Pandas
Python for Data Analytics

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+ Outlines

pandas

$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$

- Python Data Analysis Library
- Viewing and Inspecting Data
- Selection of Data
- Filter, Sort and Groupby
- Data Cleaning
- Join/Combine
- Series
- DataFrame

- Axis indexing, the special pandas-flavored sauce
- Data alignment
- GroupBy
- Hierarchical indexes
- pandas.core
- The pandas roadmap
- pandas for "Big Data"
- Summary

Reference:

(1)http://pandas.pydata.org,

(2) https://medium.com/@adi.bronshtein/a-quick-introduction-to-the-pandas-python-library-f1b678f34673

(3) Wes McKinney Lecture, pandas: Powerful data analysis tools for Python

Python Data Analysis Library

- *pandas* is an open source, BSD-licensed library providing high-performance, easy-to-use data structures and data analysis tools for the Python programming language.
- *pandas* is a NumFOCUS sponsored project. This will help ensure the success of development of *pandas* as a world-class open-source project, and makes it possible to donate to the project

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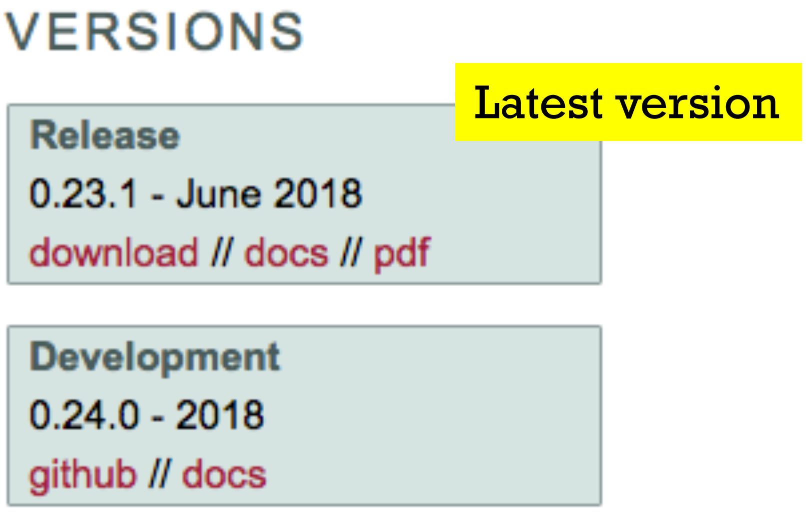
OPEN CODE = BETTER SCIENCE



VERSIONS

Latest version

Release

0.23.1 - June 2018

download // docs // pdf

Development

0.24.0 - 2018

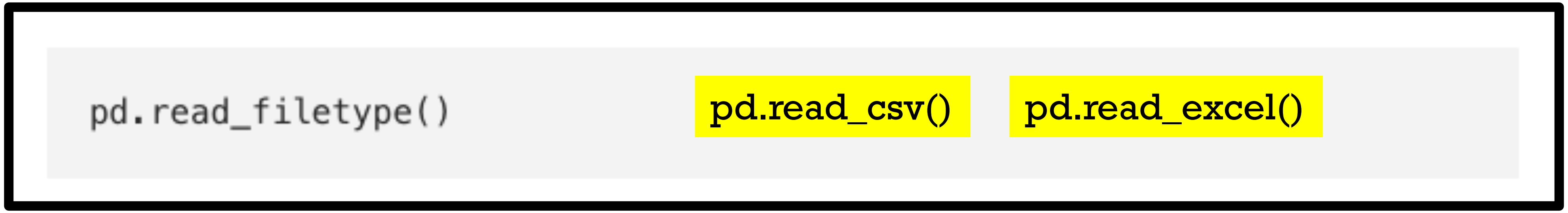
github // docs

+ pandas.core

- Data structures
  - Series (1D)
  - DataFrame (2D)
  - Panel (3D)
- NA-friendly statistics
- Index implementations / label-indexing
- GroupBy engine
- Time series tools
- Date range generation
- Extensible date offsets
- Hierarchical indexing stuff
- Join / concatenation algorithms
- Sparse versions of Series, DataFrame...
- IO tools: CSV files, HDF5, Excel 2003/2007
- Moving window statistics (rolling mean, ...)
- Pivot tables
- High level matplotlib interface

Loading and Saving Data with Pandas

- When you want to use Pandas for data analysis, you'll usually use it in one of three different ways:
- Convert a Python's list, dictionary or Numpy array to a Pandas data frame
- Open a local file using Pandas, usually a CSV file, but could also be a delimited text file (like TSV), Excel, etc
- Open a remote file or database like a CSV or a JSONon a website through a URL or read from a SQL table/database
- There are different commands to each of these options, but when you open a file, they would look like this:



```
pd.read_filetype()
```

pd.read_csv() pd.read_excel()

Viewing and Inspecting Data

- Now that you've loaded your data, it's time to take a look.

- How does the data frame look? Running the name of the data frame would give you the entire table, but you can also get the first n rows with **df.head(n)** or the last n rows with **df.tail(n).**

- **df.shape** would give you the number of rows and columns.

- **df.info()** would give you the index, datatype and memory information.

- The command **s.value_counts(dropna=False)** would allow you to view unique values and counts for a series (like a column or a few columns).

- A very useful command is **df.describe()** which inputs summary statistics for numerical columns.

Viewing and Inspecting Data (cont.)

- It is also possible to get **statistics** on the entire data frame or a series (a column, etc.):
- **df.mean() --** Returns the mean of all columns
- **df.corr() --** Returns the correlation between columns in a data frame
- **df.count() --** Returns the number of non-null values in each data frame column
- **df.max() --** Returns the highest value in each column
- **df.min() --** Returns the lowest value in each column
- **df.median() --** Returns the median of each column
- **df.std() --** Returns the standard deviation of each colum

Selection of Data

- One of the things that is so much easier in Pandas is selecting the data you want in comparison to selecting a value from a list or a dictionary.

- You can select a column (**df[col]**) and return column with label col as Series or a few columns (**df[[coll, col2]]**) and returns columns as a new DataFrame.

- You can select by position (**s.iloc[0]**), or by index (**s.loc['index_one']**).

- In order to select the first row you can use **df.iloc[0,:]** and in order to select the first element of the first column you would run **df.iloc[0,0]**.

- These can also be used in different combinations, so I hope it gives you an idea of the different selection and indexing you can perform in Pandas.

Filter, Sort and Group by

- You can use different conditions to filter columns. For example, df[df[year] > 1984] would give you only the column year is greater than 1984.

- You can use & (and) or | (or) to add different conditions to your filtering.
  - These is also called *boolean filtering*.

- It is possible to sort values in a certain column in an ascending order using **df.sort_values(col1)** ; and also in a descending order using **df.sort_values(col2,ascending=False)**.

- Furthermore, it's possible to sort values by col1 in ascending order then col2 in descending order by using **df.sort_values([col1,col2],ascending=[True,False])**.

Filter, Sort and Group by (cont.)

- The last command in this section is groupby.
- It involves splitting the data into groups based on some criteria, applying a function to each group independently and combining the results into a data structure.
- df.groupby(col) returns a groupby object for values from one column.
- While **df.groupby([col1,col2])** returns a groupby object for values from multiple columns.

Data Cleansing

- Data cleansing is a very important step in data analysis.
- For example, we always check for missing values in the data by running **pd.isnull()** which checks for null Values, and returns a boolean array (an array of *true* for missing values and *false* for non-missing values).
- In order to get a sum of null/missing values, run **pd.isnull().sum(). pd.notnull()** is the opposite of pd.isnull().
- After you get a list of missing values you can get rid of them, or drop them by using **df.dropna()** to drop the rows or **df.dropna(axis=1)** to drop the columns.

+ Data Cleansing (cont.)

- A different approach would be to fill the missing values with other values by using **df.fillna(x)** which fills the missing values with x
- you can put there whatever you want or **s.fillna(s.mean())** to replace all null values with the mean
  - mean can be replaced with almost any function from the statistics section.
- It is sometimes necessary to replace values with different values.
- For example, **s.replace(1,'one')** would replace all values equal to 1 with 'one'.
  - It’s possible to do it for multiple values: **s.replace([1,3],['one','three'])** would replace all 1 with 'one' and 3 with 'three'.
- You can also rename specific columns by running: **df.rename(columns={'old_name': 'new_ name'})**or use **df.set_index(‘student_id')** to change the index of the data frame (PK).

Join/Combine

- The last set of basic Pandas commands are for joining or combining data frames or rows/columns. The three commands are:
- **df1.append(df2);** add the rows in df1 to the end of df2 (columns should be identical)
- **df.concat([df1, df2],axis=1);** add the columns in df1 to the end of df2 (rows should be identical)
- **df1.join(df2,on=col1,how='inner');** SQL-style join the columns in df1with the columns on df2 where the rows for col have identical values. how can be equal to one of: 'left', 'right', 'outer', 'inner'

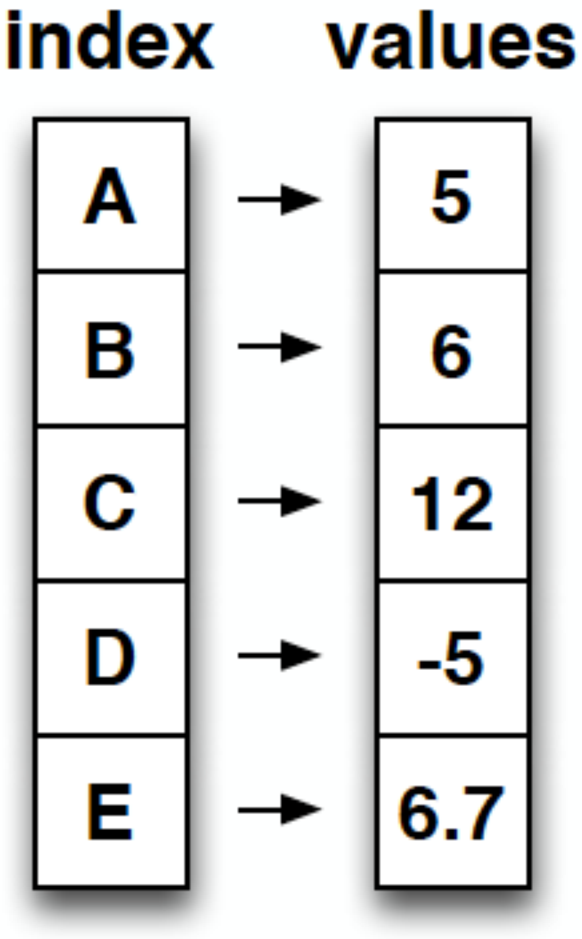
Data Structures in Pandas

- *1) Series (1D)
- *2) DataFrame (2D)
- 3) Panel (3D)

Data Structure: 1D

Series

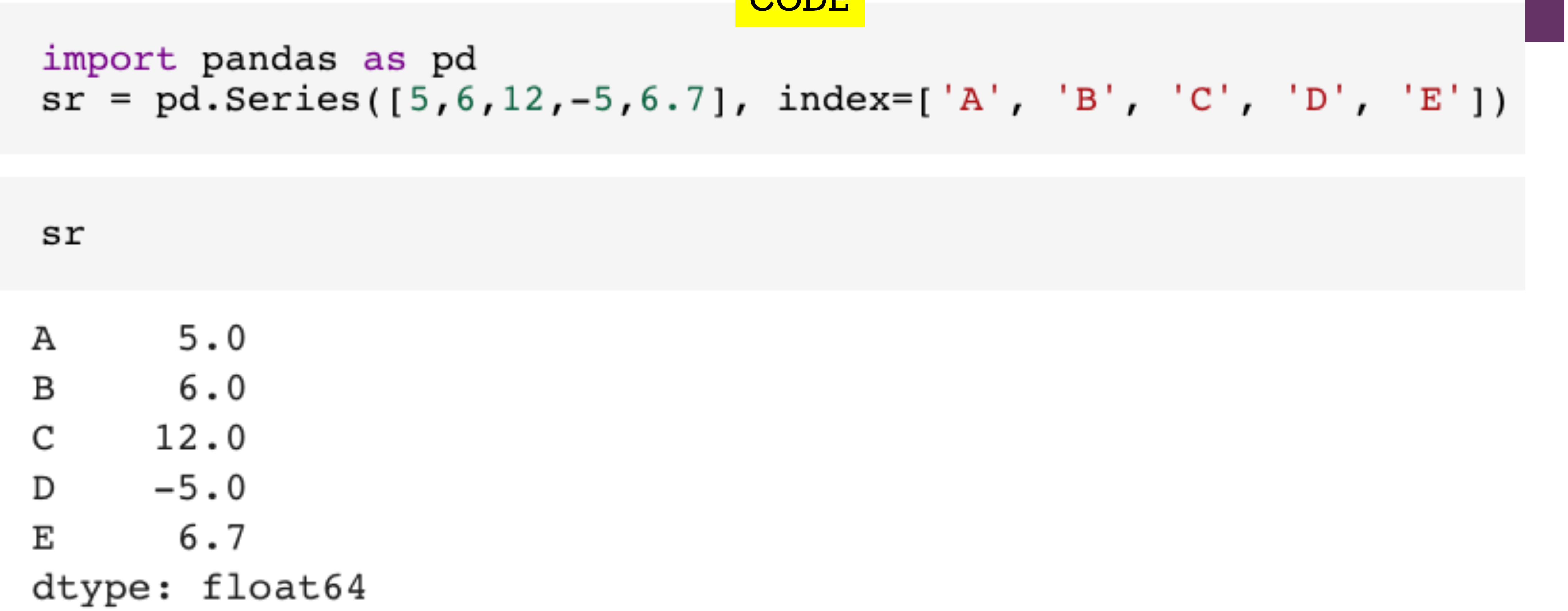
- Subclass of numpy.ndarray
- Data: any type
- Index labels need not be ordered
- Duplicates are possible (but result in reduced functionality)



index		values
A	→	5
B	→	6
C	→	12
D	→	-5
E	→	6.7

Series (cont.)

CODE



```
import pandas as pd
sr = pd.Series([5,6,12,-5,6.7], index=['A', 'B', 'C', 'D', 'E'])
```

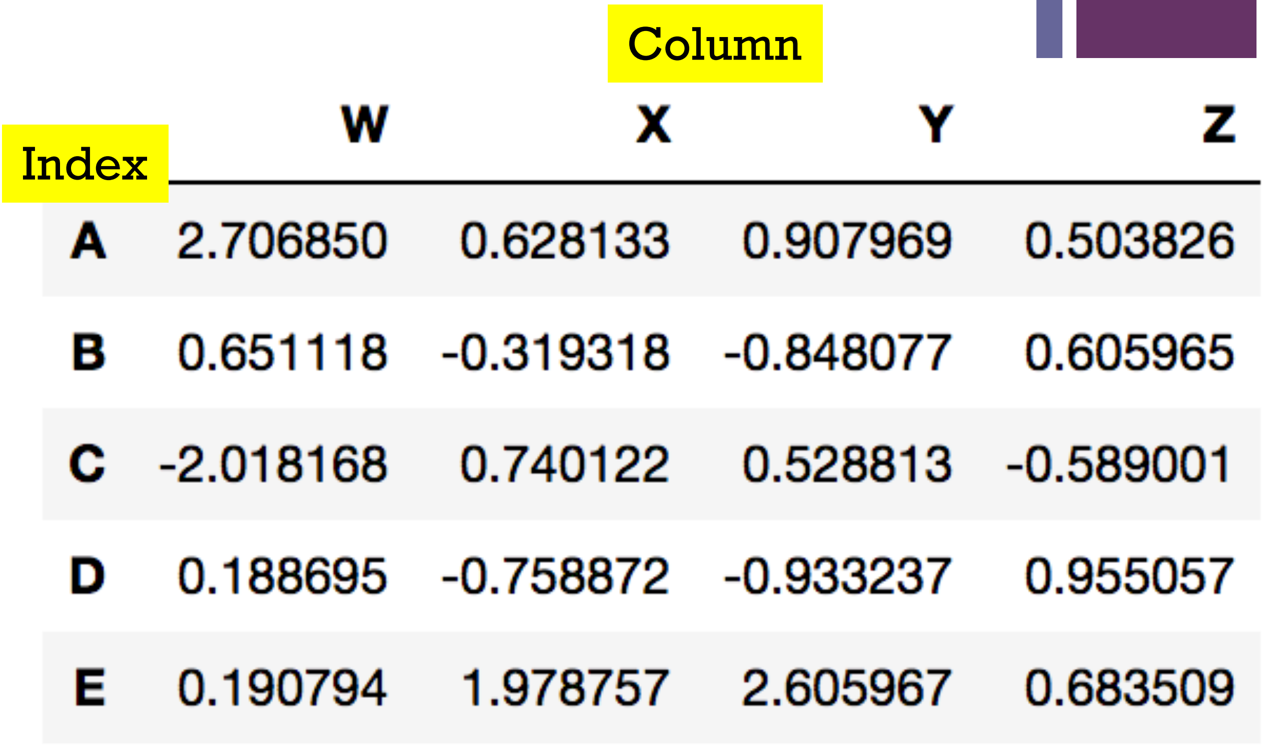
```
sr
```

```
A      5.0
B      6.0
C     12.0
D     -5.0
E      6.7
dtype: float64
```

Data Structure: 2D

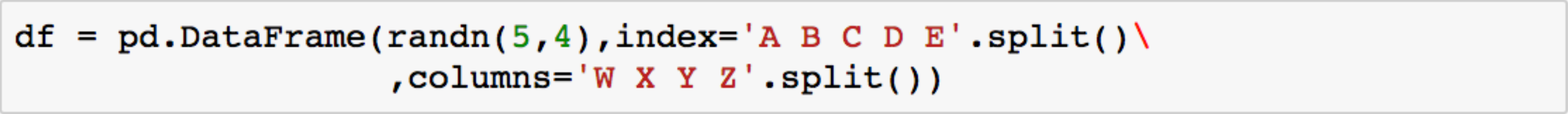
DataFrame

- NumPy array-like
- Each column can have a different type
- Row and column index
- Size mutable: insert and delete columns


Column
Index

	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

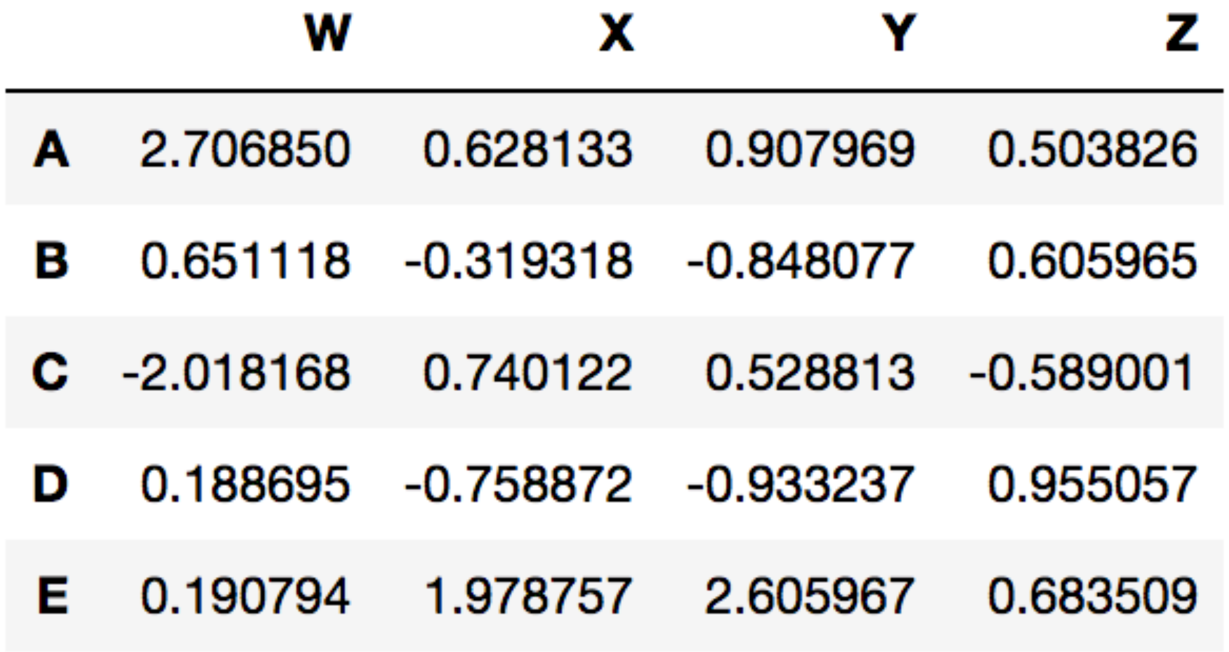
DataFrame (cont.) code



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

Column

Index

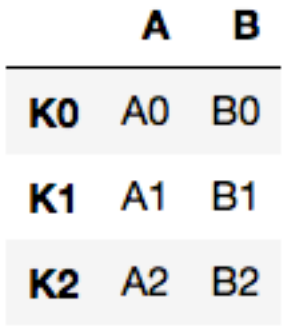


	W	X	Y	Z
A	2.706850	0.628133	0.907969	0.503826
B	0.651118	-0.319318	-0.848077	0.605965
C	-2.018168	0.740122	0.528813	-0.589001
D	0.188695	-0.758872	-0.933237	0.955057
E	0.190794	1.978757	2.605967	0.683509

Data alignment

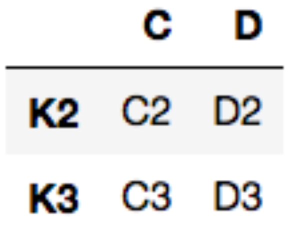
- Binary operations are joins!

DF: left



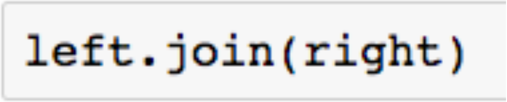
	A	B
K0	A0	B0
K1	A1	B1
K2	A2	B2

DF: right

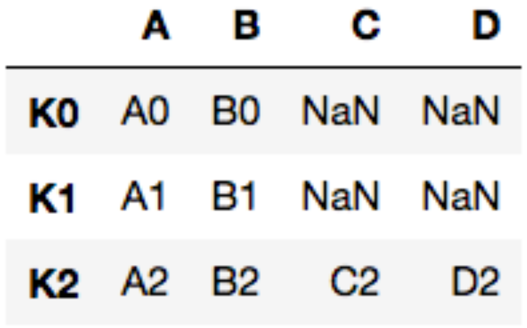


	C	D
K2	C2	D2
K3	C3	D3

Code: 1

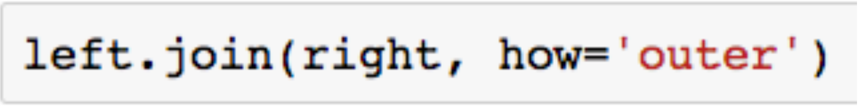


```
left.join(right)
```

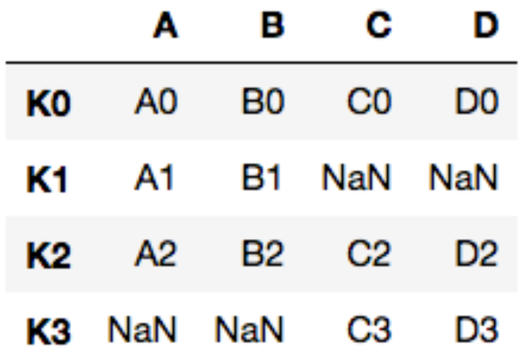


	A	B	C	D
K0	A0	B0	NaN	NaN
K1	A1	B1	NaN	NaN
K2	A2	B2	C2	D2

Code: 2



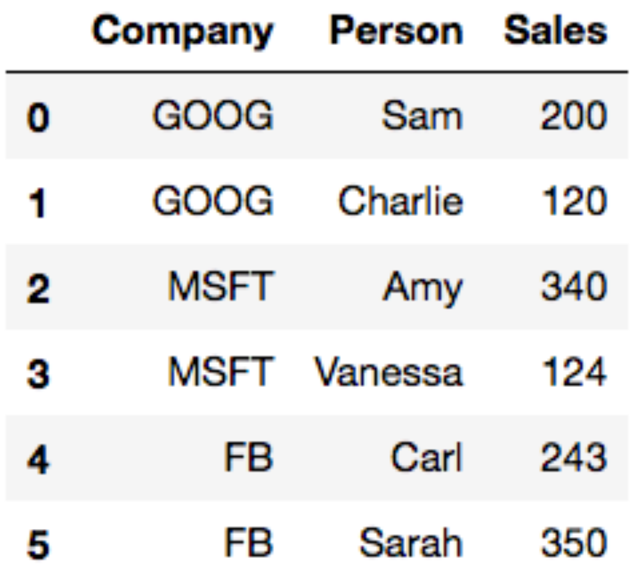
```
left.join(right, how='outer')
```



	A	B	C	D
K0	A0	B0	C0	D0
K1	A1	B1	NaN	NaN
K2	A2	B2	C2	D2
K3	NaN	NaN	C3	D3

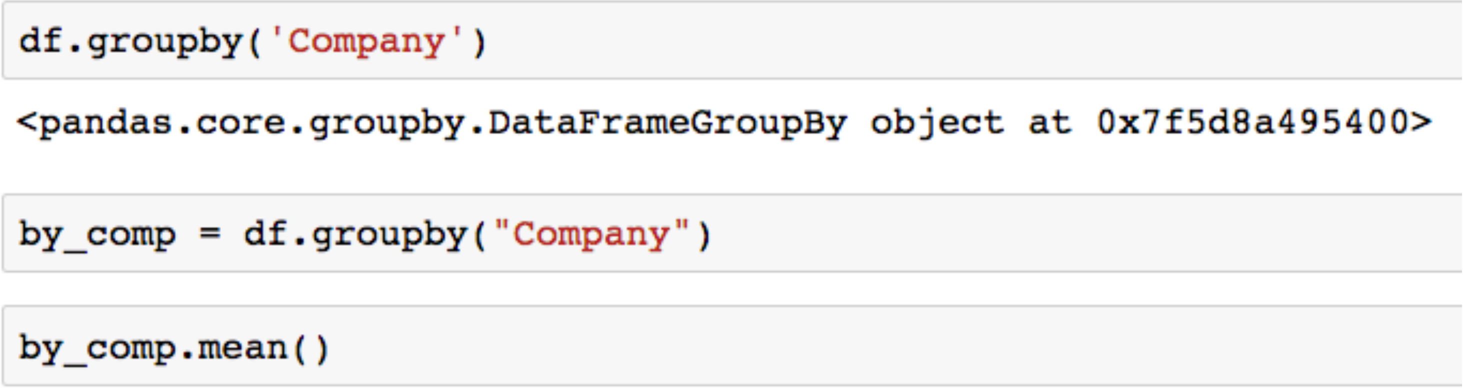
Group by

DF Example



	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

Code

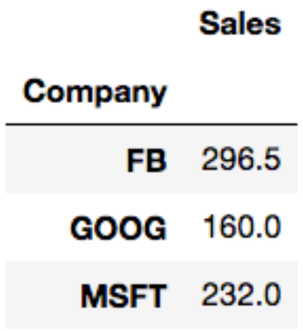


```
df.groupby('Company')
```

```
<pandas.core.groupby.DataFrameGroupBy object at 0x7f5d8a495400>
```

```
by_comp = df.groupby("Company")
```

```
by_comp.mean()
```



	Sales
Company	
FB	296.5
GOOG	160.0
MSFT	232.0

Output

Pandas Summary

- A fast and efficient **DataFrame** object for data manipulation with integrated indexing;
- Tools for **reading and writing data** between in-memory data structures and different formats: CSV and text files, Microsoft Excel, SQL databases, and the fast HDF5 format;
- Intelligent **data alignment** and integrated handling of **missing data**: gain automatic label-based alignment in computations and easily manipulate messy data into an orderly form;
- Flexible **reshaping** and pivoting of data sets;

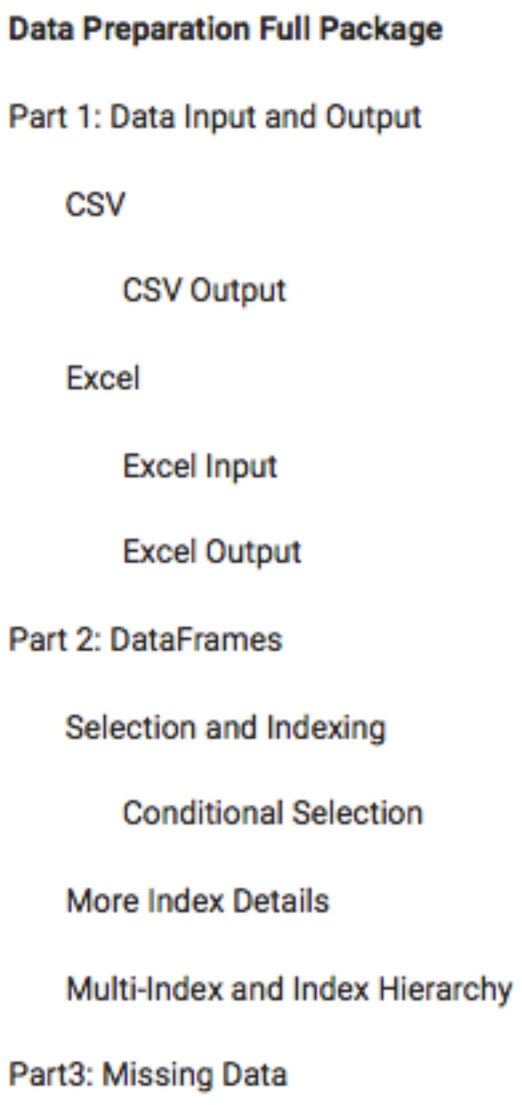
Summary: Library Highlights (cont.)

- Intelligent label-based **slicing**, **fancy indexing**, and **subsetting** of large data sets;
- Columns can be inserted and deleted from data structures for **size mutability**;
- Aggregating or transforming data with a powerful **group by** engine allowing split-apply-combine operations on data sets;
- High performance **merging and joining** of data sets;
- **Hierarchical axis indexing** provides an intuitive way of working with high-dimensional data in a lower-dimensional data structure;

Summary: Library Highlights (cont.)

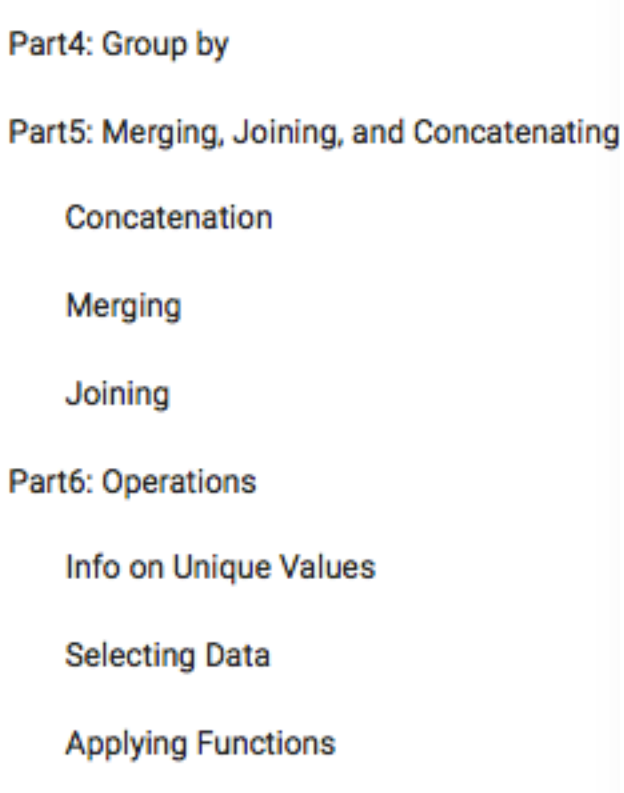
- **Time series**-functionality: date range generation and frequency conversion, moving window statistics, moving window linear regressions, date shifting and lagging. Even create domain-specific time offsets and join time series without losing data;
- Highly **optimized for performance**, with critical code paths written in Cython or C.
- Python with *pandas* is in use in a wide variety of **academic and commercial** domains, including Finance, Neuroscience, Economics, Statistics, Advertising, Web Analytics, and more.

+ Lab: Pandas



Data Preparation Full Package

- Part 1: Data Input and Output
  - CSV
    - CSV Output
  - Excel
    - Excel Input
    - Excel Output
- Part 2: DataFrames
  - Selection and Indexing
    - Conditional Selection
  - More Index Details
  - Multi-Index and Index Hierarchy
- Part3: Missing Data



- Part4: Group by
- Part5: Merging, Joining, and Concatenating
  - Concatenation
  - Merging
  - Joining
- Part6: Operations
  - Info on Unique Values
  - Selecting Data
  - Applying Functions

Any Questions?