04a_exploratory_pandas

June 24, 2015

1 Getting Started with Exploratory Data Analysis

3 important Python packages 1. NumPy for efficient computation on arrays 2. Pandas for data analysis 3. Matplotlib for plotting in the notebook

```
In [2]: import os
        import numpy as np
        import pandas as pd
        import matplotlib.pyplot as plt
        %matplotlib inline
```

1.1 Pandas

Python module for manipulating tabular data

1.2 `pandas`

- Provides python a `DataFrame`
- Structured manipulation tools
- Built on top of `numpy`
- Huge growth from 2011-2012
- Very **efficient**
- Great for *medium* data

Resources

- pandas.pydata.org
- Python for Data Analysis by Wes McKinney
- Data Wrangling Kung Fu with Pandas by Wes McKinney
- Cheat sheet by Quandl

1.2.1 Why `pandas`?

> 80% of the effort in data analysis is spent cleaning data. Hadley Wickham

Efficency

- Different views of data
- Tidy data by Hadley Wickham

Raw data is often in the wrong format

- How often to you download an array ready for array-oriented computing?
- e.g. `scikit-learn` interface

Storage may be best in a different format

- Sparse representations
- Upload to database

1.3 Simple example using the Walrus data

1.3.1 Reading a CSV file as text

```
In [3]: filename = os.path.join('Walrus_Data','Walruses.csv')
        f = open(filename, 'r')
        lines = f.readlines()
        lines[:10]
```

```
Out[3]: ['Walrus,DateTimeUTC,Xcoord,Ycoord,Behav,Longitude,Latitude\r\n',
         '271,5/31/2008 19:25,"95,616.95","-528,324.60",1.009,-167.9560949,65.24871506\r\n',
         '271,6/1/2008 3:24,"84,741.71","-511,653.75",1.0005,-168.1779869,65.40121711\r\n',
         '271,6/1/2008 11:24,"71,834.45","-491,176.95",1.00625,-168.4443605,65.58796906\r\n',
         '271,6/1/2008 19:24,"65,275.80","-478,935.62",1.02025,-168.5802843,65.6991429\r\n',
         '271,6/2/2008 3:24,"69,343.24","-473,948.91",1.00775,-168.4892154,65.74298362\r\n',
         '271,6/2/2008 11:24,"72,634.53","-457,308.67",1,-168.4082441,65.89142326\r\n',
         '271,6/2/2008 19:24,"73,253.86","-425,586.14",1,-168.3764825,66.17566325\r\n',
         '271,6/3/2008 3:24,"79,223.97","-401,784.87",1.00975,-168.2291622,66.38754225\r\n',
         '271,6/3/2008 11:24,"77,052.23","-382,920.49",1.20225,-168.2658694,66.5571914\r\n']
```

1.3.2 Creating a DataFrame

```
df = pd.read_csv(filename)
print df
```

Why store it this way?

- Different type
- Different metric

1.3.3 Converting the DateTimeUTC Column

NumPy datetime64 dtype

1.3.4 Converting the Xcoord and Ycoord

thousands=‘,’

```
In [4]: ?pd.read_csv
```

```
In [6]: filename = os.path.join('Walrus_Data','Walruses.csv')
        df = pd.read_csv(filename, parse_dates=[1],
                         thousands=',')
        df.head(5)
```

```
Out[6]:    Walrus         DateTimeUTC    Xcoord     Ycoord    Behav   Longitude  \
        0     271 2008-05-31 19:25:00  95616.95 -528324.60  1.00900 -167.956095
        1     271 2008-06-01 03:24:00  84741.71 -511653.75  1.00050 -168.177987
        2     271 2008-06-01 11:24:00  71834.45 -491176.95  1.00625 -168.444360
        3     271 2008-06-01 19:24:00  65275.80 -478935.62  1.02025 -168.580284
        4     271 2008-06-02 03:24:00  69343.24 -473948.91  1.00775 -168.489215
```

```
    Latitude
0  65.248715
1  65.401217
2  65.587969
3  65.699143
4  65.742984
```

```
In [10]: df.describe()
```

```
Out[10]:            Walrus         Xcoord         Ycoord       Behav   Longitude  \
         count  454.000000     454.000000     454.000000  454.000000  454.000000
         mean   281.759912  192488.612731   26570.073264    1.432807 -153.571969
         std     19.599907  192785.195478  225551.527159    0.391243   59.339289
         min    271.000000 -473786.460000 -528324.600000    1.000000 -179.603905
         25%    271.000000   73500.247500  -74775.707500    1.056688 -167.684144
         50%    271.000000  269021.360000  102471.775000    1.296250 -162.206341
         75%    281.000000  291732.090000  212473.185000    1.866563 -161.616675
         max    322.000000  504837.070000  246443.380000    1.996250  179.723232

                  Latitude
         count  454.000000
         mean    70.085316
         std      1.933906
         min     65.248715
         25%     69.287408
         50%     70.793950
         75%     71.576913
         max     72.041307
```

1.3.5 Indexing

```
In [45]: df[2:10]
```

```
Out[45]:   Walrus         DateTimeUTC    Xcoord     Ycoord    Behav   Longitude  \
         2    271 2008-06-01 11:24:00  71834.45 -491176.95  1.00625 -168.444360
         3    271 2008-06-01 19:24:00  65275.80 -478935.62  1.02025 -168.580284
         4    271 2008-06-02 03:24:00  69343.24 -473948.91  1.00775 -168.489215
         5    271 2008-06-02 11:24:00  72634.53 -457308.67  1.00000 -168.408244
         6    271 2008-06-02 19:24:00  73253.86 -425586.14  1.00000 -168.376483
         7    271 2008-06-03 03:24:00  79223.97 -401784.87  1.00975 -168.229162
         8    271 2008-06-03 11:24:00  77052.23 -382920.49  1.20225 -168.265869
         9    271 2008-06-03 19:24:00  73380.11 -379615.25  1.24225 -168.346486

             Latitude
         2  65.587969
         3  65.699143
         4  65.742984
         5  65.891423
         6  66.175663
         7  66.387542
         8  66.557191
         9  66.587727
```

```
In [7]: print(len(df))
        df[-5:]
```

```
454
```

```
Out[7]:      Walrus         DateTimeUTC     Xcoord     Ycoord    Behav   Longitude  \
        449     322 2009-07-05 12:11:00 -465471.95  169270.91  1.32675  177.051563
        450     322 2009-07-05 20:11:00 -473786.46  174848.10  1.52075  176.794183
        451     322 2009-07-06 04:11:00 -462401.15  175580.80  1.47450  177.097679
        452     322 2009-07-06 12:11:00 -449812.23  178045.34  1.47200  177.424821
        453     322 2009-07-06 20:11:00 -443963.94  180789.20  1.46775  177.568265

              Latitude
        449  71.071287
        450  71.104176
        451  71.132315
        452  71.177357
        453  71.212108
```

1.3.6 Hierarchical columns

```
In [8]: wd = df.pivot(index='DateTimeUTC', columns='Walrus') #row, column, values (optional)
        wd[:7]
```

```
Out[8]:                        Xcoord                      Ycoord                  \
        Walrus                    271        281 322          271          281 322
        DateTimeUTC
        2008-05-31 19:25:00  95616.95        NaN NaN -528324.60          NaN NaN
        2008-06-01 03:24:00  84741.71        NaN NaN -511653.75          NaN NaN
        2008-06-01 11:24:00  71834.45        NaN NaN -491176.95          NaN NaN
        2008-06-01 19:24:00  65275.80        NaN NaN -478935.62          NaN NaN
        2008-06-02 02:25:00       NaN   65600.95 NaN        NaN -417464.74 NaN
        2008-06-02 03:24:00  69343.24        NaN NaN -473948.91          NaN NaN
        2008-06-02 10:24:00       NaN   61574.27 NaN        NaN -421676.30 NaN

                               Behav                Longitude                  \
        Walrus                   271    281 322          271          281 322
        DateTimeUTC
        2008-05-31 19:25:00  1.00900    NaN NaN -167.956095          NaN NaN
        2008-06-01 03:24:00  1.00050    NaN NaN -168.177987          NaN NaN
        2008-06-01 11:24:00  1.00625    NaN NaN -168.444360          NaN NaN
        2008-06-01 19:24:00  1.02025    NaN NaN -168.580284          NaN NaN
        2008-06-02 02:25:00      NaN  1.544 NaN         NaN -168.541792 NaN
        2008-06-02 03:24:00  1.00775    NaN NaN -168.489215          NaN NaN
        2008-06-02 10:24:00      NaN  1.567 NaN         NaN -168.633333 NaN

                              Latitude
        Walrus                     271        281 322
        DateTimeUTC
        2008-05-31 19:25:00  65.248715        NaN NaN
        2008-06-01 03:24:00  65.401217        NaN NaN
        2008-06-01 11:24:00  65.587969        NaN NaN
        2008-06-01 19:24:00  65.699143        NaN NaN
        2008-06-02 02:25:00        NaN  66.250190 NaN
        2008-06-02 03:24:00  65.742984        NaN NaN
        2008-06-02 10:24:00        NaN  66.213262 NaN
```

```
In [48]: wd['Behav'][:5]
```

```
Out[48]: Walrus                    271    281  322
         DateTimeUTC
         2008-05-31 19:25:00  1.00900    NaN  NaN
         2008-06-01 03:24:00  1.00050    NaN  NaN
         2008-06-01 11:24:00  1.00625    NaN  NaN
         2008-06-01 19:24:00  1.02025    NaN  NaN
         2008-06-02 02:25:00      NaN  1.544  NaN
```

```
In [11]: longLat = df[['Walrus', 'Longitude', 'Latitude']]
         longLat[2:10:2]
```

```
Out[11]:    Walrus   Longitude   Latitude
         2     271 -168.444360  65.587969
         4     271 -168.489215  65.742984
         6     271 -168.376483  66.175663
         8     271 -168.265869  66.557191
```

```
In [15]: wd[['Longitude', 'Latitude']][::50]
```

```
Out[15]:                       Longitude                              Latitude            \
         Walrus                      271         281         322         271        281
         DateTimeUTC
         2008-05-31 19:25:00 -167.956095         NaN         NaN   65.248715        NaN
         2008-06-09 18:24:00         NaN -169.854440         NaN         NaN  66.761239
         2008-06-18 02:24:00         NaN -170.786003         NaN         NaN  66.934435
         2008-07-02 11:24:00 -161.826253         NaN         NaN   70.555427        NaN
         2008-07-19 03:24:00 -158.004690         NaN         NaN   71.153361        NaN
         2008-08-04 19:24:00 -161.169659         NaN         NaN   71.449231        NaN
         2008-08-21 11:24:00 -162.127242         NaN         NaN   71.795703        NaN
         2008-09-07 03:24:00 -161.886692         NaN         NaN   71.839187        NaN
         2009-06-19 04:11:00         NaN         NaN -163.064091         NaN        NaN
         2009-07-05 20:11:00         NaN         NaN  176.794183         NaN        NaN


         Walrus                     322
         DateTimeUTC
         2008-05-31 19:25:00        NaN
         2008-06-09 18:24:00        NaN
         2008-06-18 02:24:00        NaN
         2008-07-02 11:24:00        NaN
         2008-07-19 03:24:00        NaN
         2008-08-04 19:24:00        NaN
         2008-08-21 11:24:00        NaN
         2008-09-07 03:24:00        NaN
         2009-06-19 04:11:00  71.241689
         2009-07-05 20:11:00  71.104176
```

```
In [9]: wd['Behav'][281].values
```

```
Out[9]: array([     nan,      nan,      nan,      nan,  1.544  ,      nan,
                1.567  ,      nan,  1.62975,      nan,  1.70475,      nan,
                1.82125,      nan,  1.8405 ,      nan,  1.80675,      nan,
                1.73125,      nan,  1.7165 ,      nan,  1.69875,      nan,
                1.62175,      nan,  1.654  ,      nan,  1.70825,      nan,
                1.24925,      nan,  1.0765 ,      nan,  1.0415 ,      nan,
                1.048  ,       nan,  1.04925,       nan,  1.0425 ,       nan,
                1.05   ,       nan,  1.16075,       nan,  1.3745 ,       nan,
                1.38275,       nan,  1.3365 ,       nan,  1.30775,       nan,
                1.29125,       nan,  1.30925,       nan,  1.24925,       nan,
                1.2215 ,       nan,  1.255  ,       nan,  1.36875,       nan,
                1.4405 ,       nan,  1.4865 ,       nan,  1.50425,       nan,
                1.52275,       nan,  1.5245 ,       nan,  1.53975,       nan,
                1.53825,       nan,  1.53775,       nan,  1.52325,       nan,
                1.49275,       nan,  1.47225,       nan,  1.42675,       nan,
                1.3735 ,       nan,  1.29825,       nan,  1.22075,       nan,
                1.14375,       nan,  1.0705 ,       nan,  1.05375,       nan,
                1.165  ,       nan,  1.32725,       nan,  1.4355 ,       nan,
                1.4635 ,       nan,  1.45175,       nan,  1.429  ,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,       nan,      nan,       nan,      nan,       nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan,        nan,        nan,
                    nan,        nan,        nan,        nan])
```

1.3.7 Extracting with a Condition

- Extracting Walrus 271 from the table

```
In [18]: df[df.Walrus == 271][:5]
```

```
Out[18]:    Walrus         DateTimeUTC    Xcoord     Ycoord    Behav   Longitude  \
         0     271 2008-05-31 19:25:00  95616.95 -528324.60  1.00900 -167.956095
         1     271 2008-06-01 03:24:00  84741.71 -511653.75  1.00050 -168.177987
         2     271 2008-06-01 11:24:00  71834.45 -491176.95  1.00625 -168.444360
         3     271 2008-06-01 19:24:00  65275.80 -478935.62  1.02025 -168.580284
         4     271 2008-06-02 03:24:00  69343.24 -473948.91  1.00775 -168.489215

             Latitude
         0  65.248715
         1  65.401217
         2  65.587969
         3  65.699143
         4  65.742984
```

```
In [21]: wd.columns
```

```
Out[21]: MultiIndex(levels=[[u'Xcoord', u'Ycoord', u'Behav', u'Longitude', u'Latitude'], [271, 281, 322
                    labels=[[0, 0, 0, 1, 1, 1, 2, 2, 2, 3, 3, 3, 4, 4, 4], [0, 1, 2, 0, 1, 2, 0, 1, 2, 
                    names=[None, u'Walrus'])
```

```
In [32]: wd[[('Latitude', 271), ('Longitude', 271)]][:5]
```

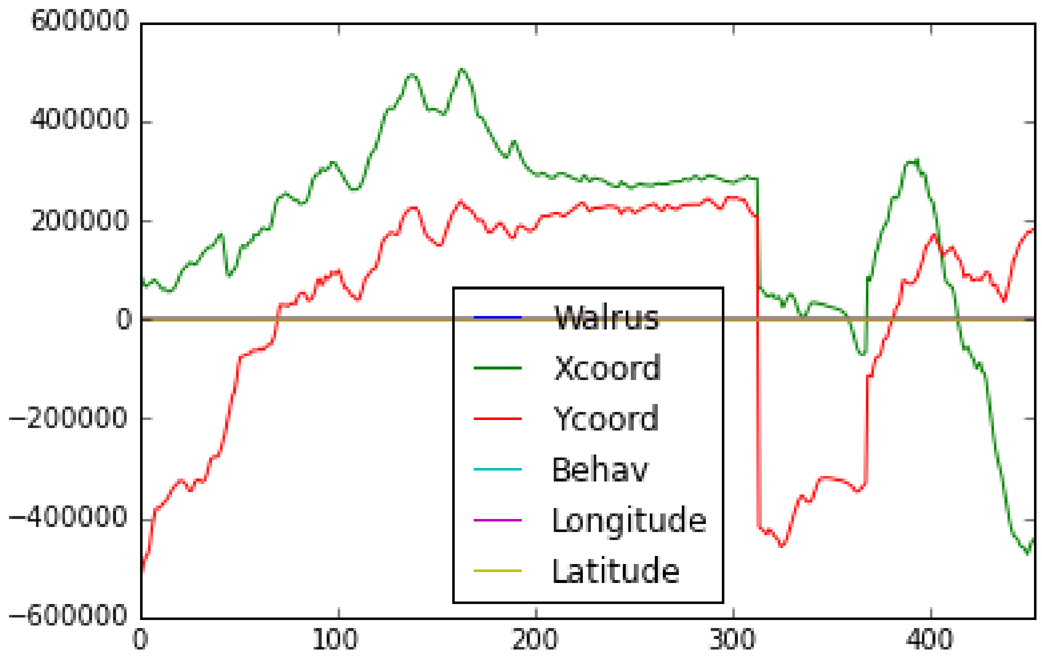
```
Out[32]:                       Latitude   Longitude
         Walrus                     271         271
         DateTimeUTC
         2008-05-31 19:25:00  65.248715 -167.956095
         2008-06-01 03:24:00  65.401217 -168.177987
         2008-06-01 11:24:00  65.587969 -168.444360
         2008-06-01 19:24:00  65.699143 -168.580284
         2008-06-02 02:25:00        NaN         NaN
```

1.4 Simple Plotting

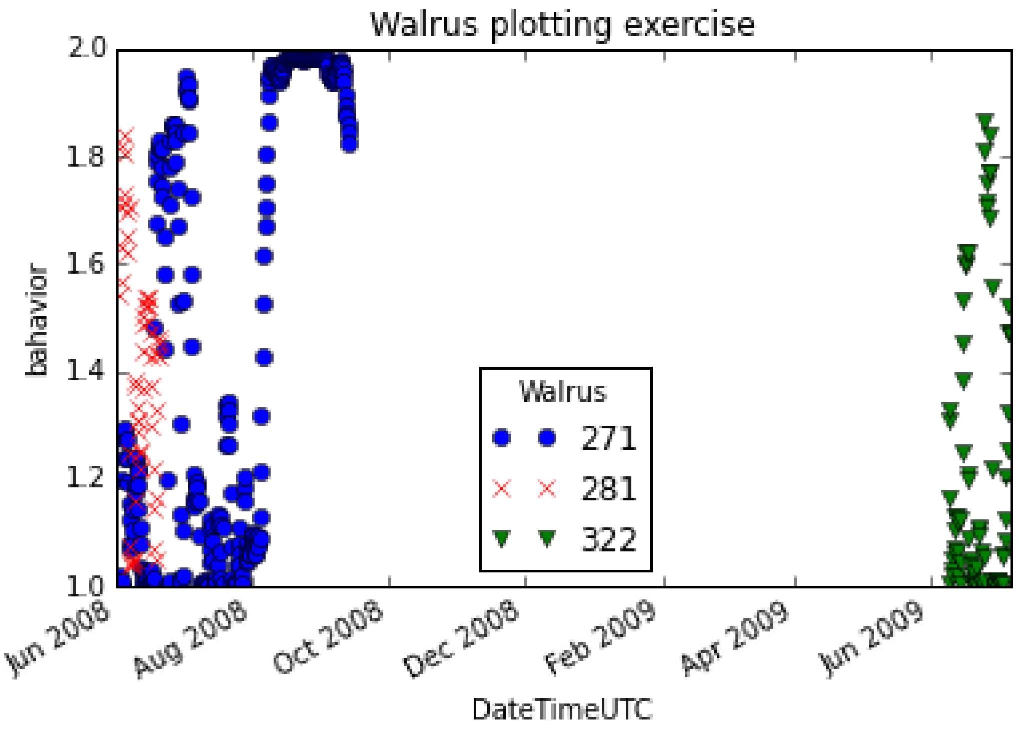
- Plot the behavior of each walrus over time

```
In [34]: df.plot()
```

```
Out[34]: <matplotlib.axes._subplots.AxesSubplot at 0x1057dcd50>
```



```
In [44]: wd['Behav'].plot(style=['bo','rx','gv'])
         plt.ylabel('bahavior')
         plt.title('Walrus plotting exercise')
         plt.savefig('walrus_behav.pdf')
         plt.show()
```



```
In [61]: !ls
```

```
01_exploratory_pandas.ipynb                  06_CSV_to_NetCDF_Solution.ipynb
01_introduction-IPython-notebook.ipynb          Walrus_Data
01_introduction-IPython-notebook.pdf         data_overview.png
01_introduction-IPython-notebook_files          ipython-notebook-keyboard.png
02_Data_Transfer.pdf                         ipython-notebook-sharing.png
03_HPC_File_Systems.pdf                         ipython-notebook.png
04_python_reading-plotting.ipynb         rc_logo.png
05_Data_Conversion_Cleaning.pdf                 traditional_python.png
06_CSV_to_NetCDF_Exercise.ipynb                 walrus_behav.png
```

1.4.1 Importing the image into the Markdown

```
In [ ]:
```