

# Notebook

March 7, 2019

## 1 Key Python Libraries for Working with Data

In this lesson I'm just going to describe the main libraries that we'll see when we work with data in Python.

### 1.1 Numpy

Numpy is the first library we work with. By convention, it's imported with `import numpy as np`. Numpy really provides two things to our workflow:

1. Math that goes faster than unadorned Python could do it—which is important when you're doing statistics, because under the hood computational stats can take a lot of calculations.
2. Convenient data structures as well as functions that operate on them.

Let's talk about number 2 for a minute. Numpy provides special numeric types which you don't need to worry about, but also the array, which is like a Python list, but with special properties that make it more useful for mathematical operations. The other main Python data libraries tend to assume that you're working with arrays, or something that can be converted with arrays—but lists can be pretty seamlessly converted to arrays, so that's ok.

The other great part of number 2 is that numpy lets you do math on entire arrays as well as individual numbers. For example:

```
In [1]: import numpy as np
        mynums = np.array([1, 2, 3, 4, 5])
        print(mynums * 2)
```

```
[ 2  4  6  8 10]
```

See what I did there? I just multiplied the entire array by 2 in one go. You couldn't do that with ordinary Python lists.

```
In [2]: print([1, 2, 3, 4, 5] * 2)
```

```
[1, 2, 3, 4, 5, 1, 2, 3, 4, 5]
```

Numpy also provides a lot of convenience functions, for example, for calculating mean and standard deviation. We won't go through them here, but just will introduce them as they come up in other lessons. If you're curious about the menu of options provided, however, check out the documentation:

- [mathematical functions](#)
- [random sampling](#)
- [statistical functionality](#)

Numpy is a *huge* package with tons more stuff, and also really complicated features to handle things like multidimensional data. But you won't need to worry about that stuff.

## 1.2 Pandas

Pandas is a library that helps us work with structured data (like Excel-spreadsheet-type data), which is what we'll be focusing on for the statistics work in this course. By convention, we import pandas as pd.

Pandas is the library you'll use to read in data from things like CSV and Excel spreadsheets. (Note: it's usually better to just export an Excel spreadsheet, or google docs, or whatever else, to CSV format and then ingest it in Python from there. Excel can be a bit of a monster to deal with.)

The Pandas data format is called a DataFrame. You can think of it as Python's version of a spreadsheet. Let's look at one. I'll just pull down a CSV of data from my own book to play with.

```
In [3]: import pandas as pd
        df = pd.read_csv("http://rulelaw.net/downloads/rol-scores.csv")
```

We can look at the first few rows of data with the head() method on a dataframe

```
In [4]: df.head()
```

```
Out[4]:
```

	State	Pop. In Millions for 2012	RoLScore	elec_pros	pol_plur	\
0	Albania	3.2	42.60	8	10	
1	Argentina	41.1	51.94	11	15	
2	Australia	22.7	73.28	12	15	
3	Austria	8.4	73.15	12	15	
4	Bangladesh	154.7	31.57	9	11	

	free_expr	assoc_org	per_auto	2012GDP	hprop	hfisc	hbiz	hlab	\
0	13	8	9	1.264810e+10	30	92.6	81.0	49.0	
1	14	11	13	4.755020e+11	15	64.3	60.1	47.4	
2	16	12	15	1.532410e+12	90	66.4	95.5	83.5	
3	16	12	15	3.947080e+11	90	51.1	73.6	80.4	
4	9	8	9	1.163550e+11	20	72.7	68.0	51.9	

	htra	hinv
0	79.8	65
1	67.6	40
2	86.2	80
3	86.8	85
4	54.0	55

Incidentally, I apologize for the fact that the headings of this table might not be properly aligned with the data below them on the website. I'm working on this problem. But you can look in the lessons github repo, and it'll be better formatted.

You can treat a Pandas DataFrame kind of like a dictionary where the keys are the columns. For example:

```
In [5]: df["State"]
```

```
Out[5]: 0          Albania
        1          Argentina
        2          Australia
        3          Austria
        4          Bangladesh
        5          Belgium
        6          Bolivia
        7  Bosnia and Herzegovina
        8          Botswana
        9          Brazil
       10          Bulgaria
       11          Burkina Faso
       12          Cambodia
       13          Cameroon
       14          Canada
       15          Chile
       16          China
       17          Colombia
       18          Cote d'Ivoire
       19          Croatia
       20          Czech Republic
       21          Denmark
       22          Dominican Republic
       23          Ecuador
       24          Egypt
       25          El Salvador
       26          Estonia
       27          Ethiopia
       28          Finland
       29          France
       ...
       61          Pakistan
       62          Panama
       63          Peru
       64          Philippines
       65          Poland
       66          Portugal
       67          Romania
       68          Russia
       69          Senegal
```

```

70             Serbia
71         Sierra Leone
72             Singapore
73             Slovenia
74         South Africa
75         South Korea
76             Spain
77         Sri Lanka
78             Sweden
79         Tanzania
80             Tunisia
81             Turkey
82             Uganda
83             Ukraine
84         United Kingdom
85         United States
86             Uruguay
87         Uzbekistan
88         Venezuela
89             Zambia
90             Zimbabwe
Name: State, Length: 91, dtype: object

```

You can also create new columns by assigning things to them, often by applying mathematical transformations to other columns. For example, we could create a column in our current dataframe that does a bunch of silly math to another.

(Under the hood, Pandas columns use Numpy arrays with some extra juice on them, so we can do the same stuff we did before like multiplying a whole column with something in one fell swoop.)

```
In [6]: df["stupid math"] = (df["RoLScore"] / 2) + df["per_auto"]
```

```
In [7]: df.head()
```

```

Out[7]:
   State  Pop. In Millions for 2012  RoLScore  elec_pros  pol_plur \
0  Albania                3.2      42.60         8        10
1  Argentina             41.1      51.94        11        15
2  Australia             22.7      73.28        12        15
3   Austria              8.4      73.15        12        15
4 Bangladesh          154.7      31.57         9        11

   free_expr  assoc_org  per_auto  2012GDP  hprop  hfisc  hbiz  hlab \
0         13          8         9  1.264810e+10    30   92.6  81.0  49.0
1         14         11        13  4.755020e+11    15   64.3  60.1  47.4
2         16         12        15  1.532410e+12    90   66.4  95.5  83.5
3         16         12        15  3.947080e+11    90   51.1  73.6  80.4
4          9          8         9  1.163550e+11    20   72.7  68.0  51.9

   htra  hin  stupid math

```

0	79.8	65	30.300
1	67.6	40	38.970
2	86.2	80	51.640
3	86.8	85	51.575
4	54.0	55	24.785

We can also access subtables of a DataFrame by passing a list of columns.

```
In [8]: df[["State", "RoLScore"]].head()
```

```
Out[8]:
```

	State	RoLScore
0	Albania	42.60
1	Argentina	51.94
2	Australia	73.28
3	Austria	73.15
4	Bangladesh	31.57

There's lots more to do with Pandas as well. I've assigned an introduction from DataCamp for this week in [chapter 2 of this lesson](#).

### 1.3 Matplotlib/Seaborn

Matplotlib is the Python library that handles data visualization. For the most part, however, we won't be working with matplotlib directly. It has a really bad API. Like, terrible.

Instead, we'll be using seaborn. Again, the convention among Python data people is to import it using a short name: `import seaborn as sns`

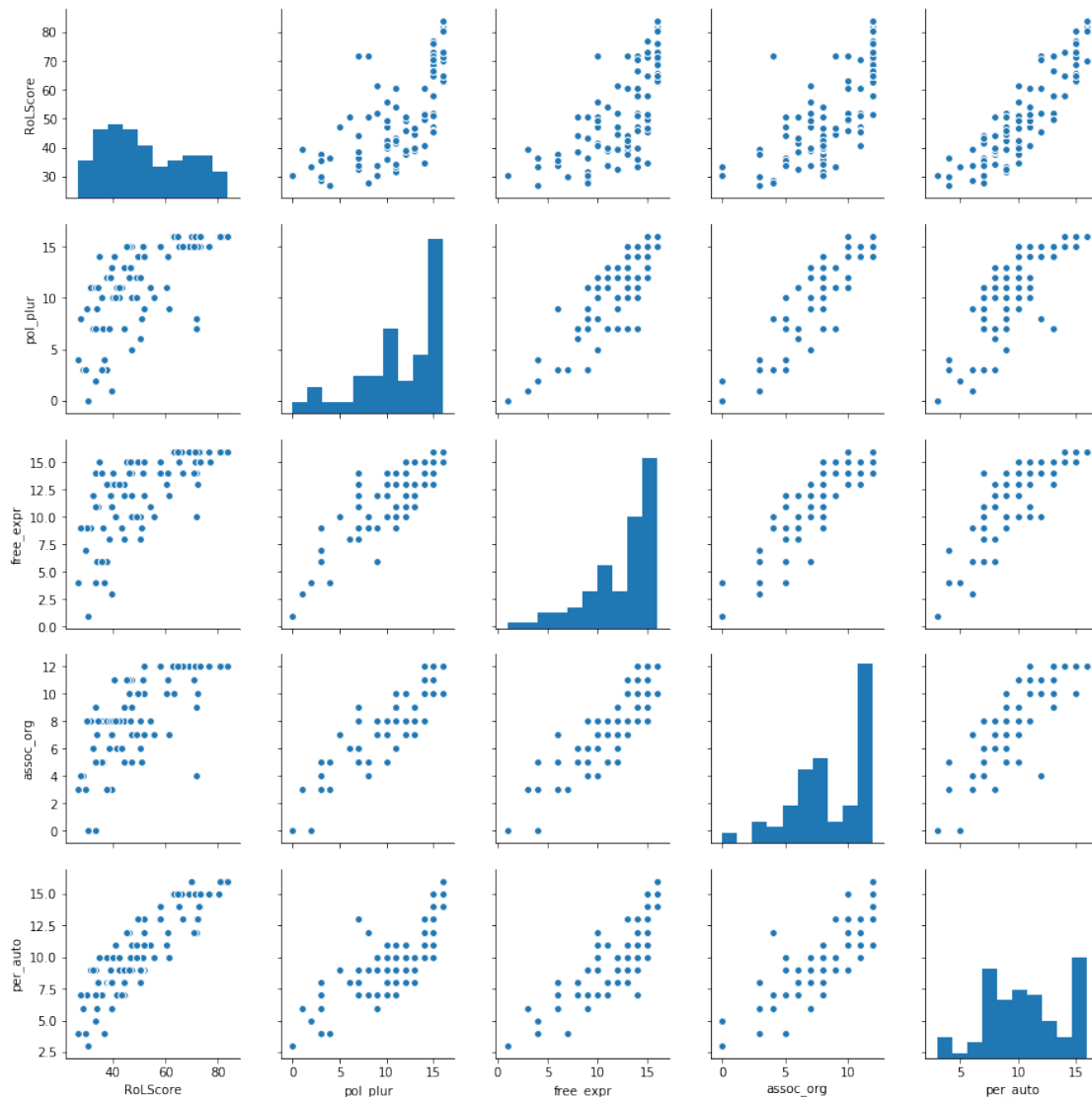
Seaborn provides us with some very fancy and easy to use plots. It can handle Pandas columns, Numpy arrays, ordinary Python lists, you name it.

I won't show more than one example here because there's another lesson covering several visualizations, but check out the official seaborn [example gallery](#) for the cool stuff you can do.

Also, before you can get plots to show up in jupyter notebooks, you probably have to do `%matplotlib inline` to tell the notebook to render plots within the webpage.

```
In [9]: import seaborn as sns
        %matplotlib inline
        sns.pairplot(df[["RoLScore", "pol_plur", "free_expr", "assoc_org", "per_auto"]])
```

```
Out[9]: <seaborn.axisgrid.PairGrid at 0x1108aeda0>
```



## 1.4 Statsmodels and/or Scipy

Statsmodels and Scipy are libraries that provide a bunch of statistical functionality. For example, if you want to do a hypothesis test, you'd go there. Statsmodels has more robust functionality, more or less, but also pretty terrible documentation, weird rules about what you have to import, etc. I'll probably grab bits and pieces of each library as we go forward into our stats section.

Here's an example from statsmodels. Don't worry too much about it for now.

```
In [10]: import statsmodels.formula.api as smf
         regression = smf.ols('RoLScore ~ assoc_org + per_auto + hprop', data=df).fit()
         print(regression.summary())
```

OLS Regression Results

=====

```

Dep. Variable:          RoLScore    R-squared:          0.880
Model:                  OLS         Adj. R-squared:      0.876
Method:                 Least Squares   F-statistic:        212.4
Date:                   Fri, 25 Jan 2019   Prob (F-statistic):  6.49e-40
Time:                   23:48:52         Log-Likelihood:     -283.38
No. Observations:      91             AIC:                574.8
Df Residuals:          87             BIC:                584.8
Df Model:               3
Covariance Type:       nonrobust

```

```

=====
              coef      std err          t      P>|t|      [0.025      0.975]
-----
Intercept      12.1298        2.084        5.821      0.000        7.988       16.271
assoc_org      -0.2617        0.406       -0.644      0.521       -1.070        0.546
per_auto        2.6070        0.492        5.298      0.000        1.629        3.585
hprop          0.2985        0.040        7.386      0.000        0.218        0.379
=====
Omnibus:                0.049    Durbin-Watson:          2.109
Prob(Omnibus):          0.976    Jarque-Bera (JB):        0.031
Skew:                   -0.030    Prob(JB):                0.984
Kurtosis:               2.931    Cond. No.                200.
=====

```

Warnings:

[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.