Pandas and Friends

- Austin Godber
- Mail: godber@uberhip.com
- Twitter: @godber

- Presented at DesertPy (http://desertpy.com), Jan 2015.

What does it do?

Pandas is a Python data analysis tool built on top of NumPy that provides a suite of data structures and data manipulation functions to work on those data structures. It is particularly well suited for working with time series data.

Getting Started - Installation

Installing with pip or apt-get::

```
pip install pandas
# or
sudo apt-get install python-pandas
```

- Mac - Homebrew or MacPorts to get the dependencies, then pip
- Windows - Python(x,y)?
- Commercial Pythons: Anaconda, Canopy

Getting Started - Dependencies

Dependencies, required, recommended and optional

```
# Required
numpy, python-dateutil, pytx
# Recommended
numexpr, bottleneck
# Optional
cython, scipy, pytables, matplotlib, statsmodels, openpyxl
```

Pandas' Friends!

Pandas works along side and is built on top of several other Python projects.

- IPython

- Numpy
- Matplotlib

Pandas gets along with EVERYONE!

Background - IPython

IPython is a fancy python console. Try running `ipython` or `ipython --pylab` on your command line. Some IPython tips

```
# Special commands, 'magic functions', begin with %
%quickref, %who, %run, %reset
# Shell Commands
ls, cd, pwd, mkdir
# Need Help?
help(), help(obj), obj?, function?
# Tab completion of variables, attributes and methods
```

Background - IPython Notebook

There is a web interface to IPython, known as the IPython notebook, start it like this

```
ipython notebook
# or to get all of the pylab components
ipython notebook --pylab
```

IPython - Follow Along

Follow along by connecting to TMPNB.ORG!

- http://tmpnb.org (http://tmpnb.org)

Background - NumPy

- NumPy is the foundation for Pandas
- Numerical data structures (mostly Arrays)
- Operations on those.
- Less structure than Pandas provides.

Background - NumPy - Arrays

In [1]:
```
import numpy as np
# np.zeros, np.ones
data0 = np.zeros((2, 4))

data0
```

Out[1]:
```
array([[ 0.,  0.,  0.,  0.],
       [ 0.,  0.,  0.,  0.]])
```

In [2]:
```
# Make an array with 20 entries 0..19
data1 = np.arange(20)
# print the first 8
data1[0:8]
```

Out[2]:
```
array([0, 1, 2, 3, 4, 5, 6, 7])
```

Background - NumPy - Arrays

In [3]:
```
# make it a 4,5 array
data = np.arange(20).reshape(4, 5)
data
```

Out[3]:
```
array([[ 0,  1,  2,  3,  4],
       [ 5,  6,  7,  8,  9],
       [10, 11, 12, 13, 14],
       [15, 16, 17, 18, 19]])
```

Background - NumPy - Arrays

Arrays have NumPy specific types, `dtypes`, and can be operated on.

In [4]:
```
print("dtype: ", data.dtype)
result = data * 20.5
print(result)
```

```
('dtype: ', dtype('int64'))
[[   0.    20.5   41.    61.5   82. ]
 [ 102.5  123.   143.5  164.   184.5]
 [ 205.   225.5  246.   266.5  287. ]
 [ 307.5  328.   348.5  369.   389.5]]
```

Now, on to Pandas

Pandas

- Tabular, Timeseries, Matrix Data - labeled or not
- Sensible handling of missing data and data alignment
- Data selection, slicing and reshaping features
- Robust data import utilities.
- Advanced time series capabilities

Data Structures

- Series - 1D labeled array
- DataFrame - 2D labeled array
- Panel - 3D labeled array (More D)

Assumed Imports

In my code samples, assume I import the following

In [5]:
```
import pandas as pd
import numpy as np
```

Series

- one-dimensional labeled array
- holds any data type
- axis labels known as index
- implicit integert indexes
- `dict`-like

Create a Simple Series

In [6]:
```
s1 = pd.Series([1, 2, 3, 4, 5])
s1
```

Out[6]:
```
0    1
1    2
2    3
3    4
4    5
dtype: int64
```

Series Operations

In [7]:
```
# integer multiplication
print(s1 * 5)
```

```
0     5
1    10
2    15
3    20
4    25
dtype: int64
```

Series Operations - Cont.

In [8]:
```
# float multiplication
print(s1 * 5.0)
```

```
0     5
1    10
2    15
3    20
4    25
dtype: float64
```

Series Index

In [9]:
```
s2 = pd.Series([1, 2, 3, 4, 5],
               index=['a', 'b', 'c', 'd', 'e'])
s2
```

Out[9]:
```
a    1
b    2
c    3
d    4
e    5
dtype: int64
```

Date Convenience Functions

A quick aside ...

In [10]:
```
dates = pd.date_range('20130626', periods=5)
print(dates)
print()
print(dates[0])
```

```
<class 'pandas.tseries.index.DatetimeIndex'>
[2013-06-26, ..., 2013-06-30]
Length: 5, Freq: D, Timezone: None
()
2013-06-26 00:00:00
```

Datestamps as Index

In [11]:
```
s3 = pd.Series([1, 2, 3, 4, 5], index=dates)
print(s3)
```

```
2013-06-26    1
2013-06-27    2
2013-06-28    3
2013-06-29    4
2013-06-30    5
Freq: D, dtype: int64
```

Selecting By Index

Note that the integer index is retained along with the new date index.

In [12]:
```
print(s3[0])
print(type(s3[0]))
print()
print(s3[1:3])
print(type(s3[1:3]))
```

```
1
<type 'numpy.int64'>
()
2013-06-27    2
2013-06-28    3
Freq: D, dtype: int64
<class 'pandas.core.series.Series'>
```

Selecting by value

In [13]:
```
s3[s3 < 3]
```

Out[13]:
```
2013-06-26    1
2013-06-27    2
Freq: D, dtype: int64
```

Selecting by Label (Date)

In [14]:
```
s3['20130626':'20130628']
```

Out[14]:
```
2013-06-26    1
2013-06-27    2
2013-06-28    3
Freq: D, dtype: int64
```

Series Wrapup

Things not covered but you should look into:

- Other instantiation options: `dict`
- Operator Handling of missing data `NaN`
- Reforming Data and Indexes
- Boolean Indexing
- Other Series Attributes:
  - `index` - `index.name`
  - `name` - Series name

DataFrame

- 2-dimensional labeled data structure
- Like a SQL Table, Spreadsheet or `dict` of `Series` objects.
- Columns of potentially different types
- Operations, slicing and other behavior just like `Series`

DataFrame - Simple

In [15]:
```
data1 = pd.DataFrame(np.random.rand(4, 4))
data1
```

Out[15]:

	0	1	2	3
0	0.002581	0.851980	0.097265	0.648841
1	0.732965	0.820690	0.895176	0.582483
2	0.176504	0.068942	0.466759	0.918777
3	0.938426	0.097954	0.696534	0.684424

DataFrame - Index/Column Names

In [16]:
```
dates = pd.date_range('20130626', periods=4)
data2 = pd.DataFrame(
    np.random.rand(4, 4),
    index=dates, columns=list('ABCD'))
data2
```

Out[16]:

	A	B	C	D
2013-06-26	0.831222	0.209279	0.340186	0.928447
2013-06-27	0.252513	0.452392	0.862822	0.738837
2013-06-28	0.309083	0.822918	0.924720	0.964607
2013-06-29	0.827998	0.539519	0.248369	0.377682

DataFrame - Operations

In [17]:
```
data2['E'] = data2['B'] + 5 * data2['C']
data2
```

Out[17]:

	A	B	C	D	E
2013-06-26	0.831222	0.209279	0.340186	0.928447	1.910210
2013-06-27	0.252513	0.452392	0.862822	0.738837	4.766505
2013-06-28	0.309083	0.822918	0.924720	0.964607	5.446516
2013-06-29	0.827998	0.539519	0.248369	0.377682	1.781366

See? You never need Excel again!

DataFrame - Column Access

Deleting a column.

In [18]:
```
# Deleting a Column
del data2['E']
data2
```

Out[18]:

	A	B	C	D
2013-06-26	0.831222	0.209279	0.340186	0.928447
2013-06-27	0.252513	0.452392	0.862822	0.738837
2013-06-28	0.309083	0.822918	0.924720	0.964607
2013-06-29	0.827998	0.539519	0.248369	0.377682

DataFrame

Remember this, data2, for the next examples.

In [19]:
```
data2
```

Out[19]:

	A	B	C	D
2013-06-26	0.831222	0.209279	0.340186	0.928447
2013-06-27	0.252513	0.452392	0.862822	0.738837
2013-06-28	0.309083	0.822918	0.924720	0.964607
2013-06-29	0.827998	0.539519	0.248369	0.377682

DataFrame - Column Access

As a dict

```
In [20]: data2['B']
```

```
Out[20]: 2013-06-26    0.209279
         2013-06-27    0.452392
         2013-06-28    0.822918
         2013-06-29    0.539519
         Freq: D, Name: B, dtype: float64
```

DataFrame - Column Access

As an attribute

```
In [21]: data2.B
```

```
Out[21]: 2013-06-26    0.209279
         2013-06-27    0.452392
         2013-06-28    0.822918
         2013-06-29    0.539519
         Freq: D, Name: B, dtype: float64
```

DataFrame - Row Access

By row label

```
In [22]: data2.loc['20130627']
```

```
Out[22]: A    0.252513
         B    0.452392
         C    0.862822
         D    0.738837
         Name: 2013-06-27 00:00:00, dtype: float64
```

DataFrame - Row Access

By integer location

```
In [23]: data2.iloc[1]
```

```
Out[23]: A    0.252513
         B    0.452392
         C    0.862822
         D    0.738837
         Name: 2013-06-27 00:00:00, dtype: float64
```

DataFrame - Cell Access

Access column, then row or use iloc and row/column indexes.

In [24]:
```
print(data2.B[0])
print(data2['B'][0])
print(data2.iloc[0,1])  # [row,column]
```

```
0.209279059059
0.209279059059
0.209279059059
```

DataFrame - Taking a Peek

Look at the beginning of the DataFrame

In [25]:
```
data3 = pd.DataFrame(np.random.rand(100, 4))
data3.head()
```

Out[25]:

	0	1	2	3
0	0.796264	0.332496	0.860904	0.488276
1	0.405906	0.309003	0.159129	0.597427
2	0.107366	0.791943	0.080191	0.187125
3	0.176196	0.931741	0.742967	0.953014
4	0.567175	0.673101	0.069275	0.208249

DataFrame - Taking a Peek

Look at the end of the DataFrame.

In [26]:
```
data3.tail()
```

Out[26]:

	0	1	2	3
95	0.175699	0.187918	0.407732	0.441582
96	0.638801	0.264603	0.210135	0.721955
97	0.947213	0.674040	0.087639	0.240926
98	0.220907	0.309761	0.659022	0.894547
99	0.452450	0.365101	0.043229	0.911712

DataFrame Wrap Up

Just remember,

- A `DataFrame` is just a bunch of `Series` grouped together.
- Any one dimensional slice returns a `Series`
- Any two dimensional slice returns another `DataFrame`.
- Elements are typically NumPy types or Objects.

Panel

Like DataFrame but 3 or more dimensions.

IO Tools

Robust IO tools to read in data from a variety of sources

- CSV - pd.read_csv() (http://pandas.pydata.org/pandas-docs/stable/io.html#io-read-csv-table)
- Clipboard - pd.read_clipboard() (http://pandas.pydata.org/pandas-docs/stable/io.html#clipboard)
- SQL - pd.read_sql_table() (http://pandas.pydata.org/pandas-docs/stable/io.html#sql-queries)
- Excel - pd.read_excel() (http://pandas.pydata.org/pandas-docs/stable/io.html#io-excel)

Plotting

- Matplotlib - s.plot() (http://pandas.pydata.org/pandas-docs/stable/visualization.html#plotting-with-matplotlib) - Standard Python Plotting Library
- Trellis - rplot() (http://pandas.pydata.org/pandas-docs/stable/rplot.html) - An 'R' inspired Matplotlib based plotting tool

Bringing it Together - Data

The csv file (`phx-temps.csv`) contains Phoenix weather data from GSOD::

```
1973-01-01 00:00:00,53.1,37.9
1973-01-02 00:00:00,57.9,37.0
...
2012-12-30 00:00:00,64.9,39.0
2012-12-31 00:00:00,55.9,41.0
```

Bringing it Together - Code

Simple `read_csv()`

In [27]:
```
# simple readcsv
phxtemps1 = pd.read_csv('phx-temps.csv')
phxtemps1.head()
```

Out[27]:

	1973-01-01 00:00:00	53.1	37.9
0	1973-01-02 00:00:00	57.9	37.0
1	1973-01-03 00:00:00	59.0	37.0
2	1973-01-04 00:00:00	57.9	41.0
3	1973-01-05 00:00:00	54.0	39.9
4	1973-01-06 00:00:00	55.9	37.9

Bringing it Together - Code

Advanced `read_csv()`, parsing the dates and using them as the index, and naming the columns.

In [28]:
```
# define index, parse dates, name columns
phxtemps2 = pd.read_csv(
    'phx-temps.csv', index_col=0,
    names=['highs', 'lows'], parse_dates=True)
phxtemps2.head()
```

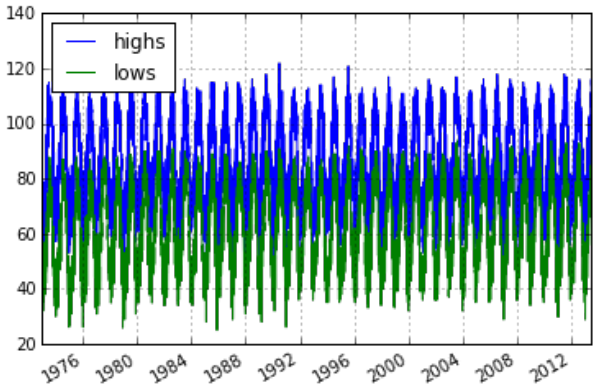
Out[28]:

	highs	lows
1973-01-01	53.1	37.9
1973-01-02	57.9	37.0
1973-01-03	59.0	37.0
1973-01-04	57.9	41.0
1973-01-05	54.0	39.9

Bringing it Together - Plot

In [29]:
```
import matplotlib.pyplot as plt
%matplotlib inline
phxtemps2.plot()  # pandas convenience method
```

Out[29]: <matplotlib.axes._subplots.AxesSubplot at 0x7fca44e8e550>



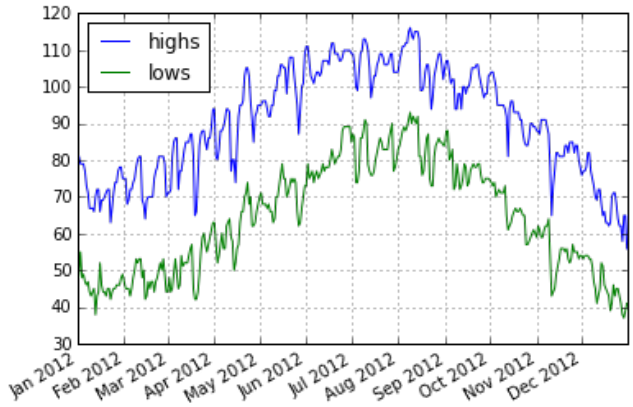
Boo, Pandas and Friends would cry if they saw such a plot.

Bringing it Together - Plot

Lets see a smaller slice of time:

In [30]:
```
phxtemps2['20120101':'20121231'].plot()
```

Out[30]: <matplotlib.axes._subplots.AxesSubplot at 0x7fca3c66f1d0>

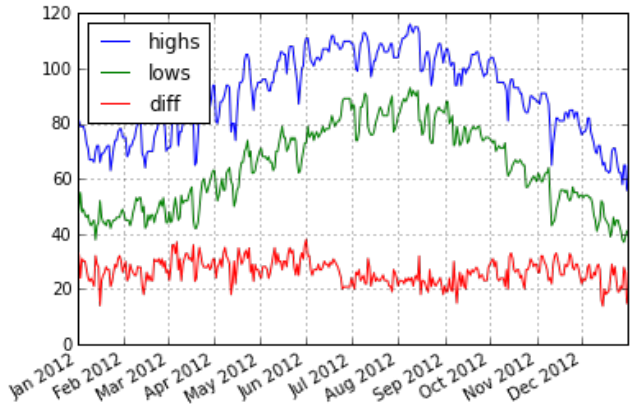


Bringing it Together - Plot

Lets operate on the `DataFrame` ... lets take the differnce between the highs and lows.

In [31]:
```
phxtemps2['diff'] = phxtemps2.highs - phxtemps2.lows
phxtemps2['20120101':'20121231'].plot()
```

Out[31]: <matplotlib.axes._subplots.AxesSubplot at 0x7fca3c6ba650>



Pandas Alternatives

- AstroPy seems to have similar data structures.
- I suspect there are others.

References

- Pandas Documentation (http://pandas.pydata.org/pandas-docs/stable/index.html)
- Python for Data Analysis (http://www.amazon.com/Python-Data-Analysis-Wes-McKinney/dp/1449319793/)
- Presentation Source (https://github.com/desertpy/presentations)

Thanks! - Pandas and Friends

- Austin Godber
- Mail: godber@uberhip.com
- Twitter: @godber

- Presented at DesertPy (http://desertpy.com), Jan 2015.