix case where Categorical group key was not being passed into index in GroupBy result (GH1701)
- Handle Ellipsis in Series.__getitem__/__setitem__ (GH1721)
- Fix some bugs with handling datetime64 scalars of other units in NumPy 1.6 and 1.7 (GH1717)
- Fix performance issue in MultiIndex.format (GH1746)
- Fixed GroupBy bugs interacting with DatetimeIndex asof / map methods (GH1677)
- Handle factors with NAs in pandas.rpy (GH1615)
- Fix statsmodels import in pandas.stats.var (GH1734)
- Fix DataFrame repr/info summary with non-unique columns (GH1700)
- Fix Series.istat_value for non-unique indexes (GH1694)
- Don’t lose tzinfo when passing DatetimeIndex as DataFrame column (GH1682)
- Fix tz conversion with time zones that haven’t had any DST transitions since first date in the array (GH1673)
- Fix field access with UTC->local conversion on unsorted arrays (GH1756)
- Fix isnull handling of array-like (list) inputs (GH1755)
- Fix regression in handling of Series in Series constructor (GH1671)
- Fix comparison of Int64Index with DatetimeIndex (GH1681)
- Fix min_periods handling in new rolling_max/min at array start (GH1695)
- Fix errors with how='median' and generic NumPy resampling in some cases caused by SeriesBinGrouper (GH1648, GH1688)
- When grouping by level, exclude unobserved levels (GH1697)
- Don’t lose tzinfo in DatetimeIndex when shifting by different offset (GH1683)
- Hack to support storing data with a zero-length axis in HDFStore (GH1707)
- Fix DatetimeIndex tz-aware range generation issue (GH1674)
- Fix method='time' interpolation with intraday data (GH1698)
- Don’t plot all-NA DataFrame columns as zeros (GH1696)
- Fix bug in scatter_plot with by option (GH1716)
- Fix performance problem in infer_freq with lots of non-unique stamps (GH1686)
- Fix handling of PeriodIndex as argument to create MultiIndex (GH1705)
- Fix re: unicode MultiIndex level names in Series/DataFrame repr (GH1736)
• Handle PeriodIndex in to_datetime instance method (GH1703)
• Support StaticTzInfo in DatetimeIndex infrastructure (GH1692)
• Allow MultiIndex setops with length-0 other type indexes (GH1727)
• Fix handling of DatetimeIndex in DataFrame.to_records (GH1720)
• Fix handling of general objects in isnull on which bool(...) fails (GH1749)
• Fix .ix indexing with MultiIndex ambiguity (GH1678)
• Fix .ix setting logic error with non-unique MultiIndex (GH1750)
• Basic indexing now works on MultiIndex with > 1000000 elements, regression from earlier version of pandas (GH1757)
• Handle non-float64 dtypes in fast DataFrame.corr/cov code paths (GH1761)
• Fix DatetimeIndex.isin to function properly (GH1763)
• Fix conversion of array of tz-aware datetime.datetime to DatetimeIndex with right time zone (GH1777)
• Fix DST issues with generating ancxhored date ranges (GH1778)
• Fix issue calling sort on result of Series.unique (GH1807)
• Fix numerical issue leading to square root of negative number in rolling_std (GH1840)
• Let Series.str.split accept no arguments (like str.split) (GH1859)
• Allow user to have dateutil 2.1 installed on a Python 2 system (GH1851)
• Catch ImportError less aggressively in pandas/__init__.py (GH1845)
• Fix pip source installation bug when installing from GitHub (GH1805)
• Fix error when window size > array size in rolling_apply (GH1850)
• Fix pip source installation issues via SSH from GitHub
• Fix OLS.summary when column is a tuple (GH1837)
• Fix bug in __doc__ patching when -OO passed to interpreter (GH1792 GH1741 GH1774)
• Fix unicode console encoding issue in IPython notebook (GH1782, GH1768)
• Fix unicode formatting issue with Series.name (GH1782)
• Fix bug in DataFrame.duplicated with datetime64 columns (GH1833)
• Fix bug in Panel internals resulting in error when doing fillna after truncate not changing size of panel (GH1823)
• Prevent segfault due to MultiIndex not being supported in HDFStore table format (GH1848)
• Fix UnboundLocalError in Panel.__setitem__ and add better error (GH1826)
• Fix to_csv issues with list of string entries. Isnull works on list of strings now too (GH1791)
• Fix Timestamp comparisons with datetime values outside the nanosecond range (1677-2262)
• Revert to prior behavior of normalize_date with datetime.date objects (return datetime)
• Fix broken interaction between np.nansum and Series.any/all
• Fix bug with multiple column date parsers (GH1866)
• DatetimeIndex.union(Int64Index) was broken
• Make plot x vs y interface consistent with integer indexing (GH1842)
• set_index inplace modified data even if unique check fails (GH1831)
• Only use Q-OCT/NOV/DEC in quarterly frequency inference (GH1789)
• Upcast to dtype=object when unstacking boolean DataFrame (GH1820)
• Fix float64/float32 merging bug (GH1849)
• Fixes to Period.start_time for non-daily frequencies (GH1857)
• Fix failure when converter used on index_col in read_csv (GH1835)
• Implement PeriodIndex.append so that pandas.concat works correctly (GH1815)
• Avoid Cython out-of-bounds access causing segfault sometimes in pad_2d, backfill_2d
• Fix resampling error with intraday times and anchored target time (like AS-DEC) (GH1772)
• Fix .ix indexing bugs with mixed-integer indexes (GH1799)
• Respect passed color keyword argument in Series.plot (GH1890)
• Fix rolling_min/max when the window is larger than the size of the input array. Check other malformed inputs (GH1899, GH1897)
• Rolling variance / standard deviation with only a single observation in window (GH1884)
• Fix unicode sheet name failure in to Excel (GH1828)
• Override DatetimeIndex.min/max to return Timestamp objects (GH1895)
• Fix column name formatting issue in length-truncated column (GH1906)
• Fix broken handling of copying Index metadata to new instances created by view(...) calls inside the NumPy infrastructure
• Support datetime.date again in DateOffset.rollback/rollforward
• Raise Exception if set passed to Series constructor (GH1913)
• Add TypeError when appending HDFStore table w/ wrong index type (GH1881)
• Don’t raise exception on empty inputs in EW functions (e.g. ewma) (GH1900)
• Make asof work correctly with PeriodIndex (GH1883)
• Fix extlinks in doc build
• Fill boolean DataFrame with NaN when calling shift (GH1814)
• Fix setuptools bug causing pip not to Cythonize .pyx files sometimes
• Fix negative integer indexing regression in .ix from 0.7.x (GH1888)
• Fix error while retrieving timezone and utc offset from subclasses of datetime.tzinfo without .zone and ._utcoffset attributes (GH1922)
• Fix DataFrame formatting of small, non-zero FP numbers (GH1911)
• Various fixes by upcasting of date -&gt; datetime (GH1395)
• Raise better exception when passing multiple functions with the same name, such as lambdas, to GroupBy.aggregate
• Fix DataFrame.apply with axis=1 on a non-unique index (GH1878)
• Proper handling of Index subclasses in pandas.unique (GH1759)
• Set index names in DataFrame.from_records (GH1744)
• Fix time series indexing error with duplicates, under and over hash table size cutoff (GH1821)
• Handle list keys in addition to tuples in DataFrame.xs when partial-indexing a hierarchically-indexed DataFrame (GH1796)
• Support multiple column selection in DataFrame.__getitem__ with duplicate columns (GH1943)
• Fix time zone localization bug causing improper fields (e.g. hours) in time zones that have not had a UTC transition in a long time (GH1946)
• Fix errors when parsing and working with fixed offset timezones (GH1922, GH1928)
• Fix text parser bug when handling UTC datetime objects generated by dateutil (GH1693)
• Fix plotting bug when ‘B’ is the inferred frequency but index actually contains weekends (GH1668, GH1669)
• Fix plot styling bugs (GH1666, GH1665, GH1658)
• Fix plotting bug with index/columns with unicode (GH1685)
• Fix DataFrame constructor bug when passed Series with datetime64 dtype in a dict (GH1680)
• Fixed regression in generating DatetimeIndex using timezone aware datetime.datetime (GH1676)
• Fix DataFrame bug when printing concatenated DataFrames with duplicated columns (GH1675)
• Fixed bug when plotting time series with multiple intraday frequencies (GH1732)
• Fix bug in DataFrame.duplicated to enable iterables other than list-types as input argument (GH1773)
• Fix resample bug when passed list of lambdas as how argument (GH1808)
• Repr fix for MultiIndex level with all NAs (GH1971)
• Fix PeriodIndex slicing bug when slice start/end are out-of-bounds (GH1977)
• Fix read_table bug when parsing unicode (GH1975)
• Fix BlockManager.iget bug when dealing with non-unique MultiIndex as columns (GH1970)
• Fix reset_index bug if both drop and level are specified (GH1957)
• Work around unsafe NumPy object->int casting with Cython function (GH1987)
• Fix datetime64 formatting bug in DataFrame.to_csv (GH1993)
• Default start date in pandas.io.data to 1/1/2000 as the docs say (GH2011)

38.31 pandas 0.8.1

Release date: July 22, 2012

38.31.1 New Features

• Add vectorized, NA-friendly string methods to Series (GH1621, GH620)
• Can pass dict of per-column line styles to DataFrame.plot (GH1559)
• Selective plotting to secondary y-axis on same subplot (GH1640)
• Add new bootstrap_plot plot function
• Add new parallel_coordinates plot function (GH1488)
• Add radviz plot function (GH1566)
• Add `multi_sparse` option to `set_printoptions` to modify display of hierarchical indexes (GH1538)
• Add `dropna` method to Panel (GH171)

38.31.2 Improvements to existing features

• Use moving min/max algorithms from Bottleneck in rolling_min/rolling_max for > 100x speedup. (GH1504, GH50)
• Add Cython group median method for >15x speedup (GH1358)
• Drastically improve `to_datetime` performance on ISO8601 datetime strings (with no time zones) (GH1571)
• Improve single-key groupby performance on large data sets, accelerate use of groupby with a Categorical variable
• Add ability to append hierarchical index levels with `set_index` and to drop single levels with `reset_index` (GH1569, GH1577)
• Always apply passed functions in `resample`, even if upsampling (GH1596)
• Avoid unnecessary copies in DataFrame constructor with explicit dtype (GH1572)
• Cleaner DatetimeIndex string representation with 1 or 2 elements (GH1611)
• Improve performance of array-of-Period to PeriodIndex, convert such arrays to PeriodIndex inside Index (GH1215)
• More informative string representation for weekly Period objects (GH1503)
• Accelerate 3-axis multi data selection from homogeneous Panel (GH979)
• Add `adjust` option to ewma to disable adjustment factor (GH1584)
• Add new matplotlib converters for high frequency time series plotting (GH1599)
• Handling of tz-aware datetime.datetime objects in to_datetime; raise Exception unless utc=True given (GH1581)

38.31.3 Bug Fixes

• Fix NA handling in DataFrame.to_panel (GH1582)
• Handle TypeError issues inside PyObject_RichCompareBool calls in khash (GH1318)
• Fix resampling bug to lower case daily frequency (GH1588)
• Fix kendall/spearman DataFrame.corr bug with no overlap (GH1595)
• Fix bug in DataFrame.set_index (GH1592)
• Don’t ignore axes in boxplot if by specified (GH1565)
• Fix Panel.ix indexing with integers bug (GH1603)
• Fix Partial indexing bugs (years, months, ...) with PeriodIndex (GH1601)
• Fix MultiIndex console formatting issue (GH1606)
• Unordered index with duplicates doesn’t yield scalar location for single entry (GH1586)
• Fix resampling of tz-aware time series with “anchored” freq (GH1591)
• Fix DataFrame.rank error on integer data (GH1589)
• Selection of multiple SparseDataFrame columns by list in `__getitem__` (GH1585)
• Override Index.tolist for compatibility with MultiIndex (GH1576)
• Fix hierarchical summing bug with MultiIndex of length 1 (GH1568)
• Work around numpy.concatenate use/bug in Series.set_value (GH1561)
• Ensure Series/DataFrame are sorted before resampling (GH1580)
• Fix unhandled IndexError when indexing very large time series (GH1562)
• Fix DatetimeIndex intersection logic error with irregular indexes (GH1551)
• Fix unit test errors on Python 3 (GH1550)
• Fix .ix indexing bugs in duplicate DataFrame index (GH1201)
• Better handle errors with non-existing objects in HDFStore (GH1254)
• Don’t copy int64 array data in DatetimeIndex when copy=False (GH1624)
• Fix resampling of conforming periods quarterly to annual (GH1622)
• Don’t lose index name on resampling (GH1631)
• Support python-dateutil version 2.1 (GH1637)
• Fix broken scatter_matrix axis labeling, esp. with time series (GH1625)
• Fix cases where extra keywords weren’t being passed on to matplotlib from Series.plot (GH1636)
• Fix BusinessMonthBegin logic for dates before 1st bday of month (GH1645)
• Ensure string alias converted (valid in DatetimeIndex.get_loc) in DataFrame.xs / __getitem__ (GH1644)
• Fix use of string alias timestamps with tz-aware time series (GH1647)
• Fix Series.max/min and Series.describe on len-0 series (GH1650)
• Handle None values in dict passed to concat (GH1649)
• Fix Series.interpolate with method='values' and DatetimeIndex (GH1646)
• Fix IndexError in left merges on a DataFrame with 0-length (GH1628)
• Fix DataFrame column width display with UTF-8 encoded characters (GH1620)
• Handle case in pandas.io.data.get_data_yahoo where Yahoo! returns duplicate dates for most recent business day
• Avoid downsampling when plotting mixed frequencies on the same subplot (GH1619)
• Fix read_csv bug when reading a single line (GH1553)
• Fix bug in C code causing monthly periods prior to December 1969 to be off (GH1570)

38.32 pandas 0.8.0

Release date: 6/29/2012

38.32.1 New Features

• New unified DatetimeIndex class for nanosecond-level timestamp data
• New Timestamp datetime.datetime subclass with easy time zone conversions, and support for nanoseconds
• New PeriodIndex class for timespans, calendar logic, and Period scalar object
• High performance resampling of timestamp and period data. New resample method of all pandas data structures
• New frequency names plus shortcut string aliases like ‘15h’, ‘1h30min’
• Time series string indexing shorthand (GH222)
• Add week, dayofyear array and other timestamp array-valued field accessor functions to DatetimeIndex
• Add GroupBy.prod optimized aggregation function and ‘prod’ fast time series conversion method (GH1018)
• Implement robust frequency inference function and inferred_freq attribute on DatetimeIndex (GH391)
• New tz_convert and tz_localize methods in Series / DataFrame
• Convert DatetimeIndexes to UTC if time zones are different in join/setops (GH864)
• Add limit argument for forward/backward filling to reindex, fillna, etc. (GH825 and others)
• Add support for indexes (dates or otherwise) with duplicates and common sense indexing/selection functionality
• Series/DataFrame.update methods, in-place variant of combine_first (GH961)
• Add match function to API (GH502)
• Add Cython-optimized first, last, min, max, prod functions to GroupBy (GH994, GH1043)
• Dates can be split across multiple columns (GH1227, GH1186)
• Add experimental support for converting pandas DataFrame to R data.frame via rpy2 (GH350, GH1212)
• Can pass list of (name, function) to GroupBy.aggregate to get aggregates in a particular order (GH610)
• Can pass dicts with lists of functions or dicts to GroupBy aggregate to do much more flexible multiple function aggregation (GH642, GH610)
• New ordered_merge functions for merging DataFrames with ordered data. Also supports group-wise merging for panel data (GH813)
• Add keys() method to DataFrame
• Add flexible replace method for replacing potentially values to Series and DataFrame (GH929, GH1241)
• Add ‘kde’ plot kind for Series/DataFrame.plot (GH1059)
• More flexible multiple function aggregation with GroupBy
• Add pct_change function to Series/DataFrame
• Add option to interpolate by Index values in Series.interpolate (GH1206)
• Add max_colwidth option for DataFrame, defaulting to 50
• Conversion of DataFrame through rpy2 to R data.frame (GH1282, )
• Add keys() method on DataFrame (GH1240)
• Add new match function to API (similar to R) (GH502)
• Add dayfirst option to parsers (GH854)
• Add method argument to align method for forward/backward fillin (GH216)
• Add Panel.transpose method for rearranging axes (GH695)
• Add new cut function (patterned after R) for discretizing data into equal range-length bins or arbitrary breaks of your choosing (GH415)
• Add new qcut for cutting with quantiles (GH1378)
• Add `value_counts` top level array method (GH1392)
• Added Andrews curves plot tupe (GH1325)
• Add lag plot (GH1440)
• Add autocorrelation_plot (GH1425)
• Add support for tox and Travis CI (GH1382)
• Add support for Categorical use in GroupBy (GH292)
• Add `any` and `all` methods to DataFrame (GH1416)
• Add `secondary_y` option to Series.plot
• Add experimental `lreshape` function for reshaping wide to long

38.32.2 Improvements to existing features

• Switch to klib/khash-based hash tables in Index classes for better performance in many cases and lower memory footprint
• Shipping some functions from scipy.stats to reduce dependency, e.g. Series.describe and DataFrame.describe (GH1092)
• Can create MultiIndex by passing list of lists or list of arrays to Series, DataFrame constructor, etc. (GH831)
• Can pass arrays in addition to column names to DataFrame.set_index (GH402)
• Improve the speed of “square” reindexing of homogeneous DataFrame objects by significant margin (GH836)
• Handle more dtypes when passed MaskedArrays in DataFrame constructor (GH406)
• Improved performance of join operations on integer keys (GH682)
• Can pass multiple columns to GroupBy object, e.g. grouped[[col1, col2]] to only aggregate a subset of the value columns (GH383)
• Add histogram / kde plot options for scatter_matrix diagonals (GH1237)
• Add inplace option to Series/DataFrame.rename and sort_index, DataFrame.drop_duplicates (GH805, GH207)
• More helpful error message when nothing passed to Series.reindex (GH1267)
• Can mix array and scalars as dict-value inputs to DataFrame ctor (GH1329)
• Use DataFrame columns’ name for legend title in plots
• Preserve frequency in DatetimeIndex when possible in boolean indexing operations
• Promote datetime.date values in data alignment operations (GH867)
• Add `order` method to Index classes (GH1028)
• Avoid hash table creation in large monotonic hash table indexes (GH1160)
• Store time zones in HDFStore (GH1232)
• Enable storage of sparse data structures in HDFStore (GH85)
• Enable Series.asof to work with arrays of timestamp inputs
• Cython implementation of DataFrame.corr speeds up by > 100x (GH1349, GH1354)
• Exclude “nuisance” columns automatically in GroupBy.transform (GH1364)
• Support functions-as-strings in GroupBy.transform (GH1362)
**38.32.3 API Changes**

- Rename `pandas._tseries` to `pandas.lib`
- Rename Factor to Categorical and add improvements. Numerous Categorical bug fixes
- Frequency name overhaul, WEEKDAY/EOM and rules with @ deprecated. `get_legacy_offset_name` backwards compatibility function added
- Raise `ValueError` in DataFrame.__nonzero__, so “if df” no longer works (GH1073)
- Change BDay (business day) to not normalize dates by default (GH506)
- Remove deprecated DataMatrix name
- Default merge suffixes for overlap now have underscores instead of periods to facilitate tab completion, etc. (GH1239)
- Deprecation of offset, time_rule timeRule parameters throughout codebase
- Series.append and DataFrame.append no longer check for duplicate indexes by default, add `verify_integrity` parameter (GH1394)
- Refactor Factor class, old constructor moved to Factor.from_array
- Modified internals of MultiIndex to use less memory (no longer represented as array of tuples) internally, speed up construction time and many methods which construct intermediate hierarchical indexes (GH1467)

**38.32.4 Bug Fixes**

- Fix OverflowError from storing pre-1970 dates in HDFStore by switching to datetime64 (GH179)
- Fix logical error with February leap year end in YearEnd offset
- Series([False, nan]) was getting casted to float64 (GH1074)
- Fix binary operations between boolean Series and object Series with booleans and NAs (GH1074, GH1079)
- Couldn’t assign whole array to column in mixed-type DataFrame via ix (GH1142)
- Fix label slicing issues with float index values (GH1167)
• Fix segfault caused by empty groups passed to groupby (GH1048)
• Fix occasionally misbehaved reindexing in the presence of NaN labels (GH522)
• Fix imprecise logic causing weird Series results from .apply (GH1183)
• Unstack multiple levels in one shot, avoiding empty columns in some cases. Fix pivot table bug (GH1181)
• Fix formatting of MultiIndex on Series/DataFrame when index name coincides with label (GH1217)
• Handle Excel 2003 #N/A as NaN from xlrd (GH1213, GH1225)
• Fix timestamp locale-related deserialization issues with HDFStore by moving to datetime64 representation (GH1081, GH809)
• Fix DataFrame.duplicated/drop_duplicates NA value handling (GH557)
• Actually raise exceptions in fast reducer (GH1243)
• Fix various timezone-handling bugs from 0.7.3 (GH969)
• GroupBy on level=0 discarded index name (GH1313)
• Better error message with unmergeable DataFrames (GH1307)
• Series.__repr__ alignment fix with unicode index values (GH1279)
• Better error message if nothing passed to reindex (GH1267)
• More robust NA handling in DataFrame.drop_duplicates (GH557)
• Resolve locale-based and pre-epoch HDF5 timestamp deserialization issues (GH973, GH1081, GH179)
• Implement Series.repeat (GH1229)
• Fix indexing with namedtuple and other tuple subclasses (GH1026)
• Fix float64 slicing bug (GH1167)
• Parsing integers with commas (GH796)
• Fix groupby improper data type when group consists of one value (GH1065)
• Fix negative variance possibility in nanvar resulting from floating point error (GH1090)
• Consistently set name on groupby pieces (GH184)
• Treat dict return values as Series in GroupBy.apply (GH823)
• Respect column selection for DataFrame in GroupBy.transform (GH1365)
• Fix MultiIndex partial indexing bug (GH1352)
• Enable assignment of rows in mixed-type DataFrame via .ix (GH1432)
• Reset index mapping when grouping Series in Cython (GH1423)
• Fix outer/inner DataFrame.join with non-unique indexes (GH1421)
• Fix MultiIndex groupby bugs with empty lower levels (GH1401)
• Calling fillna with a Series will have same behavior as with dict (GH1486)
• SparseSeries reduction bug (GH1375)
• Fix unicode serialization issue in HDFStore (GH1361)
• Pass keywords to pyplot.boxplot in DataFrame.boxplot (GH1493)
• Bug fixes in MonthBegin (GH1483)
• Preserve MultiIndex names in drop (GH1513)
• Fix Panel DataFrame slice-assignment bug (GH1533)
• Don’t use locals() in read_* functions (GH1547)

38.33  pandas 0.7.3

Release date: April 12, 2012

38.33.1 New Features

• Support for non-unique indexes: indexing and selection, many-to-one and many-to-many joins (GH1306)
• Added fixed-width file reader, read_fwf (GH952)
• Add group_keys argument to groupby to not add group names to MultiIndex in result of apply (GH938)
• DataFrame can now accept non-integer label slicing (GH946). Previously only DataFrame.ix was able to do so.
• DataFrame.apply now retains name attributes on Series objects (GH983)
• Numeric DataFrame comparisons with non-numeric values now raises proper TypeError (GH943). Previously raise “PandasError: DataFrame constructor not properly called!”
• Add kurt methods to Series and DataFrame (GH964)
• Can pass dict of column -> list/set NA values for text parsers (GH754)
• Allows users specified NA values in text parsers (GH754)
• Parsers checks for openpyxl dependency and raises ImportError if not found (GH1007)
• New factory function to create HDFStore objects that can be used in a with statement so users do not have to explicitly call HDFStore.close (GH1005)
• pivot_table is now more flexible with same parameters as groupby (GH941)
• Added stacked bar plots (GH987)
• scatter_matrix method in pandas/tools/plotting.py (GH935)
• DataFrame.boxplot returns plot results for ex-post styling (GH985)
• Short version number accessible as pandas.version.short_version (GH930)
• Additional documentation in panel.to_frame (GH942)
• More informative Series.apply docstring regarding element-wise apply (GH977)
• Notes on rpy2 installation (GH1006)
• Add rotation and font size options to hist method (GH1012)
• Use exogenous / X variable index in result of OLS.y._predict. Add OLS.predict method (GH1027, GH1008)

38.33.2 API Changes

• Calling apply on grouped Series, e.g. describe(), will no longer yield DataFrame by default. Will have to call unstack() to get prior behavior
• NA handling in non-numeric comparisons has been tightened up (GH933, GH953)
38.33.3 Bug Fixes

- No longer assign dummy names key_0, key_1, etc. to groupby index (GH1291)

38.34 pandas 0.7.2

Release date: March 16, 2012

38.34.1 New Features

- Add additional tie-breaking methods in DataFrame.rank (GH874)
- Add ascending parameter to rank in Series, DataFrame (GH875)
- Add sort_columns parameter to allow unsorted plots (GH918)
- IPython tab completion on GroupBy objects

38.34.2 API Changes

- Series.sum returns 0 instead of NA when called on an empty series. Analogously for a DataFrame whose rows or columns are length 0 (GH844)
38.34.3 Improvements to existing features

- Don’t use groups dict in Grouper.size (GH860)
- Use khash for Series.value_counts, add raw function to algorithms.py (GH861)
- Enable column access via attributes on GroupBy (GH882)
- Enable setting existing columns (only) via attributes on DataFrame, Panel (GH883)
- Intercept __builtin__.sum in groupby (GH885)
- Can pass dict to DataFrame.fillna to use different values per column (GH661)
- Can select multiple hierarchical groups by passing list of values in .ix (GH134)
- Add level keyword to drop for dropping values from a level (GH159)
- Add coerce_float option on DataFrame.from_records (GH893)
- Raise exception if passed date_parser fails in read_csv
- Add axis option to DataFrame.fillna (GH174)
- Fixes to Panel to make it easier to subclass (GH888)

38.34.4 Bug Fixes

- Fix overflow-related bugs in groupby (GH850, GH851)
- Fix unhelpful error message in parsers (GH856)
- Better err msg for failed boolean slicing of dataframe (GH859)
- Series.count cannot accept a string (level name) in the level argument (GH869)
- Group index platform int check (GH870)
- concat on axis=1 and ignore_index=True raises TypeError (GH795)
- Further unicode handling issues resolved (GH875)
- Fix failure in multiindex-based access in Panel (GH880)
- Fix DataFrame boolean slice assignment failure (GH881)
- Fix combineAdd NotImplementedError for SparseDataFrame (GH887)
- Fix DataFrame.to_html encoding and columns (GH890, GH891, GH909)
- Fix na-filling handling in mixed-type DataFrame (GH910)
- Fix to DataFrame.set_value with non-existant row/col (GH911)
- Fix malformed block in groupby when excluding nuisance columns (GH916)
- Fix inconsistent NA handling in dtype=object arrays (GH925)
- Fix missing center-of-mass computation in ewmcov (GH862)
- Don’t raise exception when opening read-only HDF5 file (GH847)
- Fix possible out-of-bounds memory access in 0-length Series (GH917)
38.35 pandas 0.7.1

Release date: February 29, 2012

38.35.1 New Features

- Add `to_clipboard` function to pandas namespace for writing objects to the system clipboard (GH774)
- Add `itertuples` method to DataFrame for iterating through the rows of a dataframe as tuples (GH818)
- Add ability to pass `fill_value` and method to DataFrame and Series align method (GH806, GH807)
- Add `fill_value` option to reindex, align methods (GH784)
- Enable concat to produce DataFrame from Series (GH787)
- Add `between` method to Series (GH802)
- Add HTML representation hook to DataFrame for the IPython HTML notebook (GH773)
- Support for reading Excel 2007 XML documents using openpyxl

38.35.2 Improvements to existing features

- Improve performance and memory usage of `fillna` on DataFrame
- Can concatenate a list of Series along `axis=1` to obtain a DataFrame (GH787)

38.35.3 Bug Fixes

- Fix memory leak when inserting large number of columns into a single DataFrame (GH790)
- Appending length-0 DataFrame with new columns would not result in those new columns being part of the resulting concatenated DataFrame (GH782)
- Fixed groupby corner case when passing dictionary grouper and `as_index` is False (GH819)
- Fixed bug whereby bool array sometimes had object dtype (GH820)
- Fix exception thrown on `np.diff` (GH816)
- Fix to_records where columns are non-strings (GH822)
- Fix `Index.intersection` where indices have incomparable types (GH811)
- Fix ExcelFile throwing an exception for two-line file (GH837)
- Add clearer error message in csv parser (GH835)
- Fix loss of fractional seconds in HDFStore (GH513)
- Fix DataFrame join where columns have datetimes (GH787)
- Work around NumPy performance issue in `take` (GH817)
- Improve comparison operations for NA-friendliness (GH801)
- Fix indexing operation for floating point values (GH780, GH798)
- Fix groupby case resulting in malformed dataframe (GH814)
- Fix behavior of reindex of Series dropping name (GH812)
• Improve on redundant groupby computation (GH775)
• Catch possible NA assignment to int/bool series with exception (GH839)

38.36 pandas 0.7.0

Release date: 2/9/2012

38.36.1 New Features

• New `merge` function for efficiently performing full gamut of database / relational-algebra operations. Refactored existing join methods to use the new infrastructure, resulting in substantial performance gains (GH220, GH249, GH267)
• New `concat` function for concatenating DataFrame or Panel objects along an axis. Can form union or intersection of the other axes. Improves performance of `DataFrame.append` (GH468, GH479, GH273)
• Handle differently-indexed output values in `DataFrame.apply` (GH498)
• Can pass list of dicts (e.g., a list of shallow JSON objects) to DataFrame constructor (GH526)
• Add `reorder_levels` method to Series and DataFrame (GH534)
• Add dict-like `get` function to DataFrame and Panel (GH521)
• `DataFrame.iterrows` method for efficiently iterating through the rows of a DataFrame
• Added `DataFrame.to_panel` with code adapted from `LongPanel.to_long`
• `reindex_axis` method added to DataFrame
• Add level option to binary arithmetic functions on DataFrame and Series
• Add level option to the `reindex` and `align` methods on Series and DataFrame for broadcasting values across a level (GH542, GH552, others)
• Add attribute-based item access to Panel and add IPython completion (PR GH554)
• Add `logy` option to `Series.plot` for log-scaling on the Y axis
• Add `index`, `header`, and `justify` options to `DataFrame.to_string`. Add option to (GH570, GH571)
• Can pass multiple DataFrames to `DataFrame.join` to join on index (GH115)
• Can pass multiple Panels to `Panel.join` (GH115)
• Can pass multiple DataFrames to `DataFrame.append` to concatenate (stack) and multiple Series to `Series.append` too
• Added `justify` argument to `DataFrame.to_string` to allow different alignment of column headers
• Add `sort` option to GroupBy to allow disabling sorting of the group keys for potential speedups (GH595)
• Can pass MaskedArray to Series constructor (GH563)
• Add Panel item access via attributes and IPython completion (GH554)
• Implement `DataFrame.lookup`, fancy-indexing analogue for retrieving values given a sequence of row and column labels (GH338)
• Add `verbose` option to `read_csv` and `read_table` to show number of NA values inserted in non-numeric columns (GH614)
Can pass a list of dicts or Series to DataFrame.append to concatenate multiple rows (GH464)

Add level argument to DataFrame.xs for selecting data from other MultiIndex levels. Can take one or more levels with potentially a tuple of keys for flexible retrieval of data (GH371, GH629)

New crosstab function for easily computing frequency tables (GH170)

Can pass a list of functions to aggregate with groupby on a DataFrame, yielding an aggregated result with hierarchical columns (GH166)

Add integer-indexing functions iget in Series and irow/iget in DataFrame (GH628)

Add new Series.unique function, significantly faster than numpy.unique (GH658)

Add new cummin and cummax instance methods to Series and DataFrame (GH647)

Add new value_range function to return min/max of a dataframe (GH288)

Add drop parameter to reset_index method of DataFrame and added method to Series as well (GH699)

Add isin method to Index objects, works just like Series.isin (GH GH657)

Implement array interface on Panel so that ufuncs work (re: GH740)

Add sort option to DataFrame.join (GH731)

Improved handling of NAs (propagation) in binary operations with dtype=object arrays (GH737)

Add abs method to Pandas objects

Added algorithms module to start collecting central algos

38.36.2 API Changes

Label-indexing with integer indexes now raises KeyError if a label is not found instead of falling back on location-based indexing (GH700)

Label-based slicing via ix or [] on Series will now only work if exact matches for the labels are found or if the index is monotonic (for range selections)

Label-based slicing and sequences of labels can be passed to [] on a Series for both getting and setting (GH86)

[] operator (__getitem__ and __setitem__) will raise KeyError with integer indexes when an index is not contained in the index. The prior behavior would fall back on position-based indexing if a key was not found in the index which would lead to subtle bugs. This is now consistent with the behavior of .ix on DataFrame and friends (GH328)

Rename DataFrame.delevel to DataFrame.reset_index and add deprecation warning

Series.sort (an in-place operation) called on a Series which is a view on a larger array (e.g. a column in a DataFrame) will generate an Exception to prevent accidentally modifying the data source (GH316)

Refactor to remove deprecated LongPanel class (GH552)

Deprecated Panel.to_long, renamed to to_frame

Deprecated colSpace argument in DataFrame.to_string, renamed to col_space

Rename precision to accuracy in engineering float formatter (GH GH395)

The default delimiter for read_csv is comma rather than letting csv.Sniffer infer it

Rename col_or_columns argument in DataFrame.drop_duplicates (GH GH734)
38.36.3 Improvements to existing features

- Better error message in DataFrame constructor when passed column labels don’t match data (GH497)
- Substantially improve performance of multi-GroupBy aggregation when a Python function is passed, reuse ndarray object in Cython (GH496)
- Can store objects indexed by tuples and floats in HDFStore (GH492)
- Don’t print length by default in Series.to_string, add length option (GH489)
- Improve Cython code for multi-groupby to aggregate without having to sort the data (GH93)
- Improve MultiIndex reindexing speed by storing tuples in the MultiIndex, test for backwards unpickling compatibility
- Improve column reindexing performance by using specialized Cython take function
- Further performance tweaking of Series.__getitem__ for standard use cases
- Avoid Index dict creation in some cases (i.e. when getting slices, etc.), regression from prior versions
- Friendlier error message in setup.py if NumPy not installed
- Use common set of NA-handling operations (sum, mean, etc.) in Panel class also (GH536)
- Default name assignment when calling reset_index on DataFrame with a regular (non-hierarchical) index (GH476)
- Use Cythonized groupers when possible in Series/DataFrame stat ops with level parameter passed (GH545)
- Ported skiplist data structure to C to speed up rolling_median by about 5-10x in most typical use cases (GH374)
- Some performance enhancements in constructing a Panel from a dict of DataFrame objects
- Made Index._get_duplicates a public method by removing the underscore
- Prettier printing of floats, and column spacing fix (GH395, GH571)
- Add bold_rows option to DataFrame.to_html (GH586)
- Improve the performance of DataFrame.sort_index by up to 5x or more when sorting by multiple columns
- Substantially improve performance of DataFrame and Series constructors when passed a nested dict or dict, respectively (GH540, GH621)
- Modified setup.py so that pip / setuptools will install dependencies (GH507, various pull requests)
- Unstack called on DataFrame with non-MultiIndex will return Series (GH477)
- Improve DataFrame.to_string and console formatting to be more consistent in the number of displayed digits (GH395)
- Use bottleneck if available for performing NaN-friendly statistical operations that it implemented (GH91)
- Monkey-patch context to traceback in DataFrame.apply to indicate which row/column the function application failed on (GH614)
- Improved ability of read_table and read_clipboard to parse console-formatted DataFrames (can read the row of index names, etc.)
- Can pass list of group labels (without having to convert to an ndarray yourself) to groupby in some cases (GH659)
- Use kind argument to Series.order for selecting different sort kinds (GH668)
• Add option to Series.to_csv to omit the index (GH684)
• Add `delimiter` as an alternative to `sep` in `read_csv` and other parsing functions
• Substantially improved performance of groupby on DataFrames with many columns by aggregating blocks of columns all at once (GH745)
• Can pass a file handle or StringIO to Series/DataFrame.to_csv (GH765)
• Can pass sequence of integers to DataFrame.irow(icol) and Series.iget, (GH GH654)
• Prototypes for some vectorized string functions
• Add float64 hash table to solve the Series.unique problem with NAs (GH714)
• Memoize objects when reading from file to reduce memory footprint
• Can get and set a column of a DataFrame with hierarchical columns containing “empty” (‘’) lower levels without passing the empty levels (PR GH768)

38.36.4 Bug Fixes

• Raise exception in out-of-bounds indexing of Series instead of seg-faulting, regression from earlier releases (GH495)
• Fix error when joining DataFrames of different dtypes within the same typeclass (e.g. float32 and float64) (GH486)
• Fix bug in Series.min/Series.max on objects like datetime.datetime (GH GH487)
• Preserve index names in Index.union (GH501)
• Fix bug in Index joining causing subclass information (like DateRange type) to be lost in some cases (GH500)
• Accept empty list as input to DataFrame constructor, regression from 0.6.0 (GH491)
• Can output DataFrame and Series with ndarray objects in a dtype=object array (GH490)
• Return empty string from Series.to_string when called on empty Series (GH GH488)
• Fix exception passing empty list to DataFrame.from_records
• Fix Index.format bug (excluding name field) with datetimes with time info
• Fix scalar value access in Series to always return NumPy scalars, regression from prior versions (GH510)
• Handle rows skipped at beginning of file in read_* functions (GH505)
• Handle improper dtype casting in `set_value` methods
• Unary `-` / `__neg__` operator on DataFrame was returning integer values
• Unbox 0-dim ndarrays from certain operators like all, any in Series
• Fix handling of missing columns (was combine_first-specific) in DataFrame.combine for general case (GH529)
• Fix type inference logic with boolean lists and arrays in DataFrame indexing
• Use centered sum of squares in R-square computation if entity_effects=True in panel regression
• Handle all NA case in Series.{corr, cov}, was raising exception (GH548)
• Aggregating by multiple levels with `level` argument to DataFrame, Series stat method, was broken (GH545)
• Fix Cython buf when converter passed to read_csv produced a numeric array (buffer dtype mismatch when passed to Cython type inference function) (GH GH546)
• Fix exception when setting scalar value using .ix on a DataFrame with a MultiIndex (GH551)
- Fix outer join between two DateRanges with different offsets that returned an invalid DateRange
- Cleanup DataFrame.from_records failure where index argument is an integer
- Fix Data.from_records failure when passed a dictionary
- Fix NA handling in {Series, DataFrame}.rank with non-floating point dtypes
- Fix bug related to integer type-checking in .ix-based indexing
- Handle non-string index name passed to DataFrame.from_records
- DataFrame.insert caused the columns name(s) field to be discarded (GH527)
- Fix erroneous in monotonic many-to-one left joins
- Fix DataFrame.to_string to remove extra column white space (GH571)
- Format floats to default to same number of digits (GH395)
- Added decorator to copy docstring from one function to another (GH449)
- Fix error in monotonic many-to-one left joins
- Fix __eq__ comparison between DateOffsets with different relativedelta keywords passed
- Fix exception caused by parser converter returning strings (GH583)
- Fix MultiIndex formatting bug with integer names (GH601)
- Fix bug in handling of non-numeric aggregates in Series.groupby (GH612)
- Fix TypeError with tuple subclasses (e.g. namedtuple) in DataFrame.from_records (GH611)
- Catch misreported console size when running IPython within Emacs
- Fix minor bug in pivot table margins, loss of index names and length-1 ‘All’ tuple in row labels
- Add support for legacy WidePanel objects to be read from HDFStore
- Fix out-of-bounds segfault in pad_object and backfill_object methods when either source or target array are empty
- Could not create a new column in a DataFrame from a list of tuples
- Fix bugs preventing SparseDataFrame and SparseSeries working with groupby (GH666)
- Use sort kind in Series.sort / argsort (GH668)
- Fix DataFrame operations on non-scalar, non-pandas objects (GH672)
- Don’t convert DataFrame column to integer type when passing integer to __setitem__ (GH669)
- Fix downstream bug in pivot_table caused by integer level names in MultiIndex (GH678)
- Fix SparseSeries.combine_first when passed a dense Series (GH687)
- Fix performance regression in HDFStore loading when DataFrame or Panel stored in table format with datetimes
- Raise Exception in DateRange when offset with n=0 is passed (GH683)
- Fix get/set inconsistency with .ix property and integer location but non-integer index (GH707)
- Use right dropna function for SparseSeries. Return dense Series for NA fill value (GH730)
- Fix Index.format bug causing incorrectly string-formatted Series with datetime indexes (GH726, GH758)
- Fix errors caused by object dtype arrays passed to ols (GH759)
- Fix error where column names lost when passing list of labels to DataFrame.__getitem__. (GH662)
• Fix error whereby top-level week iterator overwrote week instance
• Fix circular reference causing memory leak in sparse array / series / frame, (GH663)
• Fix integer-slicing from integers-as-floats (GH670)
• Fix zero division errors in nanops from object dtype arrays in all NA case (GH676)
• Fix csv encoding when using unicode (GH705, GH717, GH738)
• Fix assumption that each object contains every unique block type in concat, (GH708)
• Fix sortedness check of multiindex in to_panel (GH719, 720)
• Fix that None was not treated as NA in PyObjectHashtable
• Fix hashing dtype because of endianness confusion (GH747, GH748)
• Fix SparseSeries.dropna to return dense Series in case of NA fill value (GH GH730)
• Use map_infer instead of np.vectorize. handle NA sentinels if converter yields numeric array, (GH753)
• Fixes and improvements to DataFrame.rank (GH742)
• Fix catching AttributeError instead of NameError for bottleneck
• Try to cast non-MultiIndex to better dtype when calling reset_index (GH726 GH440)
• Fix #1.QNAN0’ float bug on 2.6/win64
• Allow subclasses of dicts in DataFrame constructor, with tests
• Fix problem whereby set_index destroys column multiindex (GH764)
• Hack around bug in generating DateRange from naive DateOffset (GH770)
• Fix bug in DateRange.intersection causing incorrect results with some overlapping ranges (GH771)

38.36.5 Thanks

• Craig Austin
• Chris Billington
• Marius Cobzarenco
• Mario Gamboa-Cavazos
• Hans-Martin Gaudecker
• Arthur Gerigk
• Yaroslav Halchenko
• Jeff Hammerbacher
• Matt Harrison
• Andreas Hilboll
• Luc Kesters
• Adam Klein
• Gregg Lind
• Solomon Negusse
• Wouter Overmeire
• Christian Prinoth
• Jeff Reback
• Sam Reckoner
• Craig Reeson
• Jan Schulz
• Skipper Seabold
• Ted Square
• Graham Taylor
• Aman Thakral
• Chris Uga
• Dieter Vandenbussche
• Texas P.
• Pinxing Ye
• … and everyone I forgot

38.37 pandas 0.6.1

Release date: 12/13/2011

38.37.1 API Changes

• Rename names argument in DataFrame.from_records to columns. Add deprecation warning
• Boolean get/set operations on Series with boolean Series will reindex instead of requiring that the indexes be exactly equal (GH429)

38.37.2 New Features

• Can pass Series to DataFrame.append with ignore_index=True for appending a single row (GH430)
• Add Spearman and Kendall correlation options to Series.corr and DataFrame.corr (GH428)
• Add new get_value and set_value methods to Series, DataFrame, and Panel to very low-overhead access to scalar elements. df.get_value(row, column) is about 3x faster than df[column][row] by handling fewer cases (GH437, GH438). Add similar methods to sparse data structures for compatibility
• Add Qt table widget to sandbox (GH435)
• DataFrame.align can accept Series arguments, add axis keyword (GH461)
• Implement new SparseList and SparseArray data structures. SparseSeries now derives from SparseArray (GH463)
• max_columns / max_rows options in set_printoptions (GH453)
• Implement Series.rank and DataFrame.rank, fast versions of scipy.stats.rankdata (GH428)
• Implement DataFrame.from_items alternate constructor (GH444)
• DataFrame.convert_objects method for inferring better dtypes for object columns (GH302)
• Add rolling_corr_pairwise function for computing Panel of correlation matrices (GH189)
• Add margins option to pivot_table for computing subgroup aggregates (GH GH114)
• Add Series.from_csv function (GH482)

38.37.3 Improvements to existing features

• Improve memory usage of DataFrame.describe (do not copy data unnecessarily) (GH425)
• Use same formatting function for outputting floating point Series to console as in DataFrame (GH420)
• DataFrame.delevel will try to infer better dtype for new columns (GH440)
• Exclude non-numeric types in DataFrame.{corr, cov}
• Override Index.astype to enable dtype casting (GH412)
• Use same float formatting function for Series._repr__ (GH420)
• Use available console width to output DataFrame columns (GH453)
• Accept ndarrays when setting items in Panel (GH452)
• Infer console width when printing __repr__ of DataFrame to console (PR GH453)
• Optimize scalar value lookups in the general case by 25% or more in Series and DataFrame
• Can pass DataFrame/DataFrame and DataFrame/Series to rolling_corr/rolling_cov (GH462)
• Fix performance regression in cross-sectional count in DataFrame, affecting DataFrame.dropna speed
• Column deletion in DataFrame copies no data (computes views on blocks) (GH GH158)
• MultiIndex.get_level_values can take the level name
• More helpful error message when DataFrame.plot fails on one of the columns (GH478)
• Improve performance of DataFrame.{index, columns} attribute lookup

38.37.4 Bug Fixes

• Fix O(K^2) memory leak caused by inserting many columns without consolidating, had been present since 0.4.0 (GH467)
• DataFrame.count should return Series with zero instead of NA with length-0 axis (GH423)
• Fix Yahoo! Finance API usage in pandas.io.data (GH419, GH427)
• Fix upstream bug causing failure in Series.align with empty Series (GH434)
• Function passed to DataFrame.apply can return a list, as long as it’s the right length. Regression from 0.4 (GH432)
• Don’t “accidentally” upcast scalar values when indexing using .ix (GH431)
• Fix groupby exception raised with as_index=False and single column selected (GH421)
• Implement DateOffset.__ne__ causing downstream bug (GH456)
• Fix __doc__-related issue when converting py -> pyo with py2exe
• Bug fix in left join Cython code with duplicate monotonic labels
• Fix bug when unstacking multiple levels described in GH451
• Exclude NA values in dtype=object arrays, regression from 0.5.0 (GH469)
• Use Cython map_infer function in DataFrame.applymap to properly infer output type, handle tuple return values and other things that were breaking (GH465)
• Handle floating point index values in HDFStore (GH454)
• Fixed stale column reference bug (cached Series object) caused by type change / item deletion in DataFrame (GH473)
• Index.get_loc should always raise Exception when there are duplicates
• Handle differently-indexed Series input to DataFrame constructor (GH475)
• Omit nuisance columns in multi-groupby with Python function
• Buglet in handling of single grouping in general apply
• Handle type inference properly when passing list of lists or tuples to DataFrame constructor (GH484)
• Preserve Index / MultiIndex names in GroupBy.apply concatenation step (GH GH481)

38.37.5 Thanks

• Ralph Bean
• Luca Beltrame
• Marius Cobzarenco
• Andreas Hilboll
• Jev Kuznetsov
• Adam Lichtenstein
• Wouter Overmeire
• Fernando Perez
• Nathan Pinger
• Christian Prinoth
• Alex Reyfman
• Joon Ro
• Chang She
• Ted Square
• Chris Uga
• Dieter Vandenbussche

38.38 pandas 0.6.0

Release date: 11/25/2011
38.38.1 API Changes

- Arithmetic methods like `sum` will attempt to sum dtype=object values by default instead of excluding them (GH382)

38.38.2 New Features

- Add `melt` function to `pandas.core.reshape`
- Add `level` parameter to group by level in Series and DataFrame descriptive statistics (GH313)
- Add `head` and `tail` methods to Series, analogous to DataFrame (PR GH296)
- Add `Series.isin` function which checks if each value is contained in a passed sequence (GH289)
- Add `float_format` option to `Series.to_string`
- Add `skip_footer` (GH291) and `converters` (GH343) options to `read_csv` and `read_table`
- Add proper, tested weighted least squares to standard and panel OLS (GH GH303)
- Add `drop_duplicates` and `duplicated` functions for removing duplicate DataFrame rows and checking for duplicate rows, respectively (GH319)
- Implement logical (boolean) operators `&`, `|`, `^` on DataFrame (GH347)
- Add `Series.mad`, mean absolute deviation, matching DataFrame
- Add `QuarterEnd` DateOffset (GH321)
- Add matrix multiplication function `dot` to DataFrame (GH65)
- Add `orient` option to `Panel.from_dict` to ease creation of mixed-type Panels (GH359, GH301)
- Add `DataFrame.from_dict` with similar `orient` option
- Can now pass list of tuples or list of lists to `DataFrame.from_records` for fast conversion to DataFrame (GH357)
- Can pass multiple levels to groupby, e.g. `df.groupby(level=[0, 1])` (GH GH103)
- Can sort by multiple columns in `DataFrame.sort_index` (GH92, GH362)
- Add fast `get_value` and `put_value` methods to DataFrame and micro-performance tweaks (GH360)
- Add bar plot option to `DataFrame.plot` (GH348)
- Add `idxmin` and `idxmax` functions to Series and DataFrame for computing index labels achieving maximum and minimum values (GH286)
- Add `read_clipboard` function for parsing DataFrame from OS clipboard, should work across platforms (GH300)
- Add `nunique` function to Series for counting unique elements (GH297)
- DataFrame constructor will use Series name if no columns passed (GH373)
- Support regular expressions and longer delimiters in `read_table/read_csv`, but does not handle quoted strings yet (GH364)
- Add `DataFrame.to_html` for formatting DataFrame to HTML (GH387)
- MaskedArray can be passed to DataFrame constructor and masked values will be converted to NaN (GH396)
- Add `DataFrame.boxplot` function (GH368, others)
- Can pass extra args, kwds to DataFrame.apply (GH376)
38.38.3 Improvements to existing features

- Raise more helpful exception if date parsing fails in DateRange (GH298)
- Vastly improved performance of GroupBy on axes with a MultiIndex (GH299)
- Print level names in hierarchical index in Series repr (GH305)
- Return DataFrame when performing GroupBy on selected column and as_index=False (GH308)
- Can pass vector to on argument in DataFrame.join (GH312)
- Don’t show Series name if it’s None in the repr, also omit length for short Series (GH317)
- Show legend by default in DataFrame.plot, add legend boolean flag (GH324)
- Significantly improved performance of Series.order, which also makes np.unique called on a Series faster (GH327)
- Faster cythonized count by level in Series and DataFrame (GH341)
- Raise exception if dateutil 2.0 installed on Python 2.x runtime (GH346)
- Significant GroupBy performance enhancement with multiple keys with many “empty” combinations
- New Cython vectorized function map_infer speeds up Series.apply and Series.map significantly when passed elementwise Python function, motivated by GH355
- Cythonized cache_readonly, resulting in substantial micro-performance enhancements throughout the codebase (GH361)
- Special Cython matrix iterator for applying arbitrary reduction operations with 3-5x better performance than np.apply_along_axis (GH309)
- Add raw option to DataFrame.apply for getting better performance when the passed function only requires an ndarray (GH309)
- Improve performance of MultiIndex.from_tuples
- Can pass multiple levels to stack and unstack (GH370)
- Can pass multiple values columns to pivot_table (GH381)
- Can call DataFrame.delevel with standard Index with name set (GH393)
- Use Series name in GroupBy for result index (GH363)
- Refactor Series/DataFrame stat methods to use common set of NaN-friendly function
- Handle NumPy scalar integers at C level in Cython conversion routines

38.38.4 Bug Fixes

- Fix bug in DataFrame.to_csv when writing a DataFrame with an index name (GH290)
- DataFrame should clear its Series caches on consolidation, was causing “stale” Series to be returned in some corner cases (GH304)
- DataFrame constructor failed if a column had a list of tuples (GH293)
- Ensure that Series.apply always returns a Series and implement Series.round (GH314)
- Support boolean columns in Cythonized groupby functions (GH315)
- DataFrame.describe should not fail if there are no numeric columns, instead return categorical describe (GH323)
• Fixed bug which could cause columns to be printed in wrong order in DataFrame.to_string if specific list of columns passed (GH325)
• Fix legend plotting failure if DataFrame columns are integers (GH326)
• Shift start date back by one month for Yahoo! Finance API in pandas.io.data (GH329)
• Fix DataFrame.join failure on unconsolidated inputs (GH331)
• DataFrame.min/max will no longer fail on mixed-type DataFrame (GH337)
• Fix read_csv / read_table failure when passing list to index_col that is not in ascending order (GH349)
• Fix failure passing Int64Index to Index.union when both are monotonic
• Fix error when passing SparseSeries to (dense) DataFrame constructor
• Added missing bang at top of setup.py (GH352)
• Change is_monotonic on MultiIndex so it properly compares the tuples
• Fix MultiIndex outer join logic (GH351)
• Set index name attribute with single-key groupby (GH358)
• Bug fix in reflexive binary addition in Series and DataFrame for non-commutative operations (like string concatenation) (GH353)
• setupegg.py will invoke Cython (GH192)
• Fix block consolidation bug after inserting column into MultiIndex (GH366)
• Fix bug in join operations between Index and Int64Index (GH367)
• Handle min_periods=0 case in moving window functions (GH365)
• Fixed corner cases in DataFrame.apply/pivot with empty DataFrame (GH378)
• Fixed repr exception when Series name is a tuple
• Always return DateRange from asfreq (GH390)
• Pass level names to swaplevel (GH379)
• Don’t lose index names in MultiIndex.droplevel (GH394)
• Infer more proper return type in DataFrame.apply when no columns or rows depending on whether the passed function is a reduction (GH389)
• Always return NA/NaN from Series.min/max and DataFrame.min/max when all of a row/column/values are NA (GH384)
• Enable partial setting with .ix / advanced indexing (GH397)
• Handle mixed-type DataFrames correctly in unstack, do not lose type information (GH403)
• Fix integer name formatting bug in Index.format and in Series.__repr__
• Handle label types other than string passed to groupby (GH405)
• Fix bug in .ix-based indexing with partial retrieval when a label is not contained in a level
• Index name was not being pickled (GH408)
• Level name should be passed to result index in GroupBy.apply (GH416)
38.38.5 Thanks

- Craig Austin
- Marius Cobzarenco
- Joel Cross
- Jeff Hammerbacher
- Adam Klein
- Thomas Kluyver
- Jev Kuznetsov
- Kieran O’Mahony
- Wouter Overmeire
- Nathan Pinger
- Christian Prinoth
- Skipper Seabold
- Chang She
- Ted Square
- Aman Thakral
- Chris Uga
- Dieter Vandenbussche
- carljv
- rsamson

38.39 pandas 0.5.0

Release date: 10/24/2011

This release of pandas includes a number of API changes (see below) and cleanup of deprecated APIs from pre-0.4.0 releases. There are also bug fixes, new features, numerous significant performance enhancements, and includes a new ipython completer hook to enable tab completion of DataFrame columns accesses and attributes (a new feature).

In addition to the changes listed here from 0.4.3 to 0.5.0, the minor releases 4.1, 0.4.2, and 0.4.3 brought some significant new functionality and performance improvements that are worth taking a look at.

Thanks to all for bug reports, contributed patches and generally providing feedback on the library.

38.39.1 API Changes

- `read_table`, `read_csv`, and `ExcelFile.parse` default arguments for `index_col` is now None. To use one or more of the columns as the resulting DataFrame’s index, these must be explicitly specified now
- Parsing functions like `read_csv` no longer parse dates by default (GH GH225)
- Removed `weights` option in panel regression which was not doing anything principled (GH155)
- Changed `buffer` argument name in `Series.to_string` to `buf`
• `Series.to_string` and `DataFrame.to_string` now return strings by default instead of printing to `sys.stdout`

• Deprecated `nanRep` argument in various `to_string` and `to_csv` functions in favor of `na_rep`. Will be removed in 0.6 (GH275)

• Renamed `delimiter` to `sep` in `DataFrame.from_csv` for consistency

• Changed order of `Series.clip` arguments to match those of `numpy.clip` and added (unimplemented) `out` argument so `numpy.clip` can be called on a Series (GH272)

• Series functions renamed (and thus deprecated) in 0.4 series have been removed:
  – `asOf`, use `asof`
  – `toDict`, use `to_dict`
  – `toString`, use `to_string`
  – `toCSV`, use `to_csv`
  – `merge`, use `map`
  – `applymap`, use `apply`
  – `combineFirst`, use `combine_first`
  – `_firstTimeWithValued` use `first_valid_index`
  – `_lastTimeWithValued` use `last_valid_index`

• DataFrame functions renamed / deprecated in 0.4 series have been removed:
  – `asMatrix` method, use `as_matrix` or `values` attribute
  – `combineFirst`, use `combine_first`
  – `getXS`, use `xs`
  – `merge`, use `join`
  – `fromRecords`, use `from_records`
  – `fromcsv`, use `from_csv`
  – `toRecords`, use `to_records`
  – `toDict`, use `to_dict`
  – `toString`, use `to_string`
  – `toCSV`, use `to_csv`
  – `_firstTimeWithValued` use `first_valid_index`
  – `_lastTimeWithValued` use `last_valid_index`
  – `toDataMatrix` is no longer needed
  – `rows()` method, use `index` attribute
  – `cols()` method, use `columns` attribute
  – `dropEmptyRows()`, use `dropna(how='all')`
  – `dropIncompleteRows()`, use `dropna()`
  – `tapply(f)`, use `apply(f, axis=1)`
  – `tgroupby(keyfunc, aggfunc)`, use `groupby` with `axis=1`
38.39.2 Deprecations Removed

- `indexField` argument in `DataFrame.from_records`
- `missingAtEnd` argument in `Series.order`. Use `na_last` instead
- `Series.fromValue` classmethod, use regular `Series` constructor instead
- Functions `parseCSV`, `parseText`, and `parseExcel` methods in `pandas.io.parsers` have been removed
- `Index.asOfDate` function
- `Panel.getMinorXS` (use `minor_xs`) and `Panel.getMajorXS` (use `major_xs`)
- `Panel.toWide`, use `Panel.to_wide` instead

38.39.3 New Features

- Added `DataFrame.align` method with standard join options
- Added `parse_dates` option to `read_csv` and `read_table` methods to optionally try to parse dates in the index columns
- Add `nrows`, `chunksize`, and `iterator` arguments to `read_csv` and `read_table`. The last two return a new `TextParser` class capable of lazily iterating through chunks of a flat file (GH242)
- Added ability to join on multiple columns in `DataFrame.join` (GH214)
- Added private `_get_duplicates` function to `Index` for identifying duplicate values more easily
- Added column attribute access to DataFrame, e.g. `df.A` equivalent to `df['A']` if ‘A’ is a column in the DataFrame (GH213)
- Added IPython tab completion hook for DataFrame columns. (GH233, GH230)
- Implement `Series.describe` for Series containing objects (GH241)
- Add inner join option to `DataFrame.join` when joining on key(s) (GH248)
- Can select set of DataFrame columns by passing a list to `__getitem__` (GH GH253)
- Can use & and | to intersection / union Index objects, respectively (GH GH261)
- Added `pivot_table` convenience function to pandas namespace (GH234)
- Implemented `Panel.rename_axis` function (GH243)
- DataFrame will show index level names in console output
- Implemented `Panel.take`
- Add `set_eng_float_format` function for setting alternate DataFrame floating point string formatting
- Add convenience `set_index` function for creating a DataFrame index from its existing columns

38.39.4 Improvements to existing features

- Major performance improvements in file parsing functions `read_csv` and `read_table`
- Added Cython function for converting tuples to ndarray very fast. Speeds up many MultiIndex-related operations
- File parsing functions like `read_csv` and `read_table` will explicitly check if a parsed index has duplicates and raise a more helpful exception rather than deferring the check until later
• Refactored merging / joining code into a tidy class and disabled unnecessary computations in the float/object case, thus getting about 10% better performance (GH211)
• Improved speed of DataFrame.xs on mixed-type DataFrame objects by about 5x, regression from 0.3.0 (GH215)
• With new DataFrame.align method, speeding up binary operations between differently-indexed DataFrame objects by 10-25%.
• Significantly sped up conversion of nested dict into DataFrame (GH212)
• Can pass hierarchical index level name to groupby instead of the level number if desired (GH223)
• Add support for different delimiters in DataFrame.to_csv (GH244)
• Add more helpful error message when importing pandas post-installation from the source directory (GH250)
• Significantly speed up DataFrame __repr__ and count on large mixed-type DataFrame objects
• Better handling of pyx file dependencies in Cython module build (GH271)

38.39.5 Bug Fixes

• read_csv / read_table fixes
  – Be less aggressive about converting float->int in cases of floating point representations of integers like 1.0, 2.0, etc.
  – “True”/”False” will not get correctly converted to boolean
  – Index name attribute will get set when specifying an index column
  – Passing column names should force header=None (GH257)
  – Don’t modify passed column names when index_col is not None (GH258)
  – Can sniff CSV separator in zip file (since seek is not supported, was failing before)
• Worked around matplotlib “bug” in which series[:, np.newaxis] fails. Should be reported upstream to matplotlib (GH224)
• DataFrame.iteritems was not returning Series with the name attribute set. Also neither was DataFrame._series
• Can store datetime.date objects in HDFStore (GH231)
• Index and Series names are now stored in HDFStore
• Fixed problem in which data would get upcasted to object dtype in GroupBy.apply operations (GH237)
• Fixed outer join bug with empty DataFrame (GH238)
• Can create empty Panel (GH239)
• Fix join on single key when passing list with 1 entry (GH246)
• Don’t raise Exception on plotting DataFrame with an all-NA column (GH251, GH254)
• Bug min/max errors when called on integer DataFrames (GH241)
• DataFrame.iteritems and DataFrame._series not assigning name attribute
• Panel.__repr__ raised exception on length-0 major/minor axes
• DataFrame.join on key with empty DataFrame produced incorrect columns
• Implemented MultiIndex.diff (GH260)
• Int64Index.take and MultiIndex.take lost name field, fix downstream issue GH262
- Can pass list of tuples to `Series` (GH270)
- Can pass level name to `DataFrame.stack`
- Support set operations between MultiIndex and Index
- Fix many corner cases in MultiIndex set operations - Fix MultiIndex-handling bug with GroupBy.apply when returned groups are not indexed the same
- Fix corner case bugs in DataFrame.apply
- Setting DataFrame index did not cause Series cache to get cleared
- Various int32 -> int64 platform-specific issues
- Don’t be too aggressive converting to integer when parsing file with MultiIndex (GH285)
- Fix bug when slicing Series with negative indices before beginning

## 38.39.6 Thanks

- Thomas Kluyver
- Daniel Fortunov
- Aman Thakral
- Luca Beltrame
- Wouter Overmeire

## 38.40 pandas 0.4.3

**Release date:** 10/9/2011

This is largely a bugfix release from 0.4.2 but also includes a handful of new and enhanced features. Also, pandas can now be installed and used on Python 3 (thanks Thomas Kluyver!).

### 38.40.1 New Features

- Python 3 support using 2to3 (GH200, Thomas Kluyver)
- Add `name` attribute to `Series` and added relevant logic and tests. Name now prints as part of `Series.__repr__`
- Add `name` attribute to standard Index so that stacking / unstacking does not discard names and so that indexed DataFrame objects can be reliably round-tripped to flat files, pickle, HDF5, etc.
- Add `isnull` and `notnull` as instance methods on Series (GH209, GH203)

### 38.40.2 Improvements to existing features

- Skip xldr-related unit tests if not installed
- `Index.append` and `MultiIndex.append` can accept a list of Index objects to concatenate together
- Altered binary operations on differently-indexed SparseSeries objects to use the integer-based (dense) alignment logic which is faster with a larger number of blocks (GH205)
- Refactored `Series.__repr__` to be a bit more clean and consistent
38.40.3 API Changes

- `Series.describe` and `DataFrame.describe` now bring the 25% and 75% quartiles instead of the 10% and 90% deciles. The other outputs have not changed
- `Series.toString` will print deprecation warning, has been de-camelCased to `to_string`

38.40.4 Bug Fixes

- Fix broken interaction between `Index` and `Int64Index` when calling intersection. Implement `Int64Index.intersection`
- `MultiIndex.sortlevel` discarded the level names (GH202)
- Fix bugs in groupby, join, and append due to improper concatenation of `MultiIndex` objects (GH201)
- Fix regression from 0.4.1, `isnull` and `notnull` ceased to work on other kinds of Python scalar objects like `datetime`
- Raise more helpful exception when attempting to write empty DataFrame or LongPanel to `HDFStore` (GH204)
- Use stdlib csv module to properly escape strings with commas in `DataFrame.to_csv` (GH206, Thomas Kluyver)
- Fix Python ndarray access in Cython code for sparse blocked index integrity check
- Fix bug writing Series to CSV in Python 3 (GH209)
- Miscellaneous Python 3 bugfixes

38.40.5 Thanks

- Thomas Kluyver
- rsamson

38.41 pandas 0.4.2

Release date: 10/3/2011

This is a performance optimization release with several bug fixes. The new Int64Index and new merging / joining Cython code and related Python infrastructure are the main new additions

38.41.1 New Features

- Added fast Int64Index type with specialized join, union, intersection. Will result in significant performance enhancements for int64-based time series (e.g. using NumPy’s datetime64 one day) and also faster operations on DataFrame objects storing record array-like data.
- Refactored `Index` classes to have a `join` method and associated data alignment routines throughout the codebase to be able to leverage optimized joining / merging routines.
- Added `Series.align` method for aligning two series with choice of join method
- Wrote faster Cython data alignment / merging routines resulting in substantial speed increases
- Added `is_monotonic` property to `Index` classes with associated Cython code to evaluate the monotonicity of the `Index` values
• Add method `get_level_values` to `MultiIndex`
• Implemented shallow copy of `BlockManager` object in `DataFrame` internals

38.41.2 Improvements to existing features

• Improved performance of `isnull` and `notnull`, a regression from v0.3.0 (GH187)
• Wrote templating / code generation script to auto-generate Cython code for various functions which need to be available for the 4 major data types used in pandas (float64, bool, object, int64)
• Refactored code related to `DataFrame.join` so that intermediate aligned copies of the data in each `DataFrame` argument do not need to be created. Substantial performance increases result (GH176)
• Substantially improved performance of generic `Index.intersection` and `Index.union`
• Improved performance of `DateRange.union` with overlapping ranges and non-cacheable offsets (like Minute). Implemented analogous fast `DateRange.intersection` for overlapping ranges.
• Implemented `BlockManager.take` resulting in significantly faster take performance on mixed-type `DataFrame` objects (GH104)
• Improved performance of `Series.sort_index`
• Significant groupby performance enhancement: removed unnecessary integrity checks in `DataFrame` internals that were slowing down slicing operations to retrieve groups
• Added informative Exception when passing dict to `DataFrame` groupby aggregation with axis != 0

38.41.3 API Changes

38.41.4 Bug Fixes

• Fixed minor unhandled exception in Cython code implementing fast groupby aggregation operations
• Fixed bug in unstacking code manifesting with more than 3 hierarchical levels
• Throw exception when step specified in label-based slice (GH185)
• Fix isnull to correctly work with np.float32. Fix upstream bug described in GH182
• Finish implementation of as_index=False in groupby for `DataFrame` aggregation (GH181)
• Raise SkipTest for pre-epoch HDFStore failure. Real fix will be sorted out via datetime64 dtype

38.41.5 Thanks

• Uri Laserson
• Scott Sinclair

38.42 pandas 0.4.1

Release date: 9/25/2011

This is primarily a bug fix release but includes some new features and improvements
38.42.1 New Features

- Added new DataFrame methods `get_dtype_counts` and property `dtypes`
- Setting of values using `.ix` indexing attribute in mixed-type DataFrame objects has been implemented (fixes GH135)
- `read_csv` can read multiple columns into a `MultiIndex`. DataFrame’s `to_csv` method will properly write out a `MultiIndex` which can be read back (GH151, thanks to Skipper Seabold)
- Wrote fast time series merging / joining methods in Cython. Will be integrated later into DataFrame.join and related functions
- Added `ignore_index` option to `DataFrame.append` for combining unindexed records stored in a DataFrame

38.42.2 Improvements to existing features

- Some speed enhancements with internal Index type-checking function
- `DataFrame.rename` has a new `copy` parameter which can rename a DataFrame in place
- Enable unstacking by level name (GH142)
- Enable sortlevel to work by level name (GH141)
- `read_csv` can automatically “sniff” other kinds of delimiters using `csv.Sniffer` (GH146)
- Improved speed of unit test suite by about 40%
- Exception will not be raised calling `HDFStore.remove` on non-existent node with where clause
- Optimized `_ensure_index` function resulting in performance savings in type-checking Index objects

38.42.3 API Changes

38.42.4 Bug Fixes

- Fixed DataFrame constructor bug causing downstream problems (e.g. `.copy()` failing) when passing a Series as the values along with a column name and index
- Fixed single-key groupby on DataFrame with `as_index=False` (GH160)
- `Series.shift` was failing on integer Series (GH154)
- `unstack` methods were producing incorrect output in the case of duplicate hierarchical labels. An exception will now be raised (GH147)
- Calling `count` with level argument caused reduceat failure or segfault in earlier NumPy (GH169)
- Fixed `DataFrame.corrwith` to automatically exclude non-numeric data (GH144)
- Unicode handling bug fixes in `DataFrame.to_string` (GH138)
- Excluding OLS degenerate unit test case that was causing platform specific failure (GH149)
- Skip blosc-dependent unit tests for PyTables < 2.2 (GH137)
- Calling `copy` on `DateRange` did not copy over attributes to the new object (GH168)
- Fix bug in `HDFStore` in which Panel data could be appended to a Table with different item order, thus resulting in an incorrect result read back
38.42.5 Thanks

- Yaroslav Halchenko
- Jeff Reback
- Skipper Seabold
- Dan Lovell
- Nick Pentreath

38.43 pandas 0.4.0

Release date: 9/12/2011

38.43.1 New Features

- *pandas.core.sparse* module: “Sparse” (mostly-NA, or some other fill value) versions of *Series*, *DataFrame*, and *Panel*. For low-density data, this will result in significant performance boosts, and smaller memory footprint. Added *to_sparse* methods to *Series*, *DataFrame*, and *Panel*. See online documentation for more on these.

- Fancy indexing operator on *Series / DataFrame*, e.g. via .ix operator. Both getting and setting of values is supported; however, setting values will only currently work on homogeneously-typed *DataFrame* objects. Things like:
  - `series.ix[[d1, d2, d3]]`
  - `frame.ix[5:10, ['C', 'B', 'A']], frame.ix[5:10, 'A':'C']`
  - `frame.ix[date1:date2]`

- Significantly enhanced *groupby* functionality
  - Can *groupby* multiple keys, e.g. `df.groupby(['key1', 'key2'])`. Iteration with multiple groupings products a flattened tuple
  - “Nuisance” columns (non-aggregatable) will automatically be excluded from *DataFrame* aggregation operations
  - Added automatic “dispatching to *Series / DataFrame* methods to more easily invoke methods on groups. e.g. `s.groupby(crit).std()` will work even though `std` is not implemented on the *GroupBy* class

- Hierarchical / multi-level indexing
  - New the *MultiIndex* class. Integrated *MultiIndex* into *Series* and *DataFrame* fancy indexing, slicing, *__getitem__*, *__setitem__*, reindexing, etc. Added *level* keyword argument to *groupby* to enable grouping by a level of a *MultiIndex*

- New data reshaping functions: *stack* and *unstack* on *DataFrame* and *Series*
  - Integrate with MultiIndex to enable sophisticated reshaping of data

- *Index* objects (labels for axes) are now capable of holding tuples

- *Series.describe*, *DataFrame.describe* produces an R-like table of summary statistics about each data column

- *DataFrame.quantile*, *Series.quantile* for computing sample quantiles of data across requested axis

- Added general *DataFrame.dropna* method to replace *dropIncompleteRows* and *dropEmptyRows*, deprecated those.
pandas: powerful Python data analysis toolkit, Release 0.23.2

- **Series** arithmetic methods with optional fill_value for missing data, e.g. `a.add(b, fill_value=0)`. If a location is missing for both it will still be missing in the result though.
- fill_value option has been added to **DataFrame**.{add, mul, sub, div} methods similar to **Series**
- Boolean indexing with **DataFrame** objects: `data[data > 0.1] = 0.1` or `data[data> other] = 1`.
- **pytz** / tzinfo support in **DateRange**
  - `tz_localize`, `tz_normalize`, and `tz_validate` methods added
- Added **ExcelFile** class to pandas.io.parsers for parsing multiple sheets out of a single Excel 2003 document
- **GroupBy** aggregations can now optionally broadcast, e.g. produce an object of the same size with the aggregated value propagated
- Added `select` function in all data structures: reindex axis based on arbitrary criterion (function returning boolean value), e.g. `frame.select(lambda x: 'foo' in x, axis=1)`
- **DataFrame.consolidate** method, API function relating to redesigned internals
- **DataFrame.insert** method for inserting column at a specified location rather than the default __setitem__ behavior (which puts it at the end)
- **HDFStore** class in pandas.io.pytables has been largely rewritten using patches from Jeff Reback from others. It now supports mixed-type **DataFrame** and **Series** data and can store **Panel** objects. It also has the option to query **DataFrame** and **Panel** data. Loading data from legacy **HDFStore** files is supported explicitly in the code
- Added `set_printoptions` method to modify appearance of DataFrame tabular output
- `rolling_quantile` functions; a moving version of **Series.quantile** / **DataFrame.quantile**
- Generic `rolling_apply` moving window function
- New `drop` method added to **Series**, **DataFrame**, etc. which can drop a set of labels from an axis, producing a new object
- `reindex` methods now sport a `copy` option so that data is not forced to be copied then the resulting object is indexed the same
- Added `sort_index` methods to **Series** and **Panel**. Renamed **DataFrame.sort** to `sort_index`. Leaving **DataFrame.sort** for now.
- Added `skipna` option to statistical instance methods on all the data structures
- **pandas.io.data** module providing a consistent interface for reading time series data from several different sources

### 38.43.2 Improvements to existing features

- The 2-dimensional **DataFrame** and **DataMatrix** classes have been extensively redesigned internally into a single class **DataFrame**, preserving where possible their optimal performance characteristics. This should reduce confusion from users about which class to use.
  - Note that under the hood there is a new essentially “lazy evaluation” scheme within respect to adding columns to **DataFrame**. During some operations, like-typed blocks will be “consolidated” but not before.
- **DataFrame** accessing columns repeatedly is now significantly faster than **DataMatrix** used to be in 0.3.0 due to an internal **Series** caching mechanism (which are all views on the underlying data)
- Column ordering for mixed type data is now completely consistent in **DataFrame**. In prior releases, there was inconsistent column ordering in **DataMatrix**
- Improved console / string formatting of **DataMatrix** with negative numbers
- Improved tabular data parsing functions, `read_table` and `read_csv`:
- Added `skiprows` and `na_values` arguments to `pandas.io.parsers` functions for more flexible IO
- `parseCSV` / `read_csv` functions and others in `pandas.io.parsers` now can take a list of custom NA values, and also a list of rows to skip
- Can slice `DataFrame` and get a view of the data (when homogeneously typed), e.g. `frame.xs(idx, copy=False)` or `frame.ix[idx]`
- Many speed optimizations throughout `Series` and `DataFrame`
- Eager evaluation of groups when calling `groupby` functions, so if there is an exception with the grouping function it will raised immediately versus sometime later on when the groups are needed
- `datetools.WeekOfMonth` offset can be parameterized with `n` different than 1 or -1.
- Statistical methods on `DataFrame` like `mean`, `std`, `var`, `skew` will now ignore non-numerical data. Before a not very useful error message was generated. A flag `numeric_only` has been added to `DataFrame.sum` and `DataFrame.count` to enable this behavior in those methods if so desired (disabled by default)
- `DataFrame.pivot` generalized to enable pivoting multiple columns into a `DataFrame` with hierarchical columns
- `DataFrame` constructor can accept structured / record arrays
- `Panel` constructor can accept a dict of `DataFrame`-like objects. Do not need to use `from_dict` anymore (`from_dict` is there to stay, though).

### 38.43.3 API Changes

- The `DataMatrix` variable now refers to `DataFrame`, will be removed within two releases
- `WidePanel` is now known as `Panel`. The `WidePanel` variable in the pandas namespace now refers to the renamed `Panel` class
- `LongPanel` and `Panel` / `WidePanel` now no longer have a common subclass. `LongPanel` is now a subclass of `DataFrame` having a number of additional methods and a hierarchical index instead of the old `LongPanelIndex` object, which has been removed. Legacy `LongPanel` pickles may not load properly
- Cython is now required to build `pandas` from a development branch. This was done to avoid continuing to check in cythonized C files into source control. Builds from released source distributions will not require Cython
- Cython code has been moved up to a top level `pandas/src` directory. Cython extension modules have been renamed and promoted from the `lib` subpackage to the top level, i.e.
  - `pandas.lib.tseries -> pandas._tseries`
  - `pandas.lib.sparse -> pandas._sparse`
- `DataFrame` pickling format has changed. Backwards compatibility for legacy pickles is provided, but it’s recommended to consider PyTables-based `HDFStore` for storing data with a longer expected shelf life
- A `copy` argument has been added to the `DataFrame` constructor to avoid unnecessary copying of data. Data is no longer copied by default when passed into the constructor
- Handling of boolean dtype in `DataFrame` has been improved to support storage of boolean data with NA / NaN values. Before it was being converted to float64 so this should not (in theory) cause API breakage
- To optimize performance, Index objects now only check that their labels are unique when uniqueness matters (i.e. when someone goes to perform a lookup). This is a potentially dangerous tradeoff, but will lead to much better performance in many places (like groupby).
- Boolean indexing using Series must now have the same indices (labels)
- Backwards compatibility support for `begin/end/nPeriods` keyword arguments in DateRange class has been removed
• More intuitive / shorter filling aliases `ffill` (for `pad`) and `bfill` (for `backfill`) have been added to the functions that use them: `reindex`, `asfreq`, `fillna`.

• `pandas.core.mixins` code moved to `pandas.core.generic`

• `buffer` keyword arguments (e.g. `DataFrame.to_string`) renamed to `buf` to avoid using Python built-in name

• `DataFrame.rows()` removed (use `DataFrame.index`)

• Added deprecation warning to `DataFrame.cols()`, to be removed in next release

• `DataFrame` deprecations and de-camelCasing: `merge`, `asMatrix`, `toDataMatrix`, `_firstTimeWithValue`, `_lastTimeWithValue`, `toRecords`, `fromRecords`, `tgroupby`, `toString`

• `pandas.io.parsers` method deprecations
  – `parseCSV` is now `read_csv` and keyword arguments have been de-camelCased
  – `parseText` is now `read_table`
  – `parseExcel` is replaced by the `ExcelFile` class and its `parse` method

• `fillMethod` arguments (deprecated in prior release) removed, should be replaced with `method`

• `Series.fill`, `DataFrame.fill`, and `Panel.fill` removed, use `fillna` instead

• `groupby` functions now exclude NA / NaN values from the list of groups. This matches R behavior with NAs in factors e.g. with the `tapply` function

• Removed `parseText`, `parseCSV` and `parseExcel` from pandas namespace

• `Series.combineFunc` renamed to `Series.combine` and made a bit more general with a `fill_value` keyword argument defaulting to NaN

• Removed `pandas.core.pytools` module. Code has been moved to `pandas.core.common`

• Tacked on `groupName` attribute for groups in `GroupBy` renamed to `name`

• `Panel/LongPanel` `dims` attribute renamed to `shape` to be more conformant

• Slicing a `Series` returns a view now

• More `Series` deprecations / renaming: `toCSV` to `to_csv`, `asOf` to `asof`, `merge` to `map`, `applymap` to `apply`, `toDict` to `to_dict`, `combineFirst` to `combine_first`. Will print `FutureWarning`.

• `DataFrame.to_csv` does not write an “index” column label by default anymore since the output file can be read back without it. However, there is a new `index_label` argument. So you can do `index_label='index'` to emulate the old behavior

• `datetools.Week` argument renamed from `dayOfWeek` to `weekday`

• `timeRule` argument in `shift` has been deprecated in favor of using the `offset` argument for everything. So you can still pass a time rule string to `offset`

• Added optional `encoding` argument to `read_csv`, `read_table`, `to_csv`, `from_csv` to handle unicode in Python 2.x

### 38.43.4 Bug Fixes

• Column ordering in `pandas.io.parsers.parseCSV` will match CSV in the presence of mixed-type data

• Fixed handling of Excel 2003 dates in `pandas.io.parsers`

• `DateRange` caching was happening with high resolution `DateOffset` objects, e.g. `DateOffset(seconds=1)`. This has been fixed

• Fixed `__truediv__` issue in `DataFrame`
• Fixed DataFrame.toCSV bug preventing IO round trips in some cases
• Fixed bug in Series.plot causing matplotlib to barf in exceptional cases
• Disabled Index objects from being hashable, like ndarrays
• Added __ne__ implementation to Index so that operations like ts[ts != idx] will work
• Added __ne__ implementation to DataFrame
• Bug / unintuitive result when calling fillna on unordered labels
• Bug calling sum on boolean DataFrame
• Bug fix when creating a DataFrame from a dict with scalar values
• Series.{sum, mean, std, ...} now return NA/NaN when the whole Series is NA
• NumPy 1.4 through 1.6 compatibility fixes
• Fixed bug in bias correction in rolling_cov, was affecting rolling_corr too
• R-square value was incorrect in the presence of fixed and time effects in the PanelOLS classes
• HDFStore can handle duplicates in table format, will take

38.43.5 Thanks

• Joon Ro
• Michael Pennington
• Chris Uga
• Chris Withers
• Jeff Reback
• Ted Square
• Craig Austin
• William Ferreira
• Daniel Fortunov
• Tony Roberts
• Martin Felder
• John Marino
• Tim McNamara
• Justin Berka
• Dieter Vandenbussche
• Shane Conway
• Skipper Seabold
• Chris Jordan-Squire
38.44 pandas 0.3.0

Release date: February 20, 2011

38.44.1 New features

- `corrwith` function to compute column- or row-wise correlations between two DataFrame objects
- Can boolean-index DataFrame objects, e.g. `df[df > 2] = 2, px[px > last_px] = 0`
- Added comparison magic methods (`__lt__, __gt__, etc.)
- Flexible explicit arithmetic methods (add, mul, sub, div, etc.)
- Added `reindex_like` method
- Added `reindex_like` method to WidePanel
- Convenience functions for accessing SQL-like databases in `pandas.io.sql` module
- Added (still experimental) HDFStore class for storing pandas data structures using HDF5 / PyTables in `pandas.io.pytables` module
- Added WeekOfMonth date offset
- `pandas.rpy` (experimental) module created, provide some interfacing / conversion between rpy2 and pandas

38.44.2 Improvements to existing features

- Unit test coverage: 100% line coverage of core data structures
- Speed enhancement to rolling_{median, max, min}
- Column ordering between DataFrame and DataMatrix is now consistent: before DataFrame would not respect column order
- Improved `{Series, DataFrame}.plot` methods to be more flexible (can pass matplotlib Axis arguments, plot DataFrame columns in multiple subplots, etc.)

38.44.3 API Changes

- Exponentially-weighted moment functions in `pandas.stats.moments` have a more consistent API and accept a min_periods argument like their regular moving counterparts.
- `fillMethod` argument in Series, DataFrame changed to `method, FutureWarning` added.
- `fill` method in Series, DataFrame/DataMatrix, WidePanel renamed to `fillna, FutureWarning` added to `fill`
- Renamed `DataFrame.getXS` to `xs, FutureWarning` added
- Removed `cap` and `floor` functions from DataFrame, renamed to `clip_upper` and `clip_lower` for consistency with NumPy
38.44.4 Bug Fixes

- Fixed bug in IndexableSkipList Cython code that was breaking rolling_max function
- Numerous numpy.int64-related indexing fixes
- Several NumPy 1.4.0 NaN-handling fixes
- Bug fixes to pandas.io.parsers.parseCSV
- Fixed DateRange caching issue with unusual date offsets
- Fixed bug in DateRange.union
- Fixed corner case in IndexableSkipList implementation
[R16] http://docs.sqlalchemy.org
[R17] https://www.python.org/dev/peps/pep-0249/
[R27] https://docs.python.org/3/library/pickle.html
[R28] http://docs.sqlalchemy.org
[R29] https://www.python.org/dev/peps/pep-0249/
[R21] https://docs.python.org/3/library/pickle.html
[R22] http://docs.sqlalchemy.org
[R23] https://www.python.org/dev/peps/pep-0249/
pandas, 1