10 Minutes to pandas

This is a short introduction to pandas, geared mainly for new users. You can see more complex recipes in the [Cookbook](http://pandas.pydata.org/pandas-docs/stable/cookbook.html#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**

Object Creation

See the [Data Structure Intro section](http://pandas.pydata.org/pandas-docs/stable/dsintro.html#dsintro)

Creating a [**Series**](http://pandas.pydata.org/pandas-docs/stable/generated/pandas.Series.html#pandas.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**](http://pandas.pydata.org/pandas-docs/stable/generated/pandas.DataFrame.html#pandas.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]:

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

2013-01-04 0.721555 -0.706771 -1.039575 0.271860

2013-01-05 -0.424972 0.567020 0.276232 -1.087401

2013-01-06 -0.673690 0.113648 -1.478427 0.524988

Creating a DataFrame by passing a dict of objects that can be converted to series-like.

**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 test foo

1 1.0 2013-01-02 1.0 3 train foo

2 1.0 2013-01-02 1.0 3 test foo

3 1.0 2013-01-02 1.0 3 train foo

Having specific [dtypes](http://pandas.pydata.org/pandas-docs/stable/basics.html#basics-dtypes)

**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:

**In [13]:** df2.<TAB>

df2.A df2.boxplot

df2.abs df2.C

df2.add df2.clip

df2.add\_prefix df2.clip\_lower

df2.add\_suffix df2.clip\_upper

df2.align df2.columns

df2.all df2.combine

df2.any df2.combineAdd

df2.append df2.combine\_first

df2.apply df2.combineMult

df2.applymap df2.compound

df2.as\_blocks df2.consolidate

df2.asfreq df2.convert\_objects

df2.as\_matrix df2.copy

df2.astype df2.corr

df2.at df2.corrwith

df2.at\_time df2.count

df2.axes df2.cov

df2.B df2.cummax

df2.between\_time df2.cummin

df2.bfill df2.cumprod

df2.blocks df2.cumsum

df2.bool 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.

Viewing Data

See the [Basics section](http://pandas.pydata.org/pandas-docs/stable/basics.html#basics)

See the top & 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 -1.044236

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 -1.087401

**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 -1.087401

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([u'A', u'B', u'C', u'D'], dtype='object')

**In [18]:** df.values

Out[18]:

array([[ 0.4691, -0.2829, -1.5091, -1.1356],

[ 1.2121, -0.1732, 0.1192, -1.0442],

[-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 -0.034326 0.461706

max 1.212112 0.567020 0.276232 1.071804

Transposing your data

**In [20]:** df.T

Out[20]:

2013-01-01 2013-01-02 2013-01-03 2013-01-04 2013-01-05 2013-01-06

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 0.721555

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

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,.iloc and .ix.

See the indexing documentation [Indexing and Selecting Data](http://pandas.pydata.org/pandas-docs/stable/indexing.html#indexing) and [MultiIndex / Advanced Indexing](http://pandas.pydata.org/pandas-docs/stable/advanced.html#advanced)

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

2013-01-05 -0.424972

2013-01-06 -0.673690

Freq: D, Name: A, dtype: float64

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

Selection by Label

See more in [Selection by Label](http://pandas.pydata.org/pandas-docs/stable/indexing.html#indexing-label)

For getting a cross section using a label

**In [26]:** df.loc[dates[0]]

Out[26]:

A 0.469112

B -0.282863

C -1.509059

D -1.135632

Name: 2013-01-01 00:00:00, dtype: float64

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 1.212112

B -0.173215

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 (equiv to the prior method)

**In [31]:** df.at[dates[0],'A']

Out[31]: 0.46911229990718628

Selection by Position

See more in [Selection by Position](http://pandas.pydata.org/pandas-docs/stable/indexing.html#indexing-integer)

Select via the position of the passed integers

**In [32]:** df.iloc[3]

Out[32]:

A 0.721555

B -0.706771

C -1.039575

D 0.271860

Name: 2013-01-04 00:00:00, dtype: float64

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 (equiv to the prior method)

**In [38]:** df.iat[1,1]

Out[38]: -0.17321464905330858

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

2013-01-04 0.721555 -0.706771 -1.039575 0.271860

A where operation for getting.

**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()**](http://pandas.pydata.org/pandas-docs/stable/generated/pandas.Series.isin.html#pandas.Series.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

2013-01-03 -0.861849 -2.104569 -0.494929 1.071804 two

2013-01-04 0.721555 -0.706771 -1.039575 0.271860 three

2013-01-05 -0.424972 0.567020 0.276232 -1.087401 four

2013-01-06 -0.673690 0.113648 -1.478427 0.524988 three

**In [44]:** df2[df2['E'].isin(['two','four'])]

Out[44]:

A B C D E

2013-01-03 -0.861849 -2.104569 -0.494929 1.071804 two

2013-01-05 -0.424972 0.567020 0.276232 -1.087401 four

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))

**In [46]:** s1

Out[46]:

2013-01-02 1

2013-01-03 2

2013-01-04 3

2013-01-05 4

2013-01-06 5

2013-01-07 6

Freq: D, dtype: int64

**In [47]:** df['F'] = s1

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

Out[51]:

A B C D F

2013-01-01 0.000000 0.000000 -1.509059 5 NaN

2013-01-02 1.212112 -0.173215 0.119209 5 1.0

2013-01-03 -0.861849 -2.104569 -0.494929 5 2.0

2013-01-04 0.721555 -0.706771 -1.039575 5 3.0

2013-01-05 -0.424972 0.567020 0.276232 5 4.0

2013-01-06 -0.673690 0.113648 -1.478427 5 5.0

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

2013-01-01 0.000000 0.000000 -1.509059 -5 NaN

2013-01-02 -1.212112 -0.173215 -0.119209 -5 -1.0

2013-01-03 -0.861849 -2.104569 -0.494929 -5 -2.0

2013-01-04 -0.721555 -0.706771 -1.039575 -5 -3.0

2013-01-05 -0.424972 -0.567020 -0.276232 -5 -4.0

2013-01-06 -0.673690 -0.113648 -1.478427 -5 -5.0

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](http://pandas.pydata.org/pandas-docs/stable/missing_data.html#missing-data)

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

2013-01-01 0.000000 0.000000 -1.509059 5 NaN 1.0

2013-01-02 1.212112 -0.173215 0.119209 5 1.0 1.0

2013-01-03 -0.861849 -2.104569 -0.494929 5 2.0 NaN

2013-01-04 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

2013-01-02 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

2013-01-01 0.000000 0.000000 -1.509059 5 5.0 1.0

2013-01-02 1.212112 -0.173215 0.119209 5 1.0 1.0

2013-01-03 -0.861849 -2.104569 -0.494929 5 2.0 5.0

2013-01-04 0.721555 -0.706771 -1.039575 5 3.0 5.0

To get the boolean mask where values are nan

**In [60]:** pd.isnull(df1)

Out[60]:

A B C D F E

2013-01-01 False False False False True False

2013-01-02 False False False False False False

2013-01-03 False False False False False True

2013-01-04 False False False False False True

Operations

See the [Basic section on Binary Ops](http://pandas.pydata.org/pandas-docs/stable/basics.html#basics-binop)

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')

Out[65]:

A B C D F

2013-01-01 NaN NaN NaN NaN NaN

2013-01-02 NaN NaN NaN NaN NaN

2013-01-03 -1.861849 -3.104569 -1.494929 4.0 1.0

2013-01-04 -2.278445 -3.706771 -4.039575 2.0 0.0

2013-01-05 -5.424972 -4.432980 -4.723768 0.0 -1.0

2013-01-06 NaN NaN NaN NaN NaN

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 NaN

2013-01-02 1.212112 -0.173215 -1.389850 10 1.0

2013-01-03 0.350263 -2.277784 -1.884779 15 3.0

2013-01-04 1.071818 -2.984555 -2.924354 20 6.0

2013-01-05 0.646846 -2.417535 -2.648122 25 10.0

2013-01-06 -0.026844 -2.303886 -4.126549 30 15.0

**In [67]:** df.apply(**lambda** x: x.max() - x.min())

Out[67]:

A 2.073961

B 2.671590

C 1.785291

D 0.000000

F 4.000000

dtype: float64

Histogramming

See more at [Histogramming and Discretization](http://pandas.pydata.org/pandas-docs/stable/basics.html#basics-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()

Out[70]:

4 5

6 2

2 2

1 1

dtype: int64

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](https://docs.python.org/2/library/re.html) by default (and in some cases always uses them). See more at [Vectorized String Methods](http://pandas.pydata.org/pandas-docs/stable/text.html#text-string-methods).

**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

Merge

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](http://pandas.pydata.org/pandas-docs/stable/merging.html#merging)

Concatenating pandas objects together with [**concat()**](http://pandas.pydata.org/pandas-docs/stable/generated/pandas.concat.html#pandas.concat):

**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 -0.932132 1.956030 0.017587 -0.016692

8 -0.575247 0.254161 -1.143704 0.215897

9 1.193555 -0.077118 -0.408530 -0.862495

Join

SQL style merges. See the [Database style joining](http://pandas.pydata.org/pandas-docs/stable/merging.html#merging-join)

**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

Out[80]:

key rval

0 foo 4

1 foo 5

**In [81]:** pd.merge(left, right, on='key')

Out[81]:

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]})

**In [84]:** left

Out[84]:

key lval

0 foo 1

1 bar 2

**In [85]:** right

Out[85]:

key rval

0 foo 4

1 bar 5

**In [86]:** pd.merge(left, right, on='key')

Out[86]:

key lval rval

0 foo 1 4

1 bar 2 5

Append

Append rows to a dataframe. See the [Appending](http://pandas.pydata.org/pandas-docs/stable/merging.html#merging-concatenation)

**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

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](http://pandas.pydata.org/pandas-docs/stable/groupby.html#groupby)

**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 a function sum to the resulting groups.

**In [93]:** df.groupby('A').sum()

Out[93]:

C D

A

bar -2.802588 2.42611

foo 3.146492 -0.63958

Grouping by multiple columns forms a hierarchical index, which we then apply the function.

**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

Reshaping

See the sections on [Hierarchical Indexing](http://pandas.pydata.org/pandas-docs/stable/advanced.html#advanced-hierarchical) and [Reshaping](http://pandas.pydata.org/pandas-docs/stable/reshaping.html#reshaping-stacking).

Stack

**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()**](http://pandas.pydata.org/pandas-docs/stable/generated/pandas.DataFrame.stack.html#pandas.DataFrame.stack) method “compresses” a level in the DataFrame’s columns.

**In [100]:** stacked = df2.stack()

**In [101]:** stacked

Out[101]:

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()**](http://pandas.pydata.org/pandas-docs/stable/generated/pandas.DataFrame.stack.html#pandas.DataFrame.stack) is[**unstack()**](http://pandas.pydata.org/pandas-docs/stable/generated/pandas.DataFrame.unstack.html#pandas.DataFrame.unstack), which by default unstacks the **last level**:

**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)

Out[103]:

second one two

first

bar A 0.029399 0.282696

B -0.542108 -0.087302

baz A -1.575170 0.816482

B 1.771208 1.100230

**In [104]:** stacked.unstack(0)

Out[104]:

first bar baz

second

one A 0.029399 -1.575170

B -0.542108 1.771208

two A 0.282696 0.816482

B -0.087302 1.100230

Pivot Tables

See the section on [Pivot Tables](http://pandas.pydata.org/pandas-docs/stable/reshaping.html#reshaping-pivot).

**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)})

**.....:**

**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:

**In [107]:** pd.pivot\_table(df, values='D', index=['A', 'B'], columns=['C'])

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

B -1.170653 NaN

C NaN 0.536826

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](http://pandas.pydata.org/pandas-docs/stable/timeseries.html#timeseries)

**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]:

2012-03-06 00:00:00+00:00 0.464000

2012-03-07 00:00:00+00:00 0.227371

2012-03-08 00:00:00+00:00 -0.496922

2012-03-09 00:00:00+00:00 0.306389

2012-03-10 00:00:00+00:00 -2.290613

Freq: D, dtype: float64

Convert 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

2012-03-07 19:00:00-05:00 -0.496922

2012-03-08 19:00:00-05:00 0.306389

2012-03-09 19:00:00-05:00 -2.290613

Freq: D, dtype: float64

Converting between time span representations

**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:

**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

Categoricals

Since version 0.15, pandas can include categorical data in a DataFrame. For full docs, see the [categorical introduction](http://pandas.pydata.org/pandas-docs/stable/categorical.html#categorical) and the [API documentation](http://pandas.pydata.org/pandas-docs/stable/api.html#api-categorical).

**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 per 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 shows also empty categories.

**In [134]:** df.groupby("grade").size()

Out[134]:

grade

very bad 1

bad 0

medium 0

good 2

very good 3

dtype: int64

Plotting

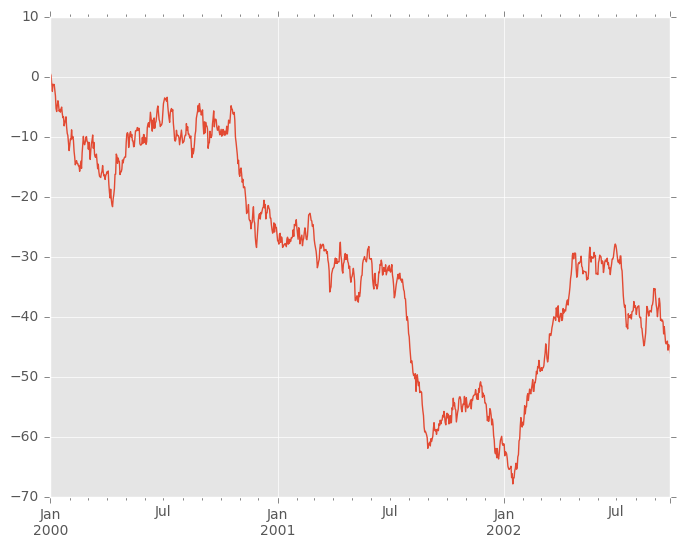
[Plotting](http://pandas.pydata.org/pandas-docs/stable/visualization.html#visualization) docs.

**In [135]:** ts = pd.Series(np.random.randn(1000), index=pd.date\_range('1/1/2000', periods=1000))

**In [136]:** ts = ts.cumsum()

**In [137]:** ts.plot()

Out[137]: <matplotlib.axes.\_subplots.AxesSubplot at 0x7ff2ab2af550>



On DataFrame, [**plot()**](http://pandas.pydata.org/pandas-docs/stable/generated/pandas.DataFrame.plot.html#pandas.DataFrame.plot) is a convenience to plot all of the columns with labels:

**In [138]:** df = pd.DataFrame(np.random.randn(1000, 4), index=ts.index,

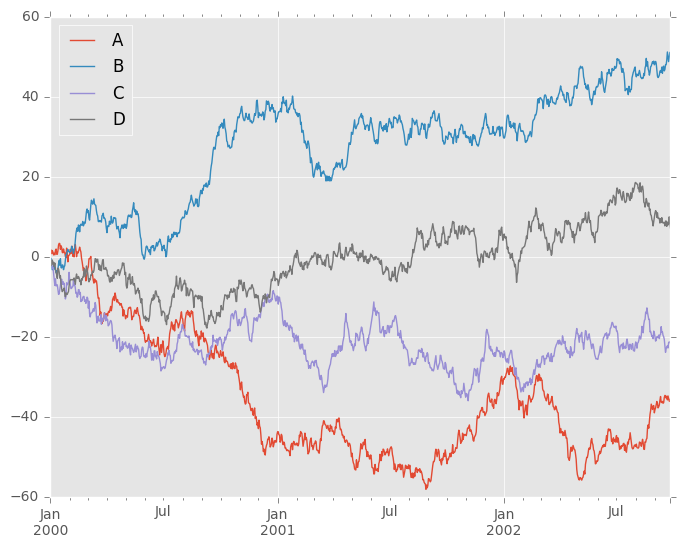
**.....:** columns=['A', 'B', 'C', 'D'])

**.....:**

**In [139]:** df = df.cumsum()

**In [140]:** plt.figure(); df.plot(); plt.legend(loc='best')

Out[140]: <matplotlib.legend.Legend at 0x7ff29c8163d0>



Getting Data In/Out

CSV

[Writing to a csv file](http://pandas.pydata.org/pandas-docs/stable/io.html#io-store-in-csv)

**In [141]:** df.to\_csv('foo.csv')

[Reading from a csv file](http://pandas.pydata.org/pandas-docs/stable/io.html#io-read-csv-table)

**In [142]:** pd.read\_csv('foo.csv')

Out[142]:

Unnamed: 0 A B C D

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

.. ... ... ... ... ...

993 2002-09-20 -10.628548 -9.153563 -7.883146 28.313940

994 2002-09-21 -10.390377 -8.727491 -6.399645 30.914107

995 2002-09-22 -8.985362 -8.485624 -4.669462 31.367740

996 2002-09-23 -9.558560 -8.781216 -4.499815 30.518439

997 2002-09-24 -9.902058 -9.340490 -4.386639 30.105593

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]

HDF5

Reading and writing to [HDFStores](http://pandas.pydata.org/pandas-docs/stable/io.html#io-hdf5)

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

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 0.449933 -0.741620 -1.962409

2000-01-07 1.235339 -0.091757 -1.543861 -1.084753

... ... ... ... ...

2002-09-20 -10.628548 -9.153563 -7.883146 28.313940

2002-09-21 -10.390377 -8.727491 -6.399645 30.914107

2002-09-22 -8.985362 -8.485624 -4.669462 31.367740

2002-09-23 -9.558560 -8.781216 -4.499815 30.518439

2002-09-24 -9.902058 -9.340490 -4.386639 30.105593

2002-09-25 -10.216020 -9.480682 -3.933802 29.758560

2002-09-26 -11.856774 -10.671012 -3.216025 29.369368

[1000 rows x 4 columns]

Excel

Reading and writing to [MS Excel](http://pandas.pydata.org/pandas-docs/stable/io.html#io-excel)

Writing to an excel file

**In [145]:** df.to\_excel('foo.xlsx', sheet\_name='Sheet1')

Reading from an excel file

**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 0.449933 -0.741620 -1.962409

2000-01-07 1.235339 -0.091757 -1.543861 -1.084753

... ... ... ... ...

2002-09-20 -10.628548 -9.153563 -7.883146 28.313940

2002-09-21 -10.390377 -8.727491 -6.399645 30.914107

2002-09-22 -8.985362 -8.485624 -4.669462 31.367740

2002-09-23 -9.558560 -8.781216 -4.499815 30.518439

2002-09-24 -9.902058 -9.340490 -4.386639 30.105593

2002-09-25 -10.216020 -9.480682 -3.933802 29.758560

2002-09-26 -11.856774 -10.671012 -3.216025 29.369368

[1000 rows x 4 columns]

Gotchas

If you are trying an operation and you see an exception like:

**>>> 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](http://pandas.pydata.org/pandas-docs/stable/basics.html#basics-compare) for an explanation and what to do.

See [Gotchas](http://pandas.pydata.org/pandas-docs/stable/gotchas.html#gotchas) as well.