



2030ICT
Introduction to Big Data Analytics

Lab 02 – Data preparation

Trimester 2 - 2019

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1. Pandas

Pandas is a Python library that makes handling tabular data easier. Since we're doing data science - this is something we'll use from time to time!

It's one of three libraries you'll encounter repeatedly in the field of data science:

Pandas

Introduces "Data Frames" and "Series" that allow you to slice and dice rows and columns of information.

NumPy

Usually you'll encounter "NumPy arrays", which are multi-dimensional array objects. It is easy to create a Pandas DataFrame from a NumPy array, and Pandas DataFrames can be cast as NumPy arrays. NumPy arrays are mainly important because of...

Scikit_Learn

The machine learning library we'll use throughout this course is scikit_learn, or sklearn, and it generally takes NumPy arrays as its input.

So, a typical thing to do is to load, clean, and manipulate your input data using Pandas. Then convert your Pandas DataFrame into a NumPy array as it's being passed into some Scikit_Learn function. That conversion can often happen automatically.

Let's start by loading some comma-separated value data using Pandas into a DataFrame:

```
In [1]: %matplotlib inline
import numpy as np
import pandas as pd

df = pd.read_csv("PastHires.csv")
df.head()
```

Out[1]:

	Years Experience	Employed?	Previous employers	Level of Education	Top-tier school	Interned	Hired
0	10	Y	4	BS	N	N	Y
1	0	N	0	BS	Y	Y	Y
2	7	N	6	BS	N	N	N
3	2	Y	1	MS	Y	N	Y
4	20	N	2	PhD	Y	N	N

head() is a handy way to visualize what you've loaded. You can pass it an integer to see some specific number of rows at the beginning of your DataFrame:

```
In [2]: df.head(10)
```

Out[2]:

	Years Experience	Employed?	Previous employers	Level of Education	Top-tier school	Interned	Hired
0	10	Y	4	BS	N	N	Y
1	0	N	0	BS	Y	Y	Y
2	7	N	6	BS	N	N	N
3	2	Y	1	MS	Y	N	Y
4	20	N	2	PhD	Y	N	N
5	0	N	0	PhD	Y	Y	Y
6	5	Y	2	MS	N	Y	Y
7	3	N	1	BS	N	Y	Y
8	15	Y	5	BS	N	N	Y
9	0	N	0	BS	N	N	N

You can also view the end of your data with tail():

```
In [3]:
```

```
df.tail(4)
```

```
Out[3]:
```

	Years Experience	Employed?	Previous employers	Level of Education	Top-tier school	Interned	Hired
9	0	N	0	BS	N	N	N
10	1	N	1	PhD	Y	N	N
11	4	Y	1	BS	N	Y	Y
12	0	N	0	PhD	Y	N	Y

We often talk about the "shape" of your DataFrame. This is just its dimensions. This particular CSV file has 13 rows with 7 columns per row:

```
In [4]:
```

```
df.shape
```

```
Out[4]:
```

```
(13, 7)
```

The total size of the data frame is the rows * columns:

```
In [5]:
```

```
df.size
```

```
Out[5]:
```

```
91
```

The len() function gives you the number of rows in a DataFrame:

```
In [6]:
```

```
len(df)
```

```
Out[6]:
```

```
13
```

If your DataFrame has named columns (in our case, extracted automatically from the first row of a .csv file,) you can get an array of them back:

```
In [7]:
```

```
df.columns
```

```
Out[7]:
```

```
Index(['Years Experience', 'Employed?', 'Previous employers',
       'Level of Education', 'Top-tier school', 'Interned', 'Hired'],
      dtype='object')
```

Extracting a single column from your DataFrame looks like this - this gives you back a "Series" in Pandas:

```
In [8]:
```

```
df['Hired']
```

```
Out[8]:
```

```
0      Y
1      Y
2      N
3      Y
4      N
5      Y
6      Y
7      Y
8      Y
9      N
10     N
11     Y
12     Y
Name: Hired, dtype: object
```

You can also extract a given range of rows from a named column, like so:

```
In [9]:
```

```
df['Hired'][:5]
```

```
Out[9]:
```

```
0      Y
1      Y
2      N
3      Y
4      N
Name: Hired, dtype: object
```

Or even extract a single value from a specified column / row combination:

```
In [10]:
```

```
df['Hired'][5]
```

```
Out[10]:
```

```
'Y'
```

To extract more than one column, you pass in a list of column names instead of a single one:

```
In [11]: df[['Years Experience', 'Hired']]
```

```
Out[11]:
```

	Years Experience	Hired
0	10	Y
1	0	Y
2	7	N
3	2	Y
4	20	N
5	0	Y
6	5	Y
7	3	Y
8	15	Y
9	0	N
10	1	N
11	4	Y
12	0	Y

You can also extract specific ranges of rows from more than one column, in the way you'd expect:

```
In [12]: df[['Years Experience', 'Hired']][:5]
```

```
Out[12]:
```

	Years Experience	Hired
0	10	Y
1	0	Y
2	7	N
3	2	Y
4	20	N

Sorting your DataFrame by a specific column looks like this:

```
In [13]: df.sort_values(['Years Experience'])
```

```
Out[13]:
```

	Years Experience	Employed?	Previous employers	Level of Education	Top-tier school	Interned	Hired
1	0	N	0	BS	Y	Y	Y
5	0	N	0	PhD	Y	Y	Y
9	0	N	0	BS	N	N	N
12	0	N	0	PhD	Y	N	Y
10	1	N	1	PhD	Y	N	N
3	2	Y	1	MS	Y	N	Y
7	3	N	1	BS	N	Y	Y
11	4	Y	1	BS	N	Y	Y
6	5	Y	2	MS	N	Y	Y
2	7	N	6	BS	N	N	N
0	10	Y	4	BS	N	N	Y
8	15	Y	5	BS	N	N	Y
4	20	N	2	PhD	Y	N	N

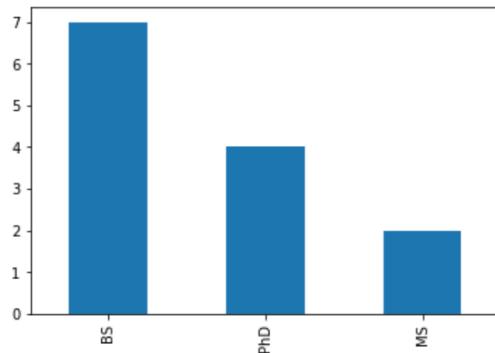
You can break down the number of unique values in a given column into a Series using value_counts() - this is a good way to understand the distribution of your data:

```
In [14]: degree_counts = df['Level of Education'].value_counts()  
degree_counts
```

```
Out[14]: BS    7  
PhD   4  
MS    2  
Name: Level of Education, dtype: int64
```

Pandas even makes it easy to plot a Series or DataFrame - just call plot():

```
In [15]: degree_counts.plot(kind='bar')  
Out[15]: <matplotlib.axes._subplots.AxesSubplot at 0x28f6d2b0240>
```



2. Series

The first main data type we will learn about for pandas is the Series data type. Let's import Pandas and explore the Series object.

A Series is very similar to a NumPy array (in fact it is built on top of the NumPy array object). What differentiates the NumPy array from a Series, is that a Series can have axis labels, meaning it can be indexed by a label, instead of just a number location. It also doesn't need to hold numeric data, it can hold any arbitrary Python Object.

Let's explore this concept through some examples:

```
In [2]: import numpy as np  
import pandas as pd
```

2.1 Creating a Series

You can convert a list, numpy array, or dictionary to a Series:

```
In [3]: labels = ['a','b','c']  
my_list = [10,20,30]  
arr = np.array([10,20,30])  
d = {'a':10,'b':20,'c':30}
```

Using Lists

```
In [4]: pd.Series(data=my_list)
```

```
Out[4]: 0    10  
1    20  
2    30  
dtype: int64
```

```
In [5]: pd.Series(data=my_list,index=labels)
```

```
Out[5]: a    10  
b    20  
c    30  
dtype: int64
```

```
In [6]: pd.Series(my_list,labels)
```

```
Out[6]: a    10  
b    20  
c    30  
dtype: int64
```

NumPy Arrays

```
In [7]: pd.Series(arr)
```

```
Out[7]: 0    10
         1    20
         2    30
        dtype: int64
```

```
In [8]: pd.Series(arr,labels)
```

```
Out[8]: a    10
         b    20
         c    30
        dtype: int64
```

Dictionary

```
In [9]: pd.Series(d)
```

```
Out[9]: a    10
         b    20
         c    30
        dtype: int64
```

2.2 Data in Series

A pandas Series can hold a variety of object types:

```
In [10]: pd.Series(data=labels)
```

```
Out[10]: 0    a
         1    b
         2    c
        dtype: object
```

```
In [11]: # Even functions (although unlikely that you will use this)
          pd.Series([sum,print,len])
```

```
Out[11]: 0      <built-in function sum>
         1      <built-in function print>
         2      <built-in function len>
        dtype: object
```

2.3 Using an index

The key to using a Series is understanding its index. Pandas makes use of these index names or numbers by allowing for fast look ups of information (works like a hash table or dictionary).

Let's see some examples of how to grab information from a Series. Let us create two series, ser1 and ser2:

```
In [12]: ser1 = pd.Series([1,2,3,4],index = ['USA', 'Germany', 'USSR', 'Japan'])
```

```
In [13]: ser1
```

```
Out[13]: USA      1
          Germany  2
          USSR     3
          Japan    4
         dtype: int64
```

```
In [14]: ser2 = pd.Series([1,2,5,4],index = ['USA', 'Germany','Italy', 'Japan'])
```

```
In [15]: ser2
```

```
Out[15]: USA      1
          Germany  2
          Italy    5
          Japan    4
         dtype: int64
```

```
In [16]: ser1['USA']
```

```
Out[16]: 1
```

Operations are then also done based off of index:

```
In [17]: ser1 + ser2
```

```
Out[17]: Germany    4.0
          Italy      NaN
          Japan     8.0
          USA      2.0
          USSR      NaN
dtype: float64
```

Let's stop here for now and move on to DataFrames, which will expand on the concept of Series!

3. DataFrames

DataFrames are the workhorse of pandas and are directly inspired by the R programming language. We can think of a DataFrame as a bunch of Series objects put together to share the same index. Let's use pandas to explore this topic!

```
In [183]: import pandas as pd
import numpy as np
```

```
In [184]: from numpy.random import randn
np.random.seed(101)
```

```
In [185]: df = pd.DataFrame(randn(5,4),index='A B C D E'.split(),columns='W X Y Z'.split())
```

```
In [186]: df
```

```
Out[186]:
```

	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	-0.319318	-0.848077	0.605965
C	-2.018168	0.740122	0.528813	-0.589001
D	0.188695	-0.758872	-0.933237	0.955057
E	0.190794	1.978757	2.605967	0.683509

3.1 Selection and Indexing

Let's learn the various methods to grab data from a DataFrame

```
In [187]: df['W']
```

```
Out[187]: A    2.706850
          B    0.651118
          C   -2.018168
          D    0.188695
          E    0.190794
Name: W, dtype: float64
```

```
In [188]: # Pass a list of column names
df[['W','Z']]
```

```
Out[188]:
```

	W	Z
A	2.706850	0.503826
B	0.651118	0.605965
C	-2.018168	-0.589001
D	0.188695	0.955057
E	0.190794	0.683509

```
In [189]: # SQL Syntax (NOT RECOMMENDED!)
df.W
```

```
Out[189]: A    2.706850
          B    0.651118
          C   -2.018168
          D    0.188695
          E    0.190794
Name: W, dtype: float64
```

DataFrame Columns are just Series

```
In [190]: type(df['W'])
```

```
Out[190]: pandas.core.series.Series
```

Creating a new column:

```
In [191]: df['new'] = df['W'] + df['Y']

In [192]: df

Out[192]:
   W      X      Y      Z    new
A  2.706850  0.628133  0.907969  0.503826  3.614819
B  0.651118 -0.319318 -0.848077  0.605965 -0.196959
C -2.018168  0.740122  0.528813 -0.589001 -1.489355
D  0.188695 -0.758872 -0.933237  0.955057 -0.744542
E  0.190794  1.978757  2.605967  0.683509  2.796762
```

Removing Columns

```
In [193]: # Return a new DataFrame with the 'new'
# column dropped
df.drop('new',axis=1)
```

```
Out[193]:
   W      X      Y      Z
A  2.706850  0.628133  0.907969  0.503826
B  0.651118 -0.319318 -0.848077  0.605965
C -2.018168  0.740122  0.528813 -0.589001
D  0.188695 -0.758872 -0.933237  0.955057
E  0.190794  1.978757  2.605967  0.683509
```

```
In [194]: # Not inplace unless specified!
df
```

```
Out[194]:
   W      X      Y      Z    new
A  2.706850  0.628133  0.907969  0.503826  3.614819
B  0.651118 -0.319318 -0.848077  0.605965 -0.196959
C -2.018168  0.740122  0.528813 -0.589001 -1.489355
D  0.188695 -0.758872 -0.933237  0.955057 -0.744542
E  0.190794  1.978757  2.605967  0.683509  2.796762
```

```
In [195]: # Drop the 'new' column of DataFrame itself
df.drop('new',axis=1,inplace=True)
```

```
In [196]: df
```

```
Out[196]:
   W      X      Y      Z
A  2.706850  0.628133  0.907969  0.503826
B  0.651118 -0.319318 -0.848077  0.605965
C -2.018168  0.740122  0.528813 -0.589001
D  0.188695 -0.758872 -0.933237  0.955057
E  0.190794  1.978757  2.605967  0.683509
```

Can also drop rows this way:

```
In [197]: df.drop('E',axis=0)
```

```
Out[197]:
   W      X      Y      Z
A  2.706850  0.628133  0.907969  0.503826
B  0.651118 -0.319318 -0.848077  0.605965
C -2.018168  0.740122  0.528813 -0.589001
D  0.188695 -0.758872 -0.933237  0.955057
```

Can also drop rows this way:

```
In [197]: df.drop('E',axis=0)
```

```
Out[197]:
   W      X      Y      Z
A  2.706850  0.628133  0.907969  0.503826
B  0.651118 -0.319318 -0.848077  0.605965
C -2.018168  0.740122  0.528813 -0.589001
D  0.188695 -0.758872 -0.933237  0.955057
```

Selecting Rows

```
In [198]: df.loc['A']
```

```
Out[198]:
   W      X      Y      Z
A  2.706850  0.628133  0.907969  0.503826
   Name: A, dtype: float64
```

Or select based off of position instead of label

```
In [199]: df.iloc[2]
```

```
Out[199]:
   W      X      Y      Z
C -2.018168  0.740122  0.528813 -0.589001
   Name: C, dtype: float64
```

Selecting subset of rows and columns

```
In [200]: df.loc['B', 'Y']
```

```
Out[200]: -0.84807698340363147
```

```
In [201]: df.loc[['A', 'B'], ['W', 'Y']]
```

```
Out[201]:
```

	W	Y
A	2.706850	0.907969
B	0.651118	-0.848077

3.2 Conditional Selection

An important feature of pandas is conditional selection using bracket notation, very similar to numpy:

```
In [202]: df
```

```
Out[202]:
```

	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	-0.319318	-0.848077	0.605965
C	-2.018168	0.740122	0.528813	-0.589001
D	0.188695	-0.758872	-0.933237	0.955057
E	0.190794	1.978757	2.605967	0.683509

```
In [203]: df>0
```

```
Out[203]:
```

	W	X	Y	Z
A	True	True	True	True
B	True	False	False	True
C	False	True	True	False
D	True	False	False	True
E	True	True	True	True

```
In [204]: df[df>0]
```

```
Out[204]:
```

	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	NaN	NaN	0.605965
C	NaN	0.740122	0.528813	NaN
D	0.188695	NaN	NaN	0.955057
E	0.190794	1.978757	2.605967	0.683509

```
In [205]: df[df['W']>0]
```

```
Out[205]:
```

	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	-0.319318	-0.848077	0.605965
D	0.188695	-0.758872	-0.933237	0.955057
E	0.190794	1.978757	2.605967	0.683509

```
In [206]: df[df['W']>0]['Y']
```

```
Out[206]: A    0.907969  
B   -0.848077  
D   -0.933237  
E    2.605967  
Name: Y, dtype: float64
```

```
In [207]: df[df['W']>0][['Y', 'X']]
```

```
Out[207]:
```

	Y	X
A	0.907969	0.628133
B	-0.848077	-0.319318
D	-0.933237	-0.758872
E	2.605967	1.978757

For two conditions you can use | and & with parenthesis:

```
In [208]: df[(df['W']>0) & (df['Y'] > 1)]
```

```
Out[208]:
```

	W	X	Y	Z
E	0.190794	1.978757	2.605967	0.683509

3.3 More Index Details

Let's discuss some more features of indexing, including resetting the index or setting it something else. We'll also talk about index hierarchy!

```
In [209]: df
```

```
Out[209]:
```

	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	-0.319318	-0.848077	0.605965
C	-2.018168	0.740122	0.528813	-0.589001
D	0.188695	-0.758872	-0.933237	0.955057
E	0.190794	1.978757	2.605967	0.683509

```
In [210]: # Reset to default 0,1...n index  
df.reset_index()
```

```
Out[210]:
```

	index	W	X	Y	Z
0	A	2.706850	0.628133	0.907969	0.503826
1	B	0.651118	-0.319318	-0.848077	0.605965
2	C	-2.018168	0.740122	0.528813	-0.589001
3	D	0.188695	-0.758872	-0.933237	0.955057
4	E	0.190794	1.978757	2.605967	0.683509

```
In [211]: newind = 'CA NY WY OR CO'.split()
```

```
In [212]: df['States'] = newind
```

```
In [213]: df
```

```
Out[213]:
```

	W	X	Y	Z	States
A	2.706850	0.628133	0.907969	0.503826	CA
B	0.651118	-0.319318	-0.848077	0.605965	NY
C	-2.018168	0.740122	0.528813	-0.589001	WY
D	0.188695	-0.758872	-0.933237	0.955057	OR
E	0.190794	1.978757	2.605967	0.683509	CO

```
In [214]: df.set_index('States')
```

```
Out[214]:
```

States	W	X	Y	Z
CA	2.706850	0.628133	0.907969	0.503826
NY	0.651118	-0.319318	-0.848077	0.605965
WY	-2.018168	0.740122	0.528813	-0.589001
OR	0.188695	-0.758872	-0.933237	0.955057
CO	0.190794	1.978757	2.605967	0.683509

```
In [215]: df
```

```
Out[215]:
```

	W	X	Y	Z	States
A	2.706850	0.628133	0.907969	0.503826	CA
B	0.651118	-0.319318	-0.848077	0.605965	NY
C	-2.018168	0.740122	0.528813	-0.589001	WY
D	0.188695	-0.758872	-0.933237	0.955057	OR
E	0.190794	1.978757	2.605967	0.683509	CO

```
In [216]: df.set_index('States', inplace=True)

In [218]: df

Out[218]:
      W      X      Y      Z
States
CA  2.706850  0.628133  0.907969  0.503826
NY  0.651118 -0.319318 -0.848077  0.605965
WY -2.018168  0.740122  0.528813 -0.589001
OR  0.188695 -0.758872 -0.933237  0.955057
CO  0.190794  1.978757  2.605967  0.683509
```

3.4 Multi-Index and Index Hierarchy

Let us go over how to work with Multi-Index, first we'll create a quick example of what a Multi-Indexed DataFrame would look like:

```
In [253]: # Index Levels
outside = ['G1', 'G1', 'G1', 'G2', 'G2', 'G2']
inside = [1, 2, 3, 1, 2, 3]
hier_index = list(zip(outside, inside))
hier_index = pd.MultiIndex.from_tuples(hier_index)

In [254]: hier_index

Out[254]: MultiIndex(levels=[['G1', 'G2'], [1, 2, 3]],
                     labels=[[0, 0, 0, 1, 1, 1], [0, 1, 2, 0, 1, 2]])

Out[254]: MultiIndex(levels=[['G1', 'G2'], [1, 2, 3]],
                     labels=[[0, 0, 0, 1, 1, 1], [0, 1, 2, 0, 1, 2]])

In [257]: df = pd.DataFrame(np.random.randn(6,2), index=hier_index, columns=['A', 'B'])
df

Out[257]:
      A      B
1  0.153661  0.167638
G1 2 -0.765930  0.962299
3  0.902826 -0.537909
1 -1.549671  0.435253
G2 2  1.259904 -0.447898
3  0.266207  0.412580
```

Now let's show how to index this! For index hierarchy we use `df.loc[]`, if this was on the columns axis, you would just use normal bracket notation `df[]`. Calling one level of the index returns the sub-dataframe:

```
In [260]: df.loc['G1']

Out[260]:
      A      B
1  0.153661  0.167638
2 -0.765930  0.962299
3  0.902826 -0.537909

In [263]: df.loc['G1'].loc[1]

Out[263]: A    0.153661
           B    0.167638
           Name: 1, dtype: float64

In [265]: df.index.names

Out[265]: FrozenList([None, None])
```

```
In [266]: df.index.names = ['Group', 'Num']
```

```
In [267]: df
```

```
Out[267]:
```

Group	Num	A	B
	1	0.153661	0.167638
G1	2	-0.765930	0.962299
	3	0.902826	-0.537909
	1	-1.549671	0.435253
G2	2	1.259904	-0.447898
	3	0.266207	0.412580

```
In [270]: df.xs('G1')
```

```
Out[270]:
```

Num	A	B
1	0.153661	0.167638
2	-0.765930	0.962299
3	0.902826	-0.537909

```
In [271]: df.xs(['G1', 1])
```

```
Out[271]: A      0.153661
B      0.167638
Name: (G1, 1), dtype: float64
```

```
In [273]: df.xs(1, level='Num')
```

```
Out[273]:
```

Group	A	B
G1	0.153661	0.167638
G2	-1.549671	0.435253

4. Missing Data

Let's show a few convenient methods to deal with Missing Data in pandas:

```
In [1]: import numpy as np
import pandas as pd
```

```
In [9]: df = pd.DataFrame({'A':[1,2,np.nan],
                           'B':[5,np.nan,np.nan],
                           'C':[1,2,3]})
```

```
In [10]: df
```

```
Out[10]:
```

	A	B	C
0	1.0	5.0	1
1	2.0	NaN	2
2	NaN	NaN	3

```
In [12]: df.dropna()
```

```
Out[12]:
```

	A	B	C
0	1.0	5.0	1

```
In [13]: df.dropna(axis=1)
```

```
Out[13]:
```

	C
0	1
1	2
2	3

```
In [14]: df.dropna(thresh=2)
```

```
Out[14]:
```

	A	B	C
0	1.0	5.0	1
1	2.0	NaN	2


```
In [15]: df.fillna(value='FILL VALUE')
```

```
Out[15]:
```

	A	B	C
0	1	5	1
1	2	FILL VALUE	2
2	FILL VALUE	FILL VALUE	3


```
In [17]: df['A'].fillna(value=df['A'].mean())
```

```
Out[17]:
```

	A
0	1.0
1	2.0
2	1.5

Name: A, dtype: float64

5. GroupBy

The groupby method allows you to group rows of data together and call aggregate functions

```
In [31]: import pandas as pd
# Create dataframe
data = {'Company': ['GOOG', 'GOOG', 'MSFT', 'MSFT', 'FB', 'FB'],
        'Person': ['Sam', 'Charlie', 'Amy', 'Vanessa', 'Carl', 'Sarah'],
        'Sales': [200, 120, 340, 124, 243, 350]}
```



```
In [32]: df = pd.DataFrame(data)
```



```
In [33]: df
```

```
Out[33]:
```

	Company	Person	Sales
0	GOOG	Sam	200
1	GOOG	Charlie	120
2	MSFT	Amy	340
3	MSFT	Vanessa	124
4	FB	Carl	243
5	FB	Sarah	350

Now you can use the .groupby() method to group rows together based off of a column name. For instance let's group based off of Company. This will create a DataFrameGroupBy object:

```
In [34]: df.groupby('Company')
```

```
Out[34]: <pandas.core.groupby.DataFrameGroupBy object at 0x113014128>
```

You can save this object as a new variable:

```
In [35]: by_comp = df.groupby("Company")
```

And then call aggregate methods off the object:

```
In [36]: by_comp.mean()
```

```
Out[36]:
```

Company	Sales
FB	296.5
GOOG	160.0
MSFT	232.0

```
In [37]: df.groupby('Company').mean()
```

```
Out[37]:
```

Company	Sales
FB	296.5
GOOG	160.0
MSFT	232.0

More examples of aggregate methods:

In [38]: `by_comp.std()`

Out[38]:

Company		
FB	75.660426	
GOOG	56.568542	
MSFT	152.735065	

In [39]: `by_comp.min()`

Out[39]:

Person Sales		
Company		
FB	Carl	243
GOOG	Charlie	120
MSFT	Amy	124

In [40]: `by_comp.max()`

Out[40]:

Person Sales		
Company		
FB	Sarah	350
GOOG	Sam	200
MSFT	Vanessa	340

In [41]: `by_comp.count()`

Out[41]:

Person Sales		
Company		
FB	2	2
GOOG	2	2
MSFT	2	2

In [42]: `by_comp.describe()`

Out[42]:

Sales		
Company		
FB	count	2.000000
FB	mean	296.500000
FB	std	75.660426
FB	min	243.000000
FB	25%	269.750000
FB	50%	296.500000
FB	75%	323.250000
FB	max	350.000000
GOOG	count	2.000000
GOOG	mean	160.000000
GOOG	std	56.568542
GOOG	min	120.000000
GOOG	25%	140.000000
GOOG	50%	160.000000
GOOG	75%	180.000000
GOOG	max	200.000000
GOOG	count	2.000000
GOOG	mean	232.000000
GOOG	std	152.735065

```
In [43]: by_comp.describe().transpose()
```

```
Out[43]:
```

	Company				FB				GOOGL				
	count	mean	std	min	25%	50%	75%	max	count	mean	...	75%	max
Sales	2.0	296.5	75.660426	243.0	269.75	296.5	323.25	350.0	2.0	160.0	...	180.0	200.0

1 rows × 24 columns

```
In [44]: by_comp.describe().transpose()['GOOG']
```

```
Out[44]:
```

	count	mean	std	min	25%	50%	75%	max
Sales	2.0	160.0	56.568542	120.0	140.0	160.0	180.0	200.0

6. Merging, Joining and Concatenating

There are 3 main ways of combining DataFrames together: Merging, Joining and Concatenating. In this lecture we will discuss these 3 methods with examples.

6.1 Concatenation

Example DataFrame

```
In [3]: import pandas as pd
```

```
In [4]: df1 = pd.DataFrame({'A': ['A0', 'A1', 'A2', 'A3'],
                           'B': ['B0', 'B1', 'B2', 'B3'],
                           'C': ['C0', 'C1', 'C2', 'C3'],
                           'D': ['D0', 'D1', 'D2', 'D3']},
                           index=[0, 1, 2, 3])
```

```
In [5]: df2 = pd.DataFrame({'A': ['A4', 'A5', 'A6', 'A7'],
                           'B': ['B4', 'B5', 'B6', 'B7'],
                           'C': ['C4', 'C5', 'C6', 'C7'],
                           'D': ['D4', 'D5', 'D6', 'D7']},
                           index=[4, 5, 6, 7])
```

```
In [6]: df3 = pd.DataFrame({'A': ['A8', 'A9', 'A10', 'A11'],
                           'B': ['B8', 'B9', 'B10', 'B11'],
                           'C': ['C8', 'C9', 'C10', 'C11'],
                           'D': ['D8', 'D9', 'D10', 'D11']},
                           index=[8, 9, 10, 11])
```

```
In [7]: df1
```

```
Out[7]:
```

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3

```
In [8]: df2
```

```
Out[8]:
```

	A	B	C	D
4	A4	B4	C4	D4
5	A5	B5	C5	D5
6	A6	B6	C6	D6
7	A7	B7	C7	D7

```
In [12]: df3
```

```
Out[12]:
```

	A	B	C	D
8	A8	B8	C8	D8
9	A9	B9	C9	D9
10	A10	B10	C10	D10
11	A11	B11	C11	D11

Concatenation basically glues together DataFrames. Keep in mind that dimensions should match along the axis you are concatenating on. You can use `pd.concat` and pass in a list of DataFrames to concatenate together:

```
In [10]: pd.concat([df1,df2,df3])
```

```
Out[10]:
```

	A	B	C	D
0	A0	B0	C0	D0
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3
4	A4	B4	C4	D4
5	A5	B5	C5	D5
6	A6	B6	C6	D6
7	A7	B7	C7	D7
8	A8	B8	C8	D8
9	A9	B9	C9	D9
10	A10	B10	C10	D10
11	A11	B11	C11	D11

```
In [18]: pd.concat([df1,df2,df3],axis=1)
```

```
Out[18]:
```

	A	B	C	D	A	B	C	D	A	B	C	D
0	A0	B0	C0	D0	NaN							
1	A1	B1	C1	D1	NaN							
2	A2	B2	C2	D2	NaN							
3	A3	B3	C3	D3	NaN							
4	NaN	NaN	NaN	NaN	A4	B4	C4	D4	NaN	NaN	NaN	NaN
5	NaN	NaN	NaN	NaN	A5	B5	C5	D5	NaN	NaN	NaN	NaN
6	NaN	NaN	NaN	NaN	A6	B6	C6	D6	NaN	NaN	NaN	NaN
7	NaN	NaN	NaN	NaN	A7	B7	C7	D7	NaN	NaN	NaN	NaN
8	NaN	A8	B8	C8	D8							
9	NaN	A9	B9	C9	D9							
10	NaN	A10	B10	C10	D10							
11	NaN	A11	B11	C11	D11							

6.2 Merging

Example DataFrame

```
In [28]: left = pd.DataFrame({'key': ['K0', 'K1', 'K2', 'K3'],
                           'A': ['A0', 'A1', 'A2', 'A3'],
                           'B': ['B0', 'B1', 'B2', 'B3']})

right = pd.DataFrame({'key': ['K0', 'K1', 'K2', 'K3'],
                      'C': ['C0', 'C1', 'C2', 'C3'],
                      'D': ['D0', 'D1', 'D2', 'D3']})
```

```
In [29]: left
```

```
Out[29]:
```

	A	B	key
0	A0	B0	K0
1	A1	B1	K1
2	A2	B2	K2
3	A3	B3	K3

```
In [30]: right
```

```
Out[30]:
```

	C	D	key
0	C0	D0	K0
1	C1	D1	K1
2	C2	D2	K2
3	C3	D3	K3

The **merge** function allows you to merge DataFrames together using a similar logic as merging SQL Tables together. For example:

```
In [35]: pd.merge(left,right,how='inner',on='key')
```

```
Out[35]:   A  B  key  C  D
0  A0  B0  K0  C0  D0
1  A1  B1  K1  C1  D1
2  A2  B2  K2  C2  D2
3  A3  B3  K3  C3  D3
```

Or to show a more complicated example:

```
In [37]: left = pd.DataFrame({'key1': ['K0', 'K0', 'K1', 'K2'],
                           'key2': ['K0', 'K1', 'K0', 'K1'],
                           'A': ['A0', 'A1', 'A2', 'A3'],
                           'B': ['B0', 'B1', 'B2', 'B3']})

right = pd.DataFrame({'key1': ['K0', 'K1', 'K1', 'K2'],
                      'key2': ['K0', 'K0', 'K0', 'K0'],
                      'C': ['C0', 'C1', 'C2', 'C3'],
                      'D': ['D0', 'D1', 'D2', 'D3']})
```

```
In [39]: pd.merge(left, right, on=['key1', 'key2'])
```

```
Out[39]:   A  B  key1  key2  C  D
0  A0  B0    K0    K0  C0  D0
1  A2  B2    K1    K0  C1  D1
2  A2  B2    K1    K0  C2  D2
```

```
In [40]: pd.merge(left, right, how='outer', on=['key1', 'key2'])
```

```
Out[40]:      A     B  key1  key2     C     D
0    A0    B0    K0    K0    C0    D0
1    A1    B1    K0    K1    NaN    NaN
2    A2    B2    K1    K0    C1    D1
3    A2    B2    K1    K0    C2    D2
4    A3    B3    K2    K1    NaN    NaN
5    NaN    NaN    K2    K0    C3    D3
```

```
In [41]: pd.merge(left, right, how='right', on=['key1', 'key2'])
```

```
Out[41]:      A     B  key1  key2     C     D
0    A0    B0    K0    K0    C0    D0
1    A2    B2    K1    K0    C1    D1
2    A2    B2    K1    K0    C2    D2
3    NaN   NaN    K2    K0    C3    D3
```

```
In [42]: pd.merge(left, right, how='left', on=['key1', 'key2'])
```

```
Out[42]:      A     B  key1  key2     C     D
0    A0    B0    K0    K0    C0    D0
1    A1    B1    K0    K1    NaN    NaN
2    A2    B2    K1    K0    C1    D1
3    A2    B2    K1    K0    C2    D2
4    A3    B3    K2    K1    NaN    NaN
```

6.3 Joining

Joining is a convenient method for combining the columns of two potentially differently-indexed DataFrames into a single result DataFrame.

```
In [46]: left = pd.DataFrame({'A': ['A0', 'A1', 'A2'],
                             'B': ['B0', 'B1', 'B2']},
                            index=['K0', 'K1', 'K2'])

right = pd.DataFrame({'C': ['C0', 'C2', 'C3'],
                      'D': ['D0', 'D2', 'D3']},
                     index=['K0', 'K2', 'K3'])
```

```
In [47]: left.join(right)
```

```
Out[47]:      A   B   C   D
K0   A0   B0   C0   D0
K1   A1   B1   NaN  NaN
K2   A2   B2   C2   D2
```

```
In [48]: left.join(right, how='outer')
```

```
Out[48]:      A   B   C   D
K0   A0   B0   C0   D0
K1   A1   B1   NaN  NaN
K2   A2   B2   C2   D2
K3   NaN  NaN   C3   D3
```

7. Operations

There are lots of operations with pandas that will be really useful to you, but don't fall into any distinct category. Let's show them here in this lecture:

```
In [5]: import pandas as pd
df = pd.DataFrame({'col1':[1,2,3,4], 'col2':[444,555,666,444], 'col3':['abc','def','ghi','xyz']})
df.head()
```

```
Out[5]:    col1  col2  col3
0       1    444    abc
1       2    555    def
2       3    666    ghi
3       4    444    xyz
```

7.1 Info on Unique Values

```
In [53]: df['col2'].unique()
```

```
Out[53]: array([444, 555, 666])
```

```
In [54]: df['col2'].nunique()
```

```
Out[54]: 3
```

```
In [55]: df['col2'].value_counts()
```

```
Out[55]: 444    2
555    1
666    1
Name: col2, dtype: int64
```

7.2 Selecting Data

```
In [56]: #Select from DataFrame using criteria from multiple columns
newdf = df[(df['col1']>2) & (df['col2']==444)]
```

```
In [57]: newdf
```

```
Out[57]:    col1  col2  col3
3       4    444    xyz
```

7.3 Applying Functions

```
In [58]: def times2(x):
           return x*2

In [59]: df['col1'].apply(times2)

Out[59]: 0    2
          1    4
          2    6
          3    8
         Name: col1, dtype: int64

In [60]: df['col3'].apply(len)

Out[60]: 0    3
          1    3
          2    3
          3    3
         Name: col3, dtype: int64

In [61]: df['col1'].sum()

Out[61]: 10
```

Permanently Removing a Column

```
In [62]: del df['col1']

In [63]: df

Out[63]:   col2  col3
0    444  abc
1    555  def
2    666  ghi
3    444  xyz
```

Get column and index names:

```
In [64]: df.columns

Out[64]: Index(['col2', 'col3'], dtype='object')

In [65]: df.index

Out[65]: RangeIndex(start=0, stop=4, step=1)
```

Sorting and Ordering a DataFrame:

```
In [66]: df

Out[66]:   col2  col3
0    444  abc
1    555  def
2    666  ghi
3    444  xyz

In [67]: df.sort_values(by='col2') #inplace=False by default

Out[67]:   col2  col3
0    444  abc
3    444  xyz
1    555  def
2    666  ghi
```

Find Null Values or Check for Null Values

```
In [68]: df.isnull()

Out[68]:   col2  col3
0  False  False
1  False  False
2  False  False
3  False  False
```

```
In [69]: # Drop rows with NaN Values  
df.dropna()
```

```
Out[69]:  
      col2  col3  
0    444   abc  
1    555   def  
2    666   ghi  
3    444   xyz
```

Filling in NaN values with something else:

```
In [3]: import numpy as np
```

```
In [6]: df = pd.DataFrame({'col1':[1,2,3,np.nan],  
                         'col2':[np.nan,555,666,444],  
                         'col3':['abc','def','ghi','xyz']})  
df.head()
```

```
Out[6]:  
      col1  col2  col3  
0    1.0   NaN   abc  
1    2.0  555.0  def  
2    3.0  666.0  ghi  
3    NaN  444.0  xyz
```

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

```
Out[7]:  
      col1  col2  col3  
0  False  True  False  
1  False  False  False  
2  False  False  False  
3  True  False  False
```

```
In [8]: df.dropna()
```

```
Out[8]:  
      col1  col2  col3  
1    2.0  555.0  def  
2    3.0  666.0  ghi
```

```
In [9]: df.fillna('FILL')
```

```
Out[9]:  
      col1  col2  col3  
0     1  FILL   abc  
1     2   555   def  
2     3   666   ghi  
3  FILL   444   xyz
```

```
In [89]: data = {'A':['foo','foo','foo','bar','bar','bar'],  
              'B':['one','one','two','two','one','one'],  
              'C':['x','y','x','y','x','y'],  
              'D':[1,3,2,5,4,1]}  
  
df = pd.DataFrame(data)
```

```
In [90]: df
```

```
Out[90]:  
      A    B    C    D  
0  foo  one   x  1  
1  foo  one   y  3  
2  foo  two   x  2  
3  bar  two   y  5  
4  bar  one   x  4  
5  bar  one   y  1
```

```
In [91]: df.pivot_table(values='D',index=['A', 'B'],columns=['C'])
```

```
Out[91]:
```

	C	x	y
A	B		
bar	one	4.0	1.0
	two	Nan	5.0
foo	one	1.0	3.0
	two	2.0	Nan

8. Data Input and Output

This notebook is the reference code for getting input and output, pandas can read a variety of file types using its pd.read_ methods. Let's take a look at the most common data types:

```
In [1]: import numpy as np  
import pandas as pd
```

8.1 CSV

CSV Input

```
In [25]: df = pd.read_csv('example.csv')
```

```
Out[25]:
```

	a	b	c	d
0	0	1	2	3
1	4	5	6	7
2	8	9	10	11
3	12	13	14	15

CSV Output

```
In [24]: df.to_csv('example.csv',index=False)
```

8.2 Excel

Pandas can read and write excel files, keep in mind, this only imports data. Not formulas or images, having images or macros may cause this read_excel method to crash.

Excel Input

```
In [35]: pd.read_excel('Excel_Sample.xlsx',sheetname='Sheet1')
```

```
Out[35]:
```

	a	b	c	d
0	0	1	2	3
1	4	5	6	7
2	8	9	10	11
3	12	13	14	15

Excel Output

```
In [33]: df.to_excel('Excel_Sample.xlsx',sheet_name='Sheet1')
```

8.3 SQL

The pandas.io.sql module provides a collection of query wrappers to both facilitate data retrieval and to reduce dependency on DB-specific API. Database abstraction is provided by SQLAlchemy if installed. In addition you will need a driver library for your database. Examples of such drivers are psycopg2 for PostgreSQL or pymysql for MySQL. For SQLite this is included in Python's standard library by default. You can find an overview of supported drivers for each SQL dialect in the SQLAlchemy docs.

If SQLAlchemy is not installed, a fallback is only provided for sqlite (and for mysql for backwards compatibility, but this is deprecated and will be removed in a future version). This mode requires a Python database adapter which respect the Python DB-API.

See also some cookbook examples for some advanced strategies.

The key functions are:

`read_sql_table(table_name, con[, schema, ...])`

Read SQL database table into a DataFrame.

read_sql_query(sql, con[, index_col, ...])

Read SQL query into a DataFrame.

read_sql(sql, con[, index_col, ...])

Read SQL query or database table into a DataFrame.

DataFrame.to_sql(name, con[, flavor, ...])

Write records stored in a DataFrame to a SQL database.

```
In [36]: from sqlalchemy import create_engine
In [37]: engine = create_engine('sqlite:///:memory:')
In [40]: df.to_sql('data', engine)
In [42]: sql_df = pd.read_sql('data', con=engine)
In [43]: sql_df
```

Out[43]:

index	a	b	c	d
0	0	0	1	2
1	1	4	5	6
2	2	8	9	10
3	3	12	13	14
				15