PANDAS

Python for Data Analysis

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pandas - Outline

- Overview
- Purpose
- Terminology
- Series
- DataFrame
- Functionality
- Data Loading
- Plotting
- What else can pandas do
- Question

pandas - Overview

- Python Data Analysis Library, similar to:
  - R
  - MATLAB
  - SAS
- Combined with the IPython toolkit
- Built on top of NumPy, SciPy, to some extent matplotlib
- **Pan**el **Da**ta **S**ystem
- Open source, BSD-licensed
- Key Components
  - Series
  - DataFrame

pandas - Purpose

- Ideal tool for data scientists
- Munging data
- Cleaning data
- Analyzing data
- Modeling data
- Organizing the results of the analysis into a form suitable for plotting or tabular display

pandas - Terminology

- **IPython** is a command shell for interactive computing in multiple programming languages, especially focused on the Python programming language, that offers enhanced introspection, rich media, additional shell syntax, tab completion, and rich history.
- **NumPy** is the fundamental package for scientific computing with Python.

pandas - Terminology

- **SciPy** (pronounced “Sigh Pie”) is a Python-based ecosystem of open-source software for mathematics, science, and engineering.
- **Matplotlib** is a python 2D plotting library which produces publication quality figures in a variety of hardcopy formats and interactive environments across platforms.
- **Data Munging** or **Data Wrangling** means taking data that's stored in one format and changing it into another format.

pandas - Terminology

- **Cython** programming language is a superset of Python with a foreign function interface for invoking C/C++ routines and the ability to declare the static type of subroutine parameters and results, local variables, and class attributes.

pandas - Data Structures: Series

- One-dimensional array-like object containing data and labels (or index)
- Lots of ways to build a Series

```
>>> import pandas as pd
>>> s = pd.Series(list('abcdef'))
>>> s
0    a
1    b
2    c
3    d
4    e
5    f
>>> s = pd.Series([2, 4, 6, 8])
>>> s
0    2
1    4
2    6
3    8
```

Series - Working with the index

- A series index can be specified
- Single values can be selected by index
- Multiple values can be selected with multiple indexes

```
>>> s = pd.Series([2, 4, 6, 8],
index = ['f', 'a', 'c', 'e'])
>>>
>>> s
f    2
a    4
c    6
e    8
>>> s['a']
4
>>> s[['a', 'c']]
a    4
c    6
```

Series - Working with the index

- Think of a Series as a fixed-length, order dict
- However, unlike dict, index items don't have to be unique

```
>>> s2 = pd.Series(range(4),
index = list('abab'))
>>> s2
a    0
b    1
a    2
b    3
>>> s['a]
>>>
>>> s['a']
4
>>> s2['a']
a    0
a    2
>>> s2['a'][0]
0
```

Series - Operations

- Filtering
- NumPy-type operations on data

```
>>> s
f    2
a    4
c    6
e    8
>>> s[s > 4]
c    6
e    8
>>> s>4
f    False
a    False
c     True
e     True
>>> s*2
f     4
a     8
c    12
e    16
```

Series - Incomplete data

- pandas can accomodate incomplete data

```
>>> sdata = {'b':100, 'c':150, 'd':200}
>>> s = pd.Series(sdata)
>>> s
b     100
c     150
d     200
>>> s = pd.Series(sdata, list('abcd'))
>>> s
a     NaN
b     100
c     150
d     200
>>> s*2
a     NaN
b     200
c     300
d     400
```

Series - Automatic alignment

- Unlike in NumPy ndarray, data is automatically aligned

```
>>> s2 = pd.Series([1, 2, 3],
index = ['c', 'b', 'a'])
>>> s2
c    1
b    2
a    3
>>> s
a    NaN
b    100
c    150
d    200
>>> s*s2
a    NaN
b    200
c    150
d    NaN
```

Data Structures: DataFrame

- Spreadsheet-like data structure containing an order collection of columns
- Has both a row and column index
- Consider as dict of Series (with shared index)

DataFrame

Creation with dict of equal-length lists

```
>>> data = {'state': ['FL', 'FL', 'GA', 'GA', 'GA'],
            'year':  [2010, 2011, 2008, 2010, 2011],
            'pop':   [18.8, 19.1, 9.7, 9.7, 9.8]}
>>> frame = pd.DataFrame(data)
>>> frame
    pop state  year
0  18.8    FL  2010
1  19.1    FL  2011
2   9.7    GA  2008
3   9.7    GA  2010
4   9.8    GA  2011
```

DataFrame

Creation with dict of dicts

```
>>> pop_data = {'FL': {2010:18.8, 2011:19.1},
                'GA': {2008: 9.7, 2010: 9.7, 2011:9.8}}
>>> pop = pd.DataFrame(pop_data)
>>> pop
        FL   GA
2008   NaN  9.7
2010  18.8  9.7
2011  19.1  9.8
```

DataFrame

- Columns can be retrieved as Series
  - dict notation
  - attribute notation
- Rows can retrieved by position or by name (using ix attribute)

```
>>> frame['state']
0     FL
1     FL
2     GA
3     GA
4     GA
Name: state
>>> frame.describe
<bound method DataFrame.describe
of      pop state  year
0   18.8     FL  2010
1   19.1     FL  2011
2    9.7     GA  2008
3    9.7     GA  2010
4    9.8     GA  2011>
```

DataFrame

- New Columns can be added (by computatoin or direct assignment)

```
>>> frame['other'] = NaN
>>> frame
   pop state  year  other
0  18.8    FL  2010    NaN
1  19.1    FL  2011    NaN
2   9.7    GA  2008    NaN
3   9.7    GA  2010    NaN
4   9.8    GA  2011    NaN
>>> frame['calc'] = frame['pop'] * 2
>>> frame
   pop state  year  other  calc
0  18.8    FL  2010    NaN  37.6
1  19.1    FL  2011    NaN  38.2
2   9.7    GA  2008    NaN  19.4
3   9.7    GA  2010    NaN  19.4
4   9.8    GA  2011    NaN  19.6
```

DataFrame - Reindexing

- Creation of new object with the data conformed to a new index

```
>>> obj = pd.Series(['blue', 'purple', 'red'],
index=[0,2,4])
>>> obj
0      blue
2    purple
4       red
>>> obj.reindex(range(4))
0      blue
1       NaN
2    purple
3       NaN
>>> obj.reindex(range(5), fill_value='black')
0      blue
1     black
2    purple
3     black
4       red
>>> obj.reindex(range(5), method='ffill')
0      blue
1      blue
2    purple
3    purple
4       red
```

Functionality

Summarizing and Descriptive Statistics

```
>>> pop
        FL   GA
2008   NaN  9.7
2010  18.8  9.7
2011  19.1  9.8
>>> pop.sum()
FL    37.9
GA    29.2
>>> pop.mean()
FL    18.950000
GA     9.733333
>>> pop.describe()
             FL        GA
count   2.000000  3.000000
mean   18.950000  9.733333
std     0.212132  0.057735
min    18.800000  9.700000
25%    18.875000  9.700000
50%    18.950000  9.700000
75%    19.025000  9.750000
max    19.100000  9.800000
```

Functionality

Boolean indexing

```
>>> pop
        FL   GA
2008   NaN  9.7
2010  18.8  9.7
2011  19.1  9.8
>>> pop < 9.8
        FL     GA
2008  False   True
2010  False   True
2011  False  False
>>> pop[pop < 9.8] = 0
>>> pop
        FL   GA
2008   NaN  0.0
2010  18.8  0.0
2011  19.1  9.8
```

Data Loading

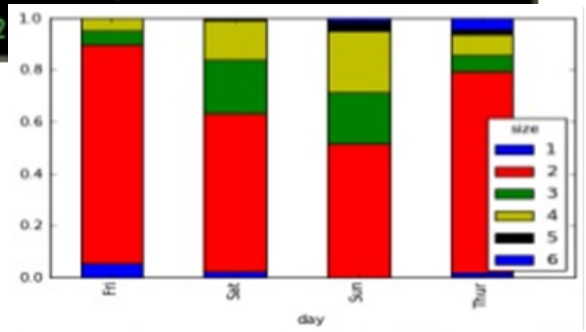
- pandas supports several ways to handle data loading
- Text file data
  - read_csv
  - read_table
- Structured data (JSON, XML, HTML)
  - works well with existing libraries
- Excel (depends upon xlrd and openpyxl packages)
- Database
  - pandas.io.sql module (read_frame)

Plotting

```
>>> tips = pd.read_csv('/users/ah6/Desktop/pandas
talk/data/tips.csv')
>>> tips.ix[:2]
   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
>>> party_counts = pd.crosstab(tips.day, tips.size)
>>> party_counts
size  1   2   3   4  5  6
day
Fri   1  16   1   1  0  0
Sat   2  53  18  13  1  0
Sun   0  39  15  18  3  1
Thur  1  48   4   5  1  3
>>> sum_by_day = party_counts.sum(1).astype(float)
```

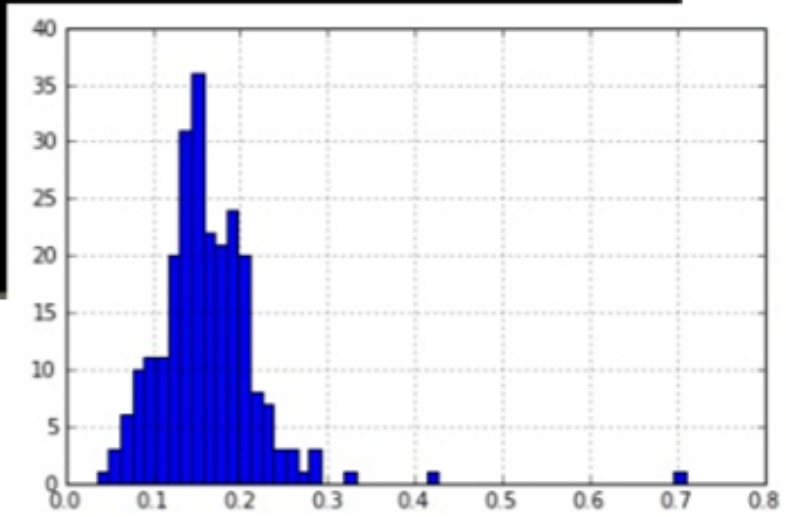
Plotting

```
>>> party_pcts = party_counts.div(sum_by_day, axis=0)
>>> party_pcts
size         1         2         3         4         5         6
day
Fri   0.052632  0.842105  0.052632  0.052632  0.000000  0.000000
Sat   0.022989  0.609195  0.206897  0.149425  0.011494  0.000000
Sun   0.000000  0.513158  0.197368  0.236842  0.039474  0.013158
Thur  0.016129  0.774194  0.064516  0.080645  0.016129  0.048387
>>> party_pcts.plot(kind='bar', stacked=True)
<matplotlib.axes.AxesSubplot at 0x6bf2
```



Plotting

```
>>> tips['tip_pct'] = tips['tip'] / tips['total_bill']
>>> tips['tip_pct'].hist(bins=50)
<matplotlib.axes.AxesSubplot at 0x6c10d30>
>>> tips['tip_pct'].describe()
count    244.000000
mean       0.160803
std        0.061072
min        0.035638
25%        0.129127
50%        0.154770
75%        0.191475
max        0.710345
```



What else?

- Data Aggregation
  - GroupBy
  - Pivot Tables
- Time Series
  - Periods/Frequencies
  - Operations with Time Series with Different Frequencies
  - Downsampling/Upsampling
  - Plotting with TimeSeries (auto-adjust scale)
- Advanced Analysis
  - Decile and Quartile Analysis
  - Signal Frontier Analysis
  - Future Contract Rolling
  - Rolling Correlation and Linear Regression

Questions?

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