Important Python Packages

Prof. Gheith Abandah

Reference: Vanderplas, Jacob T. *A Whirlwind Tour of Python*. O'Reilly Media, 2016.

Outline

- Modules and Packages
- Jupyter Notebooks
- NumPy: Numerical Python
- Pandas: Labeled Column-Oriented Data
- Matplotlib: MATLAB-style Scientific Visualization
- SciPy: Scientific Python
- Other Data Science Packages
- Exercises

Modules and Packages

- For loading **built-in** and **third-party** modules, Python provides the **`import`** statement.
- Options:
  - **Explicit import**
  - **Import with alias**
  - **Specific content import**

```
import math
math.cos(math.pi)

-1.0
```

```
import numpy as np
np.cos(np.pi)

-1.0
```

```
from math import cos, pi
cos(pi)

-1.0
```

Built-in Modules

Module	Description
`os` and `sys`	Tools for interfacing with the operating system, including navigating file directory structures and executing shell commands
`math` and `cmath`	Mathematical functions and operations on real and complex numbers
`itertools`	Tools for constructing and interacting with iterators and generators
`functools`	Tools that assist with functional programming
`random`	Tools for generating pseudorandom numbers
`pickle`	Tools for saving objects to and loading objects from disk
`json` and `csv`	Tools for reading JSON-formatted and CSV-formatted files
`urllib`	Tools for doing HTTP and other web requests

Reference: https://docs.python.org/3/library/

Importing from Third-Party Modules

- Python has excellent **ecosystem** of **free third-party modules**.
- They can be imported just as the built-in modules, but **must first be installed** on your system.
- The standard **registry** for such modules is the **Python Package Index** (PyPI): http://pypi.python.org/
- Python comes with **`pip`** (pip installs packages).

```
$ pip install jupyter numpy scipy pandas
      matplotlib scikit-learn
```

Outline

- Modules and Packages
- Jupyter Notebooks
- NumPy: Numerical Python
- Pandas: Labeled Column-Oriented Data
- Matplotlib: MATLAB-style Scientific Visualization
- SciPy: Scientific Python
- Other Data Science Packages
- Exercises

Jupyter Notebook

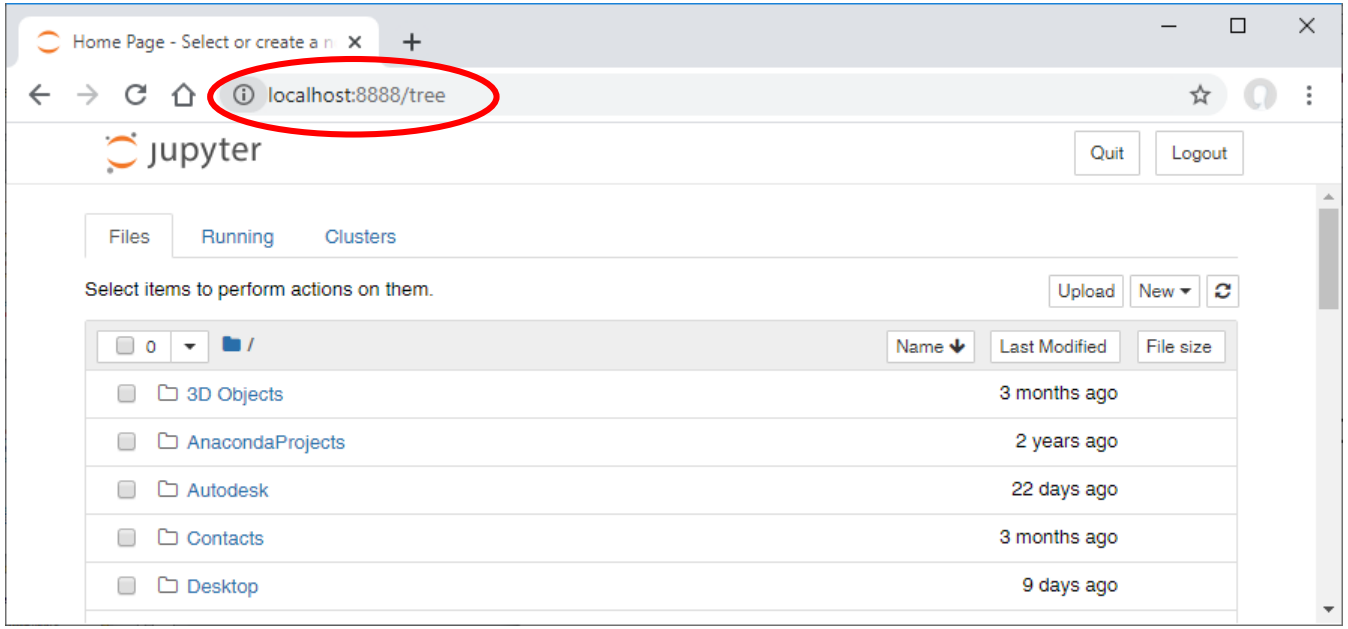
- The Jupyter Notebook is an open-source **web application** that allows you to create and share **documents** that contain live **code**, **equations**, **visualizations** and **narrative text**.

- **Website**: http://jupyter.org/

- **Tutorial** on Jupyter's website: https://jupyter-notebook.readthedocs.io/en/stable/notebook.html

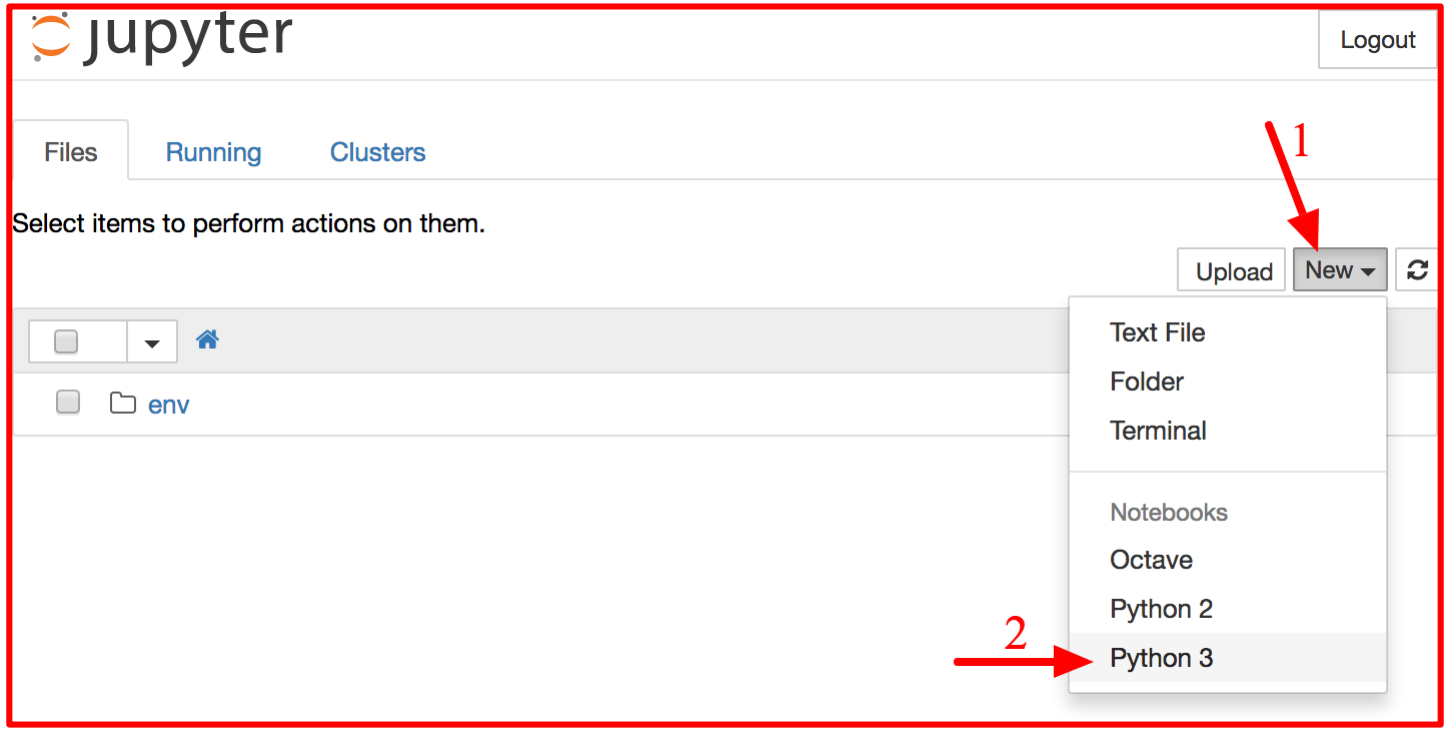
Starting Jupyter Notebook

- To start Jupyter notebooks **server** from your OS command prompt enter: `C:\>jupyter notebook`
- Then **browse** to http://localhost:8888/.



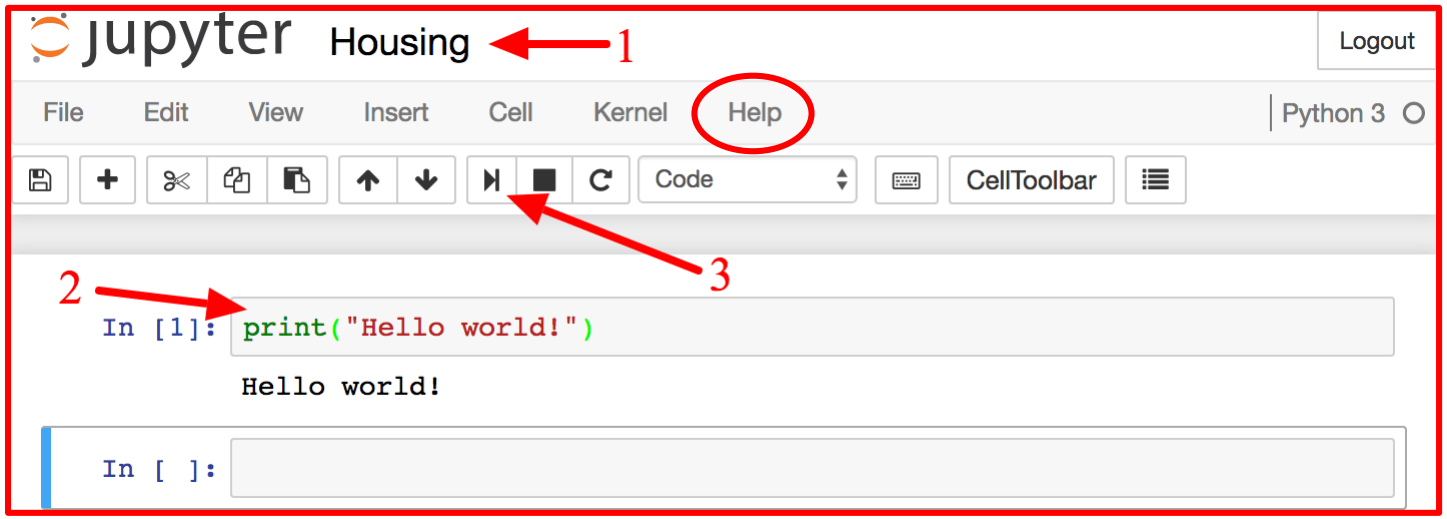
Creating Python Notebook

- Click on the **New** button and select the appropriate Python version.



Working with Notebooks

- A notebook contains a list of **cells**. Each cell can contain executable code or formatted text.
- To change the notebook **name**, click on the **title bar**.
- Type `print("Hello world!")` in the first cell, and click on the **play** button. The **result** is displayed below the cell.
- Check the **User Interface Tour** from Jupyter's **Help menu**.



Outline

- Modules and Packages
- Jupyter Notebooks
- NumPy: Numerical Python
- Pandas: Labeled Column-Oriented Data
- Matplotlib: MATLAB-style Scientific Visualization
- SciPy: Scientific Python
- Other Data Science Packages
- Exercises

NumPy: Numerical Python

- NumPy is the fundamental package for **fast scientific computing** with Python. It contains:
  - A powerful **N-dimensional array** object
  - Sophisticated (**broadcasting**) functions
  - Useful **linear algebra**, **Fourier transform**, and **random** number capabilities
- **Website**: http://www.numpy.org/
- Also, check the **tutorial** on Learn Python: https://www.learnpython.org/en/Numpy_Arrays

ndarray Creation

- **Vectors** can be created using **`arange()`**.

```
>>> import numpy as np
>>> x = np.arange(1, 5)
>>> x
array([1, 2, 3, 4])
```

- **Vectors** and **arrays** can be created using **`zeros()`** and **`ones()`**.

```
>>> y = np.zeros(5)
>>> y
array([0., 0., 0., 0., 0.])
>>> z = np.ones((3, 2))
>>> z
array([[1., 1.],
       [1., 1.],
       [1., 1.]])
```

ndarray Operations

- Allows efficient elementwise operations (**broadcasting**).

```
>>> x + x
array([2, 4, 6, 8])
>>> x ** 2
array([ 1,  4,  9, 16], dtype=int32)
```

- Also includes:
  - Reshape
  - Transpose
  - Inverse
  - etc.

```
>>> M = x.reshape((2, 2))
>>> M
array([[1, 2],
       [3, 4]])
>>> M.T
array([[1, 3],
       [2, 4]])
>>> np.linalg.inv(M)
array([[-2. ,  1. ],
       [ 1.5, -0.5]])
```

Outline

- Modules and Packages
- Jupyter Notebooks
- NumPy: Numerical Python
- Pandas: Labeled Column-Oriented Data
- Matplotlib: MATLAB-style Scientific Visualization
- SciPy: Scientific Python
- Other Data Science Packages
- Exercises

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

Creating Data Frame from Dictionary

```
dict = {"country": ["Brazil", "Russia", "India", "China"],
        "capital": ["Brasilia", "Moscow", "New Dehli", "Beijing"],
        "area": [8.516, 17.10, 3.286, 9.597],
        "population": [200.4, 143.5, 1252, 1357] }

import pandas as pd
brics = pd.DataFrame(dict)
print(brics)
```

	country	capital	area	population
0	Brazil	Brasilia	8.516	200.4
1	Russia	Moscow	17.100	143.5
2	India	New Dehli	3.286	1252.0
3	China	Beijing	9.597	1357.0

Creating Data Frame from File

```
# Import pandas as pd
import pandas as pd

# Import the cars.csv data: cars
cars = pd.read_csv('cars.csv')

# Print out cars
print(cars)
```

	Unnamed: 0	cars_per_cap	country	drives_right
0	US	809	United States	True
1	AUS	731	Australia	False
2	JAP	588	Japan	False
3	IN	18	India	False
4	RU	200	Russia	True
5	MOR	70	Morocco	True
6	EG	45	Egypt	True

Data Frame Operations

- Data Frames have many powerful **operations** such as **`sum()`**, **`info()`** and **`describe()`.**

```
>>> brics['population'].sum()
2952.9
>>> brics.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4 entries, 0 to 3
Data columns (total 4 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   country     4 non-null      object
 1   capital     4 non-null      object
 2   area        4 non-null      float64
 3   population  4 non-null      float64
dtypes: float64(2), object(2)
memory usage: 256.0+ bytes
>>> brics.describe()
              area   population
count    4.000000     4.000000
mean     9.624750   738.225000
std      5.694711   655.693223
min      3.286000   143.500000
25%      7.208500   186.175000
50%      9.056500   726.200000
75%     11.472750  1278.250000
max     17.100000  1357.000000
```

Outline

- Modules and Packages
- Jupyter Notebooks
- NumPy: Numerical Python
- Pandas: Labeled Column-Oriented Data
- Matplotlib: MATLAB-style Scientific Visualization
- SciPy: Scientific Python
- Other Data Science Packages
- Exercises

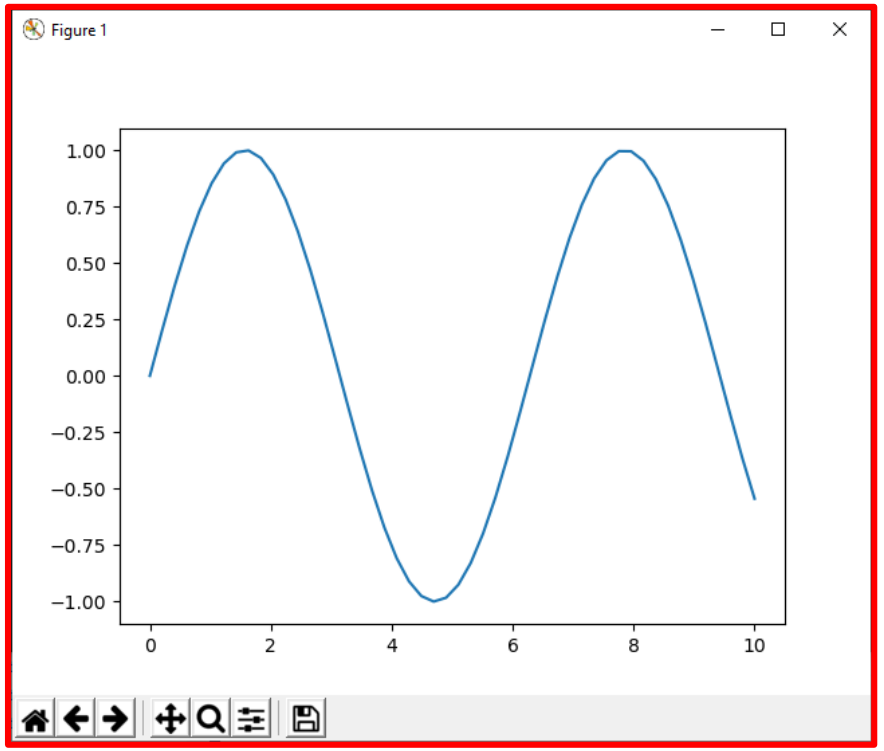
Matplotlib: MATLAB-style Scientific Visualization

- Matplotlib is a Python **plotting library** which produces publication **quality figures** in a variety of hardcopy formats.

- **Website**: https://matplotlib.org/
- Also, check the **tutorial** package website: https://matplotlib.org/tutorials/introductory/pyplot.html

Matplotlib Example

```
import numpy as np
import matplotlib.pyplot as plt
x = np.linspace(0, 10) # range of values from 0 to 10
y = np.sin(x) # sine of these values
plt.plot(x, y); # plot as a line
plt.show()
```



Outline

- Modules and Packages
- Jupyter Notebooks
- NumPy: Numerical Python
- Pandas: Labeled Column-Oriented Data
- Matplotlib: MATLAB-style Scientific Visualization
- SciPy: Scientific Python
- Other Data Science Packages
- Exercises

SciPy: Scientific Python

- Collection of **scientific functionality** that is built on NumPy.
  - `scipy.fftpack` **Fast Fourier** transforms
  - `scipy.integrate` Numerical **integration**
  - `scipy.interpolate` Numerical **interpolation**
  - `scipy.linalg` **Linear algebra** routines
  - `scipy.optimize` **Numerical optimization** of functions
  - `scipy.sparse` **Sparse matrix** storage and linear algebra
  - `scipy.stats` **Statistical analysis** routines
- **Website**: https://www.scipy.org/

Outline

- Modules and Packages
- Jupyter Notebooks
- NumPy: Numerical Python
- Pandas: Labeled Column-Oriented Data
- Matplotlib: MATLAB-style Scientific Visualization
- SciPy: Scientific Python
- Other Data Science Packages
- Exercises

Other Data Science Packages

- Scikit-Learn for **machine learning**
- Scikit-Image for **image analysis**
- StatsModels for **statistical modeling**
- AstroPy for **astronomy** and astrophysics
- NiPy for **neuro-imaging**
- and many, many more.

Outline

- Modules and Packages
- Jupyter Notebooks
- NumPy: Numerical Python
- Pandas: Labeled Column-Oriented Data
- Matplotlib: MATLAB-style Scientific Visualization
- SciPy: Scientific Python
- Other Data Science Packages
- Exercises

Exercises from http://www.practicepython.org/

- **Ex1**: Create a program that asks the user to enter their name and their age. Print out a message addressed to them that tells them the year that they will turn 100 years old.
- **Ex3**: Take a list, say for example this one: a = [1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89] and write a program that prints out all the elements of the list that are less than 5.
- **Ex5**: Take two lists, say for example these two: a = [1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89] and b = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13] and write a program that returns a list that contains only the elements that are common between the lists (without duplicates). Make sure your program works on two lists of different sizes.
- **Ex28**: Implement a function that takes as input three variables, and returns the largest of the three. Do this without using the Python max() function!

Exercises from https://www.w3resource.com/python-exercises/

- **Class 9**: Write a Python class which has two methods get_String and print_String. get_String accept a string from the user and print_String print the string in upper case.
- **Class 10**: Write a Python class named Rectangle constructed by a length and width and a method which will compute the area of a rectangle.

Exercises from https://www.w3resource.com/python-exercises/

- **NumPy 3**: Create a 3x3 matrix with values ranging from 2 to 10.
- **NumPy 73**: Write a Python program to create an array of (3, 4) shape, multiply every element value by 3 and display the new array.
- **Pandas DataFrame 4 and 5**: Write a Python program to get the first 3 rows and the 'name' and 'score' columns from the following DataFrame.

  Sample Python dictionary data and list labels:

```
exam_data = {'name': ['Anastasia', 'Dima', 'Katherine', 'James',
'Emily', 'Michael', 'Matthew', 'Laura', 'Kevin', 'Jonas'],
'score': [12.5, 9, 16.5, np.nan, 9, 20, 14.5, np.nan, 8, 19],
'attempts': [1, 3, 2, 3, 2, 3, 1, 1, 2, 1],
'qualify': ['yes', 'no', 'yes', 'no', 'no', 'yes', 'yes', 'no',
'no', 'yes']}
labels = ['a', 'b', 'c', 'd', 'e', 'f', 'g', 'h', 'i', 'j']
```

Summary

- Modules and Packages
- Jupyter Notebooks
- NumPy: Numerical Python
- Pandas: Labeled Column-Oriented Data
- Matplotlib: MATLAB-style Scientific Visualization
- SciPy: Scientific Python
- Other Data Science Packages
- Exercises