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of the European Union



Getting Started with pandas

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Getting Started with pandas

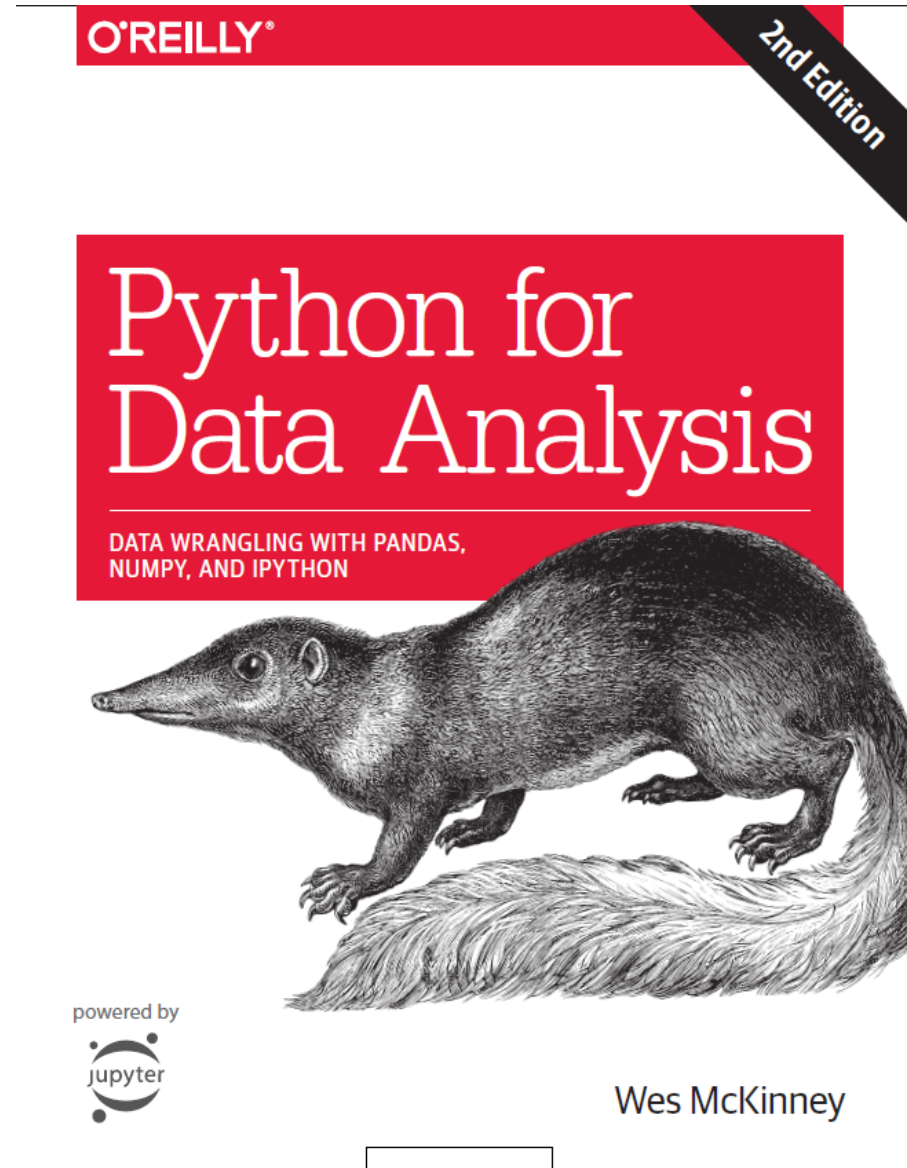
- YouTube Video from **Python Programmer**

What is Pandas? Why and How to Use Pandas in Python

<https://youtu.be/dcqPhpY7tWk>

Reference

- Chapter 5
- Wes McKinney, **Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython**, O'Reilly Media, 2nd Edition, 2018.
 - Material:
<https://github.com/wesm/pydata-book>



Outline

5.1 Introduction to pandas Data Structures

5.2 Essential Functionality

5.3 Summarizing and Computing Descriptive Statistics

Pandas: Labeled Column-Oriented Data

- Pandas is high-performance, easy-to-use **data structures** and **data analysis tools**. It contains:
 - A set of labeled array data structures (**Series** and **DataFrame**)
 - **Index objects** enabling both simple axis indexing and multi-level / hierarchical axis indexing
 - **Input/Output tools**: loading tabular data from flat files (CSV, delimited, Excel 2003), and saving and loading pandas objects
- **Website**: <https://pandas.pydata.org/>
- Also, check the **tutorial** on Learn Python: https://www.learnpython.org/en/Pandas_Basics

Outline

5.1 Introduction to pandas
Data Structures

5.2 Essential Functionality

5.3 Summarizing and
Computing Descriptive
Statistics

- Series
- DataFrame
- Index Objects

Series

- **One-dimensional** array-like object containing a **sequence of values** (of similar **types** to NumPy types) and an associated array of data labels, called its **index**.
- Has **.values** and **.index** attributes.

```
obj = pd.Series([4, 7, -5, 3])
```

```
obj
```

```
0  4
```

```
1  7
```

```
2 -5
```

```
3  3
```

```
dtype: int64
```

```
obj.values
```

```
array([ 4,  7, -5,  3])
```

```
obj.index # Like range(4)
```

```
RangeIndex(start=0, stop=4, step=1)
```

May not show in following slides

Index object

Series

- You can **specify** the **index**
 - at **creation**
 - or by **assignment**.
- You can **use labels** in the index when **selecting** single values or a set of values.

```
obj = pd.Series([7, -5, 3],  
                index=['b', 'a', 'c'])
```

```
obj  
b  7  
a -5  
c  3
```

```
obj.index = ['b', 'a', 'c']  
obj['a'] = 6  
obj[['c', 'a']]  
c  3  
a  6
```


Series

- Accepts **functions** and **operations like NumPy**:
 - **Filtering** with a Boolean array
 - **Scalar multiplication**
 - Applying **math functions**

```
obj[obj > 5]
```

```
b 7
```

```
a 6
```

```
obj * 2
```

```
b 14
```

```
a 12
```

```
c 6
```

```
np.square(obj)
```

```
b 49
```

```
a 36
```

```
c 9
```

obj	
b	7
a	6
c	3

Series

- You can check labels similar to dictionaries using the **in** operator.
- Can convert **dictionary to Series**.
- Can **rearrange** with new index.
- Support methods like **.isnull**.

```
'b' in obj
```

```
True
```

```
sdata = {'Ohio': 35000, 'Texas': 71000}
```

```
obj3 = pd.Series(sdata)
```

```
states = ['California', 'Texas']
```

```
obj4 = pd.Series(sdata, index=states)
```

```
obj4
```

```
California      NaN
```

```
Texas           71000.0
```

```
pd.isnull(obj4)
```

```
California      True
```

```
Texas           False
```

obj	
b	7
a	6
c	3

DataFrame

- **Table** of data containing an ordered collection of **columns**, each of which can be a **different** value **type**.
- Has both a **row** and **column index**; it can be thought of as a **dict of Series** all sharing the same index.
- Supports **.head** and **.tail**.

```
data = {'state': ['Ohio', 'Nevada'],  
        'year': [2002, 2001],  
        'pop': [3.6, 2.4]}  
frame = pd.DataFrame(data)  
frame.head()  
   pop  state  year  
0  3.6   Ohio  2002  
1  2.4  Nevada  2001
```

DataFrame

- You can specify **columns** and **index**.
- You can check the **columns** labels or **index** using the corresponding attributes.

```
arr = np.arange(4).reshape(2, 2)
df = pd.DataFrame(arr,
                  columns=['one', 'two'],
                  index=['a', 'b'])
```

```
df
```

	one	two
a	0	1
b	2	3

```
df.columns
```

```
Index(['one', 'two'], dtype='object')
```

DataFrame

- You can access a column or a value by `[]` or **label**.
- When used as label, the name should be **valid Python name**.
- You can access rows by **.loc** method.

df	one	two
a	0	1
b	2	3

```
df['one']
```

```
a    0
```

```
b    2
```

Series

```
df.two['b']
```

```
3
```

```
df.loc['b']
```

```
one    2
```

```
two    3
```

DataFrame

- Columns could be **assigned** scalars, vectors, or Series.
- Adding **new columns** is easy.
- Use **del** to delete columns.

df	one	two
a	0	1
b	2	3

```
val = pd.Series([-1.2, -1.5],  
                index=['b', 'a'])
```

```
df['one'] = val
```

```
df['three'] = 3
```

```
df
```

```
   one  two  three  
a -1.5   1     3  
b -1.2   3     3
```

```
del df['one']
```

```
df.columns
```

```
Index(['two', 'three'], dtype='object')
```

Index Objects

	two	three
a	1	3
b	3	3

- **Immutable** objects that hold axis labels.
- An **Index** behaves like a fixed-size set, but it allows duplicates.

```
df.index
```

```
Index(['a', 'b'], dtype='object')
```

```
labels = pd.Index(np.arange(3))
```

```
obj2 = pd.Series([1.5, -2.5, 0],  
                 index=labels)
```

```
obj2
```

```
0  1.5
```

```
1 -2.5
```

```
2  0.0
```

```
'two' in df.columns
```

```
True
```

Outline

5.1 Introduction to pandas
Data Structures

5.2 Essential Functionality

5.3 Summarizing and
Computing Descriptive
Statistics

- Reindexing
- Dropping Entries from an Axis
- Indexing, Selection, and Filtering
- Arithmetic and Data Alignment
- Function Application and Mapping
- Sorting and Ranking
- Axis Indexes with Duplicate Labels

Reindexing

- If you want to rearrange the data according to a new index, use **reindex**.
- The columns can be reindexed with the **columns** keyword.

```
obj = pd.Series([7.2, -5.3, 3.6],  
                index=['b', 'a', 'c'])
```

```
obj
```

```
b  7.2
```

```
a -5.3
```

```
c  3.6
```

```
obj2 = obj.reindex(['a', 'b', 'e'])
```

```
obj2
```

```
a -5.3
```

```
b  7.2
```

```
e  NaN
```

```
df.reindex(columns=new_index)
```

Dropping Entries from an Axis

- If you don't want some data, you can drop rows or columns.
 - **inplace**
 - or in a **new object**
- You can drop **multiple** items or **one** item.

```
data =  
pd.DataFrame(np.arange(9).reshape((3, 3)),  
             index=['Ohio', 'Colorado', 'Utah'],  
             columns=['one', 'two', 'three'])
```

```
data  
  
      one  two  three  
Ohio    0    1     2  
Colorado 3    4     5  
Utah    6    7     8
```

```
data.drop(['Utah', 'Ohio'], inplace=True)
```

```
data.drop('three', axis=1)
```

```
      one  two  
Colorado 3    4
```

Indexing, Selection, and Filtering

- You can use **integers** to index **Series** as well as labels.
- **Slicing** with **labels** includes the **endpoint**.

```
obj['b']
```

```
obj[1]
```

```
obj[['b', 'a', 'd']]
```

```
obj[[1, 3]]
```

```
obj[2:4]
```

```
obj['b':'c'] = 5
```

Indexing, Selection, and Filtering

- With DataFrames, `[]` selects **column(s)**.
- But **slicing** and selection with a **Boolean array** selects **rows**.
- The Boolean array can be of the same DataFrame size.

```
data['two']
```

```
data[:2]
```

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

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

Selection with `loc` and `iloc`

- DataFrame **indexing on the rows**: to select a subset of the rows and columns, use:
 - axis labels with `loc`
 - or integers with `iloc`.

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.loc['Colorado', ['two', 'three']]
```

```
two    5
```

```
three  6
```

```
data.iloc[2, [3, 0, 1]]
```

```
four  11
```

```
one    8
```

```
two    9
```

Arithmetic and Data Alignment

- When you are **adding objects**, if any index pairs are not the same, the respective index in the result will be the **union** of the index pairs.

s1	
a	7.3
c	-2.5
d	3.4
e	1.5

s2	
a	-2.1
c	3.6
e	-1.5
f	4.0
g	3.1

s1 + s2	
a	5.2
c	1.1
d	NaN
e	0.0
f	NaN
g	NaN

Arithmetic and Data Alignment

- In the case of **DataFrame**, **alignment** is performed on **both** the **rows** and the **columns**.

df1	b	c	d
Ohio	0.0	1.0	2.0
Texas	3.0	4.0	5.0
Colorado	6.0	7.0	8.0

df2	b	d	e
Utah	0.0	1.0	2.0
Ohio	3.0	4.0	5.0
Texas	6.0	7.0	8.0
Oregon	9.0	10.0	11.0

df1 + df2	b	c	d	e
Colorado	NaN	NaN	NaN	NaN
Ohio	3.0	NaN	6.0	NaN
Oregon	NaN	NaN	NaN	NaN
Texas	9.0	NaN	12.0	NaN
Utah	NaN	NaN	NaN	NaN

Arithmetic methods with fill values

- You can **fill** with a special value, like **0**, when an axis label is found in one object but not the other using **add(fill_value=0)**.

df1		b	c	d
Ohio	0.0	1.0	2.0	
Texas	3.0	4.0	5.0	
Colorado	6.0	7.0	8.0	

df2		b	d	e
Utah	0.0	1.0	2.0	
Ohio	3.0	4.0	5.0	
Texas	6.0	7.0	8.0	
Oregon	9.0	10.0	11.0	

```
df1.add(df2, fill_value=0)
```

Colorado	6.0	7.0	8.0	NaN
Ohio	3.0	1.0	6.0	5.0
Oregon	9.0	NaN	10.0	11.0
Texas	9.0	4.0	12.0	8.0
Utah	0.0	NaN	1.0	2.0

Arithmetic methods with fill values

- Series and DataFrame **methods** for **arithmetic**.
- The method starting with the letter **r** has arguments flipped.
- Equivalent:
`1 / df1`
`df1.rdiv(1)`

Method	Description
add, radd	Methods for addition (+)
sub, rsub	Methods for subtraction (-)
div, rdiv	Methods for division (/)
floordiv, rfloordiv	Methods for floor division (//)
mul, rmul	Methods for multiplication (*)
pow, rpow	Methods for exponentiation (**)

Operations between DataFrame and Series

- **Arithmetic** between **DataFrame** and **Series** is possible.
- By default, arithmetic matches the index of the Series on the DataFrame's columns, **broadcasting down** the **rows**.

```
series = frame.iloc[0]
```

```
series  
b  0.0  
d  1.0  
e  2.0
```

frame	b	d	e
Utah	0.0	1.0	2.0
Ohio	3.0	4.0	5.0
Texas	6.0	7.0	8.0
Oregon	9.0	10.0	11.0

```
frame - series
```

```
      b  d  e  
Utah  0.0  0.0  0.0  
Ohio  3.0  3.0  3.0  
Texas  6.0  6.0  6.0  
Oregon  9.0  9.0  9.0
```

Operations between DataFrame and Series

- If you want to **broadcast** over the **columns**, matching on the rows, you have to use one of the arithmetic methods with **axis='index'**.

```
series3 = frame['d']
```

```
series3
Utah      1.0
Ohio      4.0
Texas     7.0
Oregon   10.0
```

frame	b	d	e
Utah	0.0	1.0	2.0
Ohio	3.0	4.0	5.0
Texas	6.0	7.0	8.0
Oregon	9.0	10.0	11.0

```
frame.sub(series3, axis='index')
```

```
      b    d    e
Utah -1.0  0.0  1.0
Ohio -1.0  0.0  1.0
Texas -1.0  0.0  1.0
Oregon -1.0  0.0  1.0
```

or 0

Function Application and Mapping

- **NumPy ufuncs** work with **pandas** objects.

```
frame = pd.DataFrame(randn(2, 3),  
                      columns=list('bde'),  
                      index=['Utah', 'Ohio'])
```

```
frame
```

```
           b           d           e  
Utah -0.291993  0.085824 -0.222663  
Ohio -1.473446  1.049407 -1.035874
```

```
np.abs(frame)
```

```
           b           d           e  
Utah  0.291993  0.085824  0.222663  
Ohio  1.473446  1.049407  1.035874
```

Function Application and Mapping

- DataFrame's **apply** method applies a **function** on **one-dimensional arrays** to each column
- or row.
- Element-wise Python functions:
 - **map** for Series
 - **applymap** for DataFrame

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

```
frame.apply(f)
```

```
b    1.181453
```

```
d    0.963583
```

```
e    0.813211
```

	b	d	e
Utah	-0.291993	0.085824	-0.222663
Ohio	-1.473446	1.049407	-1.035874

```
frame.apply(f, axis='columns')
```

```
Utah    0.377817
```

```
Ohio    2.522853
```

```
frame['e'].map(f2)
```

```
frame.applymap(f2)
```

Sorting and Ranking

- You can **sort** Series and DataFrame using **sort_index**.
- You can select the **axis** and **sort direction**.
- You can also sort by the **values** of one or multiple columns.

frame	d	a	b	c
three	0	1	2	3
one	4	5	6	7

```
frame.sort_index(axis=1,  
                 ascending=False)
```

```
      d c b a  
three 0 3 2 1  
one   4 7 6 5
```

```
frame.sort_values(by=['a', 'b'])
```

Sorting and Ranking

- **Ranking** assigns ranks from **1** through the number of valid data points in an array.
- Use panda's **rank**.

Table 5-6. Tie-breaking methods with rank

Method	Description
'average'	Default: assign the average rank to each entry in the equal group
'min'	Use the minimum rank for the whole group
'max'	Use the maximum rank for the whole group
'first'	Assign ranks in the order the values appear in the data
'dense'	Like method='min', but ranks always increase by 1 in between groups rather than the number of equal elements in a group

```
obj = pd.Series([7, -5, 7, 4,  
                2, 0, 4])
```

```
obj.rank()
```

```
0 6.5
```

```
1 1.0
```

```
2 6.5
```

```
3 4.5
```

```
4 3.0
```

```
5 2.0
```

```
6 4.5
```

```
df.rank(ascending=False, method='max',  
        axis='columns')
```

Has these familiar options.

Axis Indexes with Duplicate Labels

- Indexing a label in a **Series** usually returns a **scalar**.
- Indexing a label with multiple entries returns a **Series**.
- And returns a **DataFrame** from a DataFrame.

```
df = pd.DataFrame(randn(4, 3),  
                  index=['a', 'a', 'b', 'b'])
```

```
df
```

	0	1	2
a	0.274992	0.228913	1.352917
a	0.886429	-2.001637	-0.371843
b	1.669025	-0.438570	-0.539741
b	0.476985	3.248944	-1.021228

```
df.loc['b']
```

	0	1	2
b	1.669025	-0.438570	-0.539741
b	0.476985	3.248944	-1.021228

Outline

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- Correlation and Covariance
- Unique Values, Value Counts, and Membership

5.3 Summarizing and Computing Descriptive Statistics

- pandas has **mathematical** and **statistical** methods.
- Most are **reductions** methods like the **sum** or **mean**.
- They have built-in **handling** for **missing data**.

```
df = pd.DataFrame([[1.4, np.nan],  
                  [7.1, -4.5], [np.nan, np.nan],  
                  [0.75, -1.3]],  
                  index=['a', 'b', 'c', 'd'],  
                  columns=['one', 'two'])
```

```
df  
   one  two  
a  1.40 NaN  
b  7.10 -4.5  
c   NaN NaN  
d  0.75 -1.3  
df.sum()  
one    9.25  
two   -5.80
```

```
df.sum(axis='columns')  
a    1.40  
b    2.60  
c    NaN  
d   -0.55
```

5.3 Summarizing and Computing Descriptive Statistics

- Some return **index** like **idxmax**.

```
df.idxmax()
```

```
one b
```

```
two d
```

- Or **accumulations** like **cumsum**.

```
df.cumsum()
```

```
one two
```

```
a 1.40 NaN
```

```
b 8.50 -4.5
```

```
c NaN NaN
```

```
d 9.25 -5.8
```

df	one	two
a	1.40	NaN
b	7.10	-4.5
c	NaN	NaN
d	0.75	-1.3

5.3 Summarizing and Computing Descriptive Statistics

- **describe** returns summary statistics.
- On **non-numeric** data, it produces **alternative summary** statistics.

```
df.describe()
           one         two
count  3.000000  2.000000
mean   3.083333 -2.900000
std    3.493685  2.262742
min    0.750000 -4.500000
25%    1.075000 -3.700000
50%    1.400000 -2.900000
75%    4.250000 -2.100000
max    7.100000 -1.300000
obj = pd.Series(['a', 'a',
                 'b', 'c'] * 4)

obj.describe()
count    16
unique     3
top       a
freq      8
```

df	one	two
a	1.40	NaN
b	7.10	-4.5
c	NaN	NaN
d	0.75	-1.3

Descriptive and summary statistics

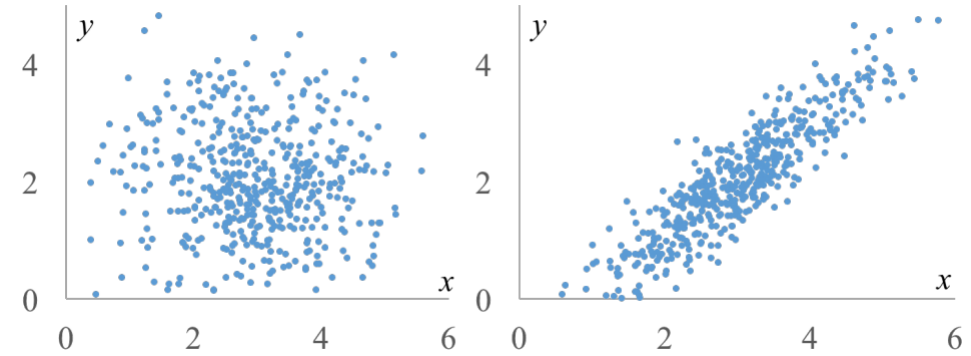
Method	Description
<code>count</code>	Number of non-NA values
<code>describe</code>	Compute set of summary statistics for Series or each DataFrame column
<code>min</code> , <code>max</code>	Compute minimum and maximum values
<code>argmin</code> , <code>argmax</code>	Compute index locations (integers) at which minimum or maximum value obtained, respectively
<code>idxmin</code> , <code>idxmax</code>	Compute index labels at which minimum or maximum value obtained, respectively
<code>quantile</code>	Compute sample quantile ranging from 0 to 1
<code>sum</code>	Sum of values
<code>mean</code>	Mean of values
<code>median</code>	Arithmetic median (50% quantile) of values
<code>mad</code>	Mean absolute deviation from mean value

Descriptive and summary statistics – cont.

<code>prod</code>	Product of all values
<code>var</code>	Sample variance of values
<code>std</code>	Sample standard deviation of values
<code>skew</code>	Sample skewness (third moment) of values
<code>kurt</code>	Sample kurtosis (fourth moment) of values
<code>cumsum</code>	Cumulative sum of values
<code>cummin, cummax</code>	Cumulative minimum or maximum of values, respectively
<code>cumprod</code>	Cumulative product of values
<code>diff</code>	Compute first arithmetic difference (useful for time series)
<code>pct_change</code>	Compute percent changes

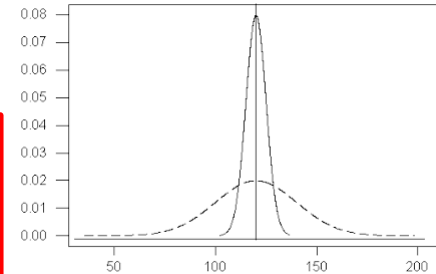
Correlation and Covariance

- **Covariance** is a quantitative measure of the extent to which the deviation of one variable from its mean matches the deviation of the other from its mean.
- **Correlation** between two random variables is the covariance of the two variables **normalized** by the variance of each variable.



$$\mu = \frac{1}{n} \sum_{i=1}^n x_i$$

$$\text{Var}(X) = \frac{1}{n} \sum_{i=1}^n (x_i - \mu)^2$$



$$\text{cov}(X, Y) = \frac{1}{n} \sum_{i=1}^n (x_i - E(X))(y_i - E(Y))$$

$$\text{Corr}(X, Y) = \frac{\text{Cov}(X, Y)}{\sqrt{\text{Var}(X) \text{Var}(Y)}}$$

Correlation and Covariance

- Case Study: **Yahoo! Finance**

```
conda install pandas-datareader
```

```
import pandas_datareader.data as web
```

```
all_data = {ticker: web.get_data_yahoo(ticker)  
            for ticker in ['AAPL', 'IBM', 'MSFT', 'GOOG']}
```

```
price = pd.DataFrame({ticker: data['Adj Close']  
                     for ticker, data in all_data.items()})
```


Correlation and Covariance

```
price.tail(3)
```

	AAPL	IBM	MSFT	GOOG
Date				
2020-11-11	119.489998	117.199997	216.550003	1752.709961
2020-11-12	119.209999	114.500000	215.440002	1749.839966
2020-11-13	119.260002	116.849998	216.509995	1777.020020

- **Percent change**

```
returns = price.pct_change()
```

```
returns.tail(3)
```

	AAPL	IBM	MSFT	GOOG
Date				
2020-11-11	0.030353	-0.006022	0.026255	0.007079
2020-11-12	-0.002343	-0.023038	-0.005126	-0.001637
2020-11-13	0.000419	0.020524	0.004967	0.015533

Correlation and Covariance

- The **cov** method of Series computes the **covariance** of the overlapping, non-NA, aligned-by-index values in two Series.
- Relatedly, **corr** computes the **correlation**.
- DataFrame's **corr** and **cov** methods return a full correlation or covariance **matrix** as a DataFrame, respectively.

```
returns[ 'MSFT' ].cov(returns[ 'IBM' ])  
0.0001597827018721651
```

```
returns.MSFT.corr(returns.IBM)  
0.5616951231541795
```



Member access

```
returns.corr()
```

	AAPL	IBM	MSFT	GOOG
AAPL	1.000000	0.479430	0.718757	0.656523
IBM	0.479430	1.000000	0.561695	0.522796
MSFT	0.718757	0.561695	1.000000	0.780058
GOOG	0.656523	0.522796	0.780058	1.000000

Unique Values, Value Counts, and Membership

- pandas has methods that extract information about the values contained in a Series.
 - Array of **unique** values
 - The **count** of each value

```
obj = pd.Series(['c', 'a', 'd',  
                'a', 'a', 'b', 'b',  
                'c', 'c'])
```

```
obj.unique()  
array(['c', 'a', 'd', 'b'],  
      dtype=object)
```

```
obj.value_counts()  
c    3  
a    3  
b    2  
d    1
```

Unique Values, Value Counts, and Membership

- pandas has methods that extract information about the values contained in a Series.
 - **membership** check
 - The resulting mask can be used to access matches.

```
obj = pd.Series(['c', 'a', 'd',  
                'a', 'a', 'b', 'b',  
                'c', 'c'])  
mask = obj.isin(['b', 'c'])
```

```
mask  
0    True  
1   False  
2   False  
3   False  
4   False  
5    True  
6    True  
7    True  
8    True
```

```
obj[mask]  
0    c  
5    b  
6    b  
7    c  
8    c
```

Homework

- Solve the homework on **pandas**

Summary

5.1 Introduction to pandas Data Structures

5.2 Essential Functionality

5.3 Summarizing and Computing Descriptive Statistics