PANDAS PART 1

Feb 27, 2015 – General Assembly, Santa Monica

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Python Data Analysis Library

Introduction to Pandas

- Wes McKinney started the project in **2008**
- Data structures with labeled axes supporting automatic or explicit **data alignment**
- **Data aggregation** (like summing across an axis)
- Flexible handling of **missing data**
- **SQL-like** operations on the data, similar to databases

Getting started with Pandas

Data Structures

- **Series**
  - A **one-dimensional** array-like object containing data and label

```
s = pd.Series(data=[1,2,3,4,5],\
              index=['first element','second element',\
                     'third','4th','5th element'])
```

- **DataFrame**
  - A tabular, **spreadsheet-like** data structure containing an ordered collection of columns, each of which can be a different value type.

```
df = pd.DataFrame({'state':['California','New York','Texas'],\
                   'Party':['D','D','R']})
```

Reindexing (Series)

- **Rearranges** the data according to the **new index**, introducing **missing values**, if any index value were not already present.

```
obj
b    6.5
d    7.2
c   -5.3
dtype: float64

obj2
a    NaN
b    6.5
c   -5.3
d    7.2
dtype: float64
```

```
obj = pd.Series(data=[6.5, 7.2, -5.3],\
                index=['b','d','c'])
obj2 = obj.reindex(['a','b','c','d'])
```

Reindexing (DataFrames)

```
frame = pd.DataFrame(data=np.arange(9).reshape((3,3)),\
                     index=['a','c','d'],\
                     columns=['Ohio','Texas','California'])
print frame
```

```
   Ohio  Texas  California
a     0      1           2
c     3      4           5
d     6      7           8
```

```
frame2 = frame.reindex(['a','b','c','d'])
print frame2
```

```
   Ohio  Texas  California
a     0      1           2
b   NaN    NaN         NaN
c     3      4           5
d     6      7           8
```

Dropping entries from an axis (Series)

- "***drop***" method returns a **new** object with the indicated value(s) deleted from an axis:

```
obj = pd.Series(data=[1,2,3,4],\
                index=['a','b','c','d'])
obj2 = obj.drop(['a','c'])
```

```
obj                 obj2
a    1              b    2
b    2              d    4
c    3              dtype: int64
d    4
dtype: int64
```

Dropping entries from an axis (DataFrames)

```
data = pd.DataFrame(np.arange(16).reshape((4,4)),\
                    index=['Ohio','Colorado','Utah','New York'],\
                    columns=['one','two','three','four'])
data2 = data.drop(['Colorado','Ohio'])
```

data

	one	two	three	four
Ohio	0	1	2	3
Colorado	4	5	6	7
Utah	8	9	10	11
New York	12	13	14	15

data2

	one	two	three	four
Utah	8	9	10	11
New York	12	13	14	15

Indexing, selection and filtering

Type	Description
`Obj[col_name(s)]`	Select column(s)
`Obj.ix[row(s)]`	Select row(s)
`Obj.ix[row(s), col(s)]`	Select row(s) & col(s)

Indexing, selection and filtering

```
data = pd.DataFrame(np.arange(16).reshape((4,4)),\
                    index=['Ohio','Colorado','Utah','New York'],\
                    columns=['one','two','three','four'])
```

```
data[['one','two']]
```

	one	two
Ohio	0	1
Colorado	4	5
Utah	8	9
New York	12	13

```
data.ix[['Ohio','Colorado'],['two','three']]
```

	two	three
Ohio	1	2
Colorado	5	6

Indexing, selection and filtering

```
rows = [0,1] #rows = ['Ohio','Colorado']
cols = [2] #cols = ['three']
data.ix[rows, cols]
```

	three
Ohio	2
Colorado	6

```
rows = [0,1] #rows = ['Ohio','Colorado']
cols = [2] #cols = ['three']
data.ix[:, cols]
```

?

Indexing, selection and filtering

```
data[data['three']>5]
```

	one	two	three	four
Colorado	4	5	6	7
Utah	8	9	10	11
New York	12	13	14	15

```
data.ix[data.three>5,0:3]
```

	one	two	three
Colorado	4	5	6
Utah	8	9	10
New York	12	13	14

```
data[data < 5]=0
print data
```

	one	two	three	four
Ohio	0	0	0	0
Colorado	0	5	6	7
Utah	8	9	10	11
New York	12	13	14	15

```
data.ix[data.three>5,0:3] = -1
print data
```

	one	two	three	four
Ohio	0	1	2	3
Colorado	-1	-1	-1	7
Utah	-1	-1	-1	11
New York	-1	-1	-1	15

Arithmetic and data alignment

- **df1+df2**
- **df1.add(df2, fill_value=0)**

```
df1 = pd.DataFrame(np.arange(9).reshape(3,3),\
                   columns=list('abc'),\
                   index=range(3))

df2 = pd.DataFrame(np.arange(16).reshape(4,4),\
                   columns=list('abcd'),\
                   index=range(4))
```

df1+df2

	a	b	c	d
0	0	2	4	NaN
1	7	9	11	NaN
2	14	16	18	NaN
3	NaN	NaN	NaN	NaN

df1.add(df2,fill_value=0)

	a	b	c	d
0	0	2	4	3
1	7	9	11	7
2	14	16	18	11
3	12	13	14	15

Function application and mapping

- `df.apply(f, axis)`
  - Applies function "*f*" on DataFrame "*df*" on axis "*axis*" hence, reducing the dimension of the DataFrame by +1.

- `df.applymap(f)`
  - Applies function "*f*" on every single element of the DataFrame

Function application and mapping

```
df = pd.DataFrame(np.random.randn(4,3),
                  columns=list('bde'),
                  index=['Utah','Ohio','Texas','Oregon'])
print df
```

```
               b         d         e
Utah   -1.188977  0.415385  1.703405
Ohio   -1.443891 -2.830466  0.450911
Texas   1.167887 -2.447571 -0.239753
Oregon  0.319426  1.838542 -0.059893
```

```
f = lambda x: '%.2f' % x
print df.applymap(f)
```

```
             b      d      e
Utah     -1.19   0.42   1.70
Ohio     -1.44  -2.83   0.45
Texas     1.17  -2.45  -0.24
Oregon    0.32   1.84  -0.06
```

Function application and mapping

```
f2 = lambda x: x.max()-x.min()
```

```
df.apply(f2, axis=0)
```

```
b    2.611778
d    4.669008
e    1.943158
```

```
df.apply(f2, axis=1)
```

```
Utah      2.892381
Ohio      3.281378
Texas     3.615457
Oregon    1.898435
```

Sorting and ranking

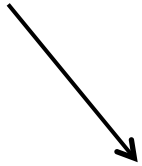
- **DataFrame**
  - *sort_index(by=[col1, col2])*
  - *sort_index(axis=1, ascending=False)*

- **Series**
  - *order()*

Sorting and ranking

```
df = pd.DataFrame({'b':[4,7,-3,2,5],
                   'a':[0,1,1,0,-1]})
```

```
df
   a  b
0  0  4
1  1  7
2  1 -3
3  0  2
4 -1  5
```



```
print df.sort_index(by=['a','b'])
```

```
   a  b
4 -1  5
3  0  2
0  0  4
2  1 -3
1  1  7
```

Missing data

- **data.dropna()**
  - Drops the NaN rows
- **data.fillna(val)**
  - Fills the NaN elements with value “val”
- **data.isnull()**
  - Returns a DataFrame with the same size but boolean values, if each element is null
- **data.notnull()**
  - Returns a DataFrame with the same size but boolean values, if each element is not null

Correlation

```
start = datetime.datetime(2000,1,1)
stop = datetime.datetime(2014,1,1)
a = pd.io.data.get_data_yahoo(['YHOO','ORCL'],start,stop)
print a.High.ORCL.corr(a.High.YHOO)
```

```
0.687492387025
```

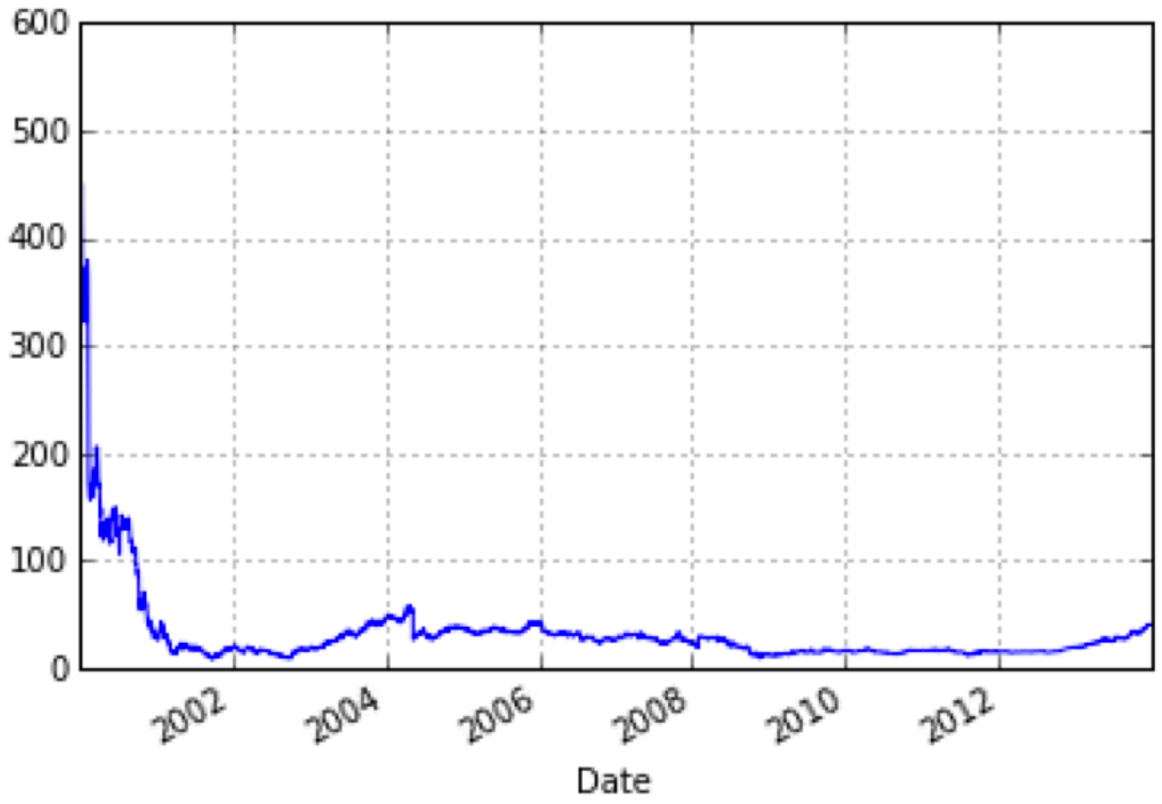
```
print a.Volume.ORCL.corr(a.Volume.YHOO)
```

```
0.133853803954
```

Plotting Series

```
a.High.YHOO.plot()
```

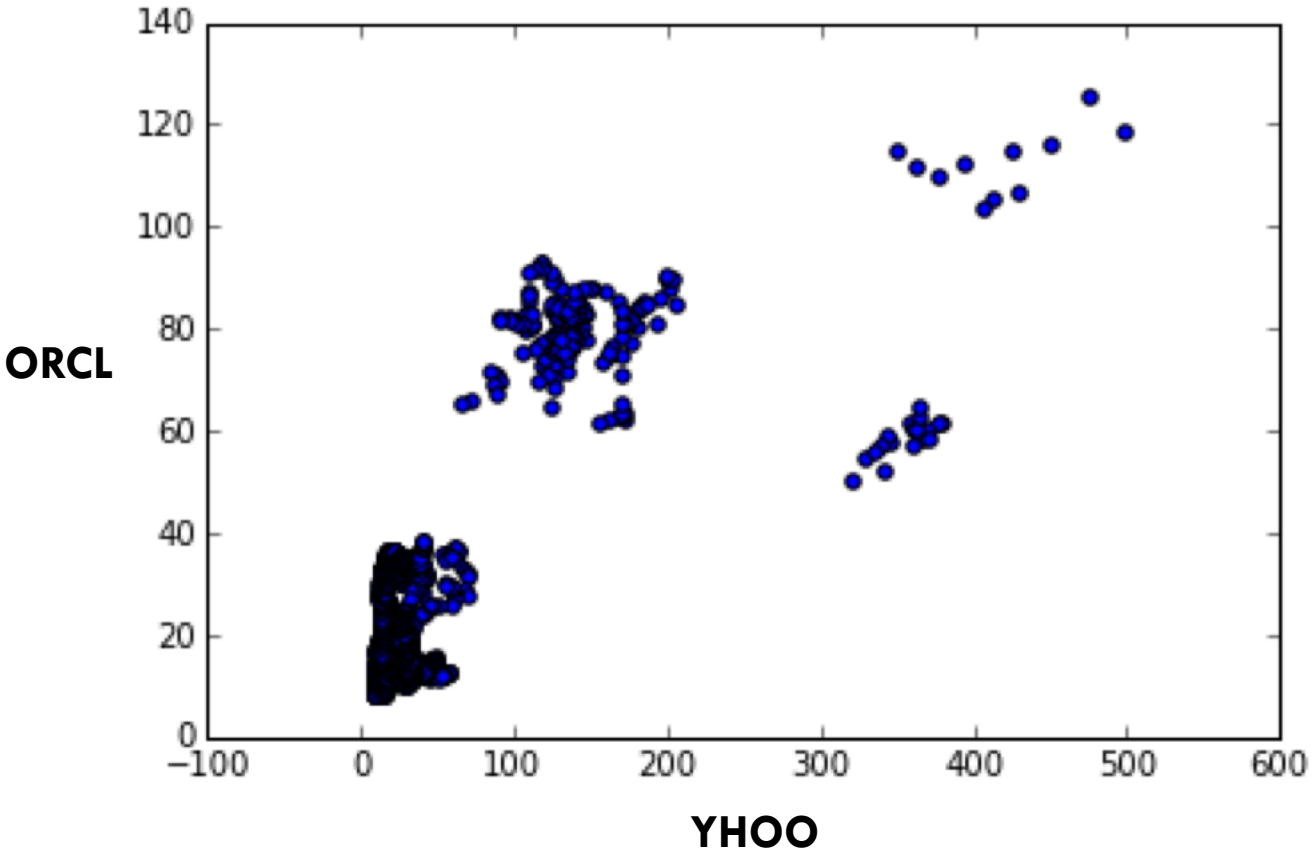
```
<matplotlib.axes._subplots.AxesSubplot at 0x10e766e10>
```



Scatter Plot of two Series

```
plt.scatter(a.High.YHOO,a.High.ORCL)
```

```
<matplotlib.collections.PathCollection at 0x10eda84d0>
```



Data Loading, Storage and File Formats

Reading and writing to file

- **read_csv**('file_name.csv', nrows=10)
  - Reads the top 10 rows of a csv file

- **to_csv**('file_name.csv', sep='|', na_rep='NULL')
  - Writes a DataFrame object into a file, using the separator '*sep*' and replacing NaN values with '*na_rep*'
  - *sys.stdout* as the name of the file will direct python to write to console as the output

Reading Excel files

- xls_file = ExcelFile('sample.xls')
- table = xls_file.parse('Sheet1')

```
xl = pd.ExcelFile('Curriculum.xlsx')
sylabus = xl.parse('Sylab')
print sylabus.head()
```

```
   Lecture#       Date                                                Topics
0         1 2015-02-11                                 Intro to Data Science
1         2 2015-02-13                                       Intro to Python
2         3 2015-02-18                                                Numpy
3         4 2015-02-20                                           SQL/Python
4         5 2015-02-25  Pandas - 1. Getting Started, 2. Data Loading, ...
```

```
xl = pd.read_excel('Curriculum.xlsx')
print xl.head()
```

```
   Lecture#       Date                                                Topics
0         1 2015-02-11                                 Intro to Data Science
1         2 2015-02-13                                       Intro to Python
```

Interacting with HTML and APIs

```
import requests
url = 'https://api.github.com/repos/pydata/pandas/milestones/28/labels'
resp = requests.get(url)
data = resp.json()
print data
```

```
[{u'url': u'https://api.github.com/repos/pydata/pandas/labels/Bug', u'col
pi.github.com/repos/pydata/pandas/labels/Enhancement', u'color': u'4E9A06
thub.com/repos/pydata/pandas/labels/Refactor', u'color': u'FCE94F', u'nam
pos/pydata/pandas/labels/Build%20problem', u'color': u'75507B', u'name': u
epos/pydata/pandas/labels/Docs', u'color': u'3465A4', u'name': u'Docs'},
labels/Groupby', u'color': u'729FCF', u'name': u'Groupby'}, {u'url': u'ht
0IO', u'color': u'06909A', u'name': u'Data IO'}, {u'url': u'https://api.g
```

Interacting with Databases

```
import sqlite3
query = """CREATE TABLE test (a VARCHAR(20),
        b VARCHAR(20), c REAL, d INTEGER);"""
con = sqlite3.connect(':memory:')
con.execute(query)
con.commit()
data = [('Atlanta','Georgia',1.25,6),\
        ('Sacramento','California',1.7,5),\
        ('Los Angeles','California',1.5,3)]
stmt = "INSERT INTO test VALUES(?,?,?,?)"
con.executemany(stmt, data)
con.commit()
```

Interacting with Databases

Traditional way:

```
cursor = con.execute('select * from test')
rows = cursor.fetchall()
for row in rows:
    print row
```

```
(u'Atlanta', u'Georgia', 1.25, 6)
(u'Sacramento', u'California', 1.7, 5)
(u'Los Angeles', u'California', 1.5, 3)
```

Pandas way:

```
print pd.read_sql('select * from test',con)
```

```
             a           b     c  d
0      Atlanta     Georgia  1.25  6
1   Sacramento  California  1.70  5
2  Los Angeles  California  1.50  3
```

Interacting with Databases

`pd.io.sql.*`

http://pandas.pydata.org/pandas-docs/dev/io.html

Clean, Transform, Merge, Reshape

Combining Datasets

- **pandas.merge**
  - **Connecting rows based on a key or keys**
  - **Similar to '*join*' in SQL**
- **pandas.concat**
  - **Glues or stacks together objects along an axis**
- **combine_first**
  - **Enables splicing together overlapping data to fill in missing values in one object with values from another.**

Database-style DataFrame Merges

```
df1 = pd.DataFrame({'key':list('bbacaab'),\
                    'data1':range(7)})
df2 = pd.DataFrame({'key':list('abd'),\
                    'data2':range(3)})
print 'df1\n',df1
print 'df2\n',df2
print pd.merge(df1, df2)
```

df1

	data1	key
0	0	b
1	1	b
2	2	a
3	3	c
4	4	a
5	5	a
6	6	b

df2

	data2	key
0	0	a
1	1	b
2	2	d

	data1	key	data2
0	0	b	1
1	1	b	1
2	6	b	1
3	2	a	0
4	4	a	0
5	5	a	0

Database-style DataFrame Merges

```
pd.merge(df1,
         df2,
         on='key1',
         how='inner')
```

Merges the two dataframes on key '*key*' using the "how" argument. In this case it is *inner* join.

Concatenating along an axis

```
df1 = pd.DataFrame(np.random.randn(3,4), columns=['a','b','c','d'])
df2 = pd.DataFrame(np.random.randn(2,3), columns=['b','d','a'])
print 'df1\n',df1
print 'df2\n',df2
print pd.concat([df1, df2])
```

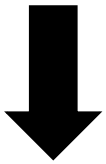
Concatenation

df1

	a	b	c	d
0	-0.811979	0.387790	0.134205	-0.425209
1	0.569688	-0.406175	0.553706	-1.318497
2	-0.477620	-0.077196	-0.663000	-0.396227

df2

	b	d	a
0	-0.533802	-1.283319	0.196668
1	-0.271687	-1.788313	1.336632



	a	b	c	d
0	-0.811979	0.387790	0.134205	-0.425209
1	0.569688	-0.406175	0.553706	-1.318497
2	-0.477620	-0.077196	-0.663000	-0.396227
0	0.196668	-0.533802	NaN	-1.283319
1	1.336632	-0.271687	NaN	-1.788313

Removing duplicates

```
data = pd.DataFrame({'k1':['one']*3+['two']*4,\
                     'k2':[1,1,2,3,3,4,4]})
print 'data\n',data
print 'data_depulicated\n',data.drop_duplicates()
```

data

	k1	k2
0	one	1
1	one	1
2	one	2
3	two	3
4	two	3
5	two	4
6	two	4

data_depulicated

	k1	k2
0	one	1
2	one	2
3	two	3
5	two	4

Replacing Values

```
data = pd.Series([1, -999, 2, -999, -1000, 3])
print 'data\n',data
data_replaced = data.replace(-999,np.nan)
print 'data_replaced\n',data_replaced
```

```
data
0        1
1     -999
2        2
3     -999
4    -1000
5        3
dtype: int64
```

```
data_replaced
0        1
1      NaN
2        2
3      NaN
4    -1000
5        3
dtype: float64
```

Group by

```
import pandas as pd
import numpy as np
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)})
```

```
grouped = df.groupby(['A'])
```

```
grouped.groups
```

```
{'bar': [1, 3, 5], 'foo': [0, 2, 4, 6, 7]}
```

Aggregation

```
import pandas as pd
import numpy as np
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)})
```

```
grouped = df.groupby(['A'])
```

```
print grouped.agg(np.sum)
```

```
            C         D
A
bar  0.212190 -0.235641
foo  2.657326 -1.143714
```

Plotting

http://matplotlib.org/gallery.html