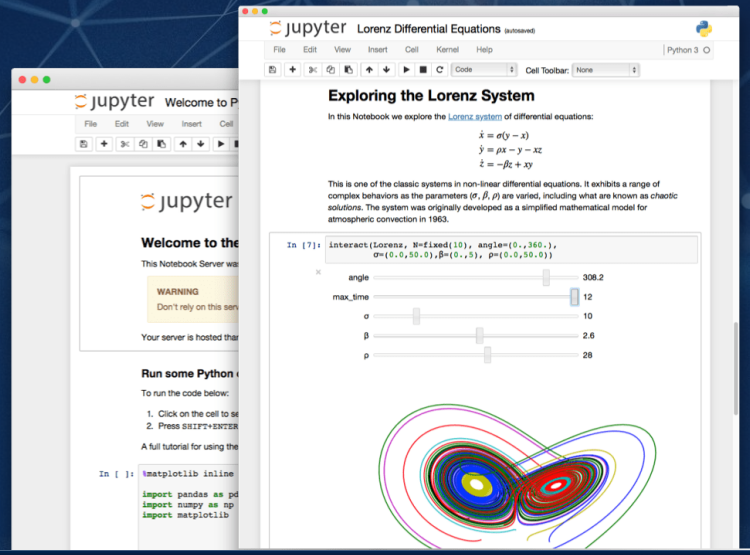
Overview Jupyter notebook



What is a Jupyter notebook?

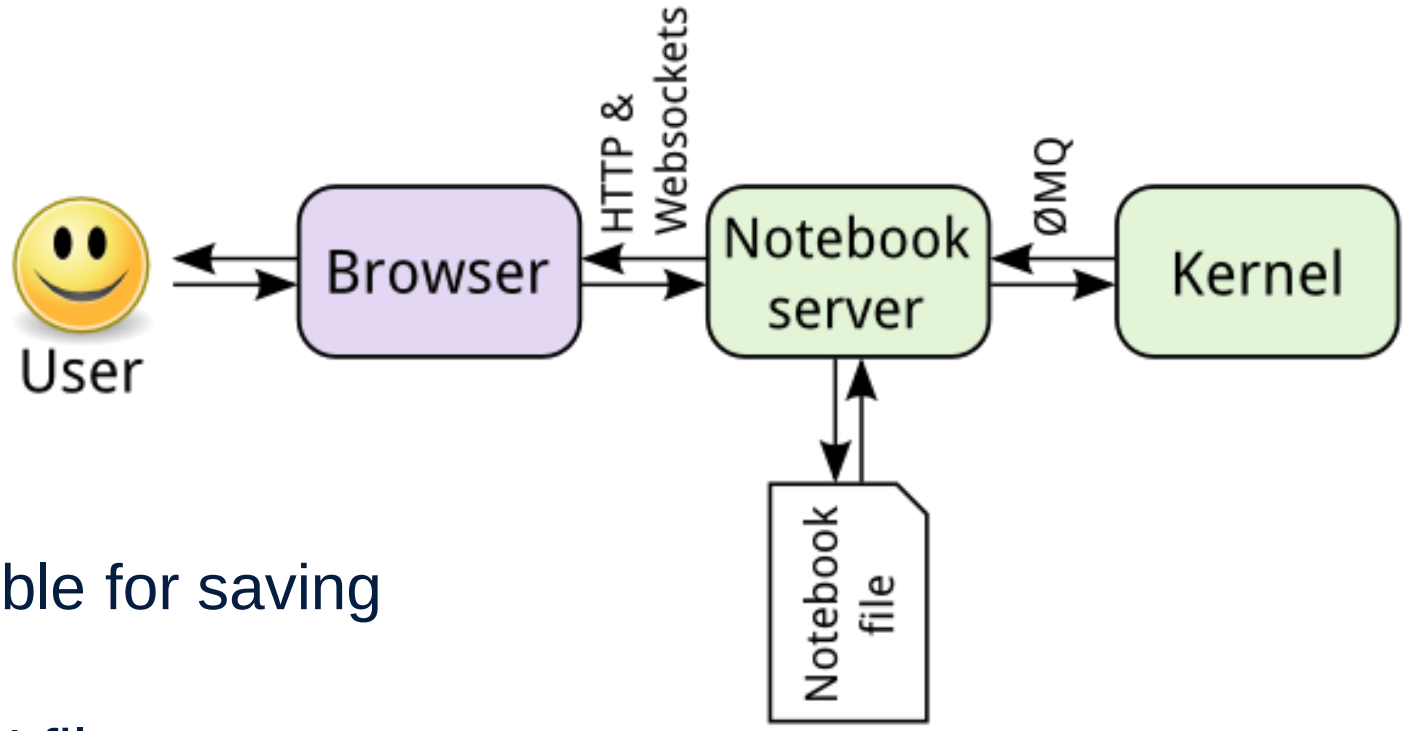
- Open source web application
- Development started in 2014 as spin-off from IPython

- Notebooks denotes documents that contain both
  - Code, and rich text elements (figures, links, equations, etc)

- Notebook documents produced by the Jupyter Notebook App
  - Client-server application to edit and run notebooks
  - Two main components: the kernels and a dashboard

- Jupyter is a loose acronym meaning Julia, Python and R
- Nowadays, Jupyter supports many other languages

Jupyter is language-agnostic



- The **notebook server** is responsible for saving and loading notebooks
- The notebook is saved as a JSON file
- The **kernel** gets sent cells of code to execute

Crash-course in Python 3.x

Spring 2020 - **week #1**

EPFL

Brief history of Python

- Open source programming language
- Conceived in the Netherlands by Guido van Rossum
- Implementation started in December 1989

- *Python 2.x is legacy, Python 3.x is the present & future of the language*
- Python 2.0 released on October 16, 2000 (current: 2.7.15)
- Python 3.0 released on December 3, 2008 (current: 3.7.3)

- High-level, portable, interpreted, object-oriented

Why Python?

- Easy, Fast & Broad
- Python Has a Healthy, Active and Supportive Community
  - Plenty of documentation, guides, tutorials and more
  - Incredibly active developer community
- Python Has Some Great Corporate Sponsors
  - Google!
- Python has Extensive Libraries

Python 3.x references

- https://docs.python.org/3.7/tutorial/
- Books include:
  - Learning Python by Mark Lutz
  - Python Essential Reference by David Beazley
  - Python for Data Analysis by William McKinney
  - https://github.com/justmarkham/DAT8#python-resources
- Python Quick Reference
  - https://github.com/justmarkham/python-reference

Common pitfalls in Python

1. Incorrect indentation, tabs and spaces
   - Never use tabs, only spaces (4)
2. Using a mutable value as a default value
   - ```
     def foo(param=[]):
         param.append(10)
         return(param)
     ```
3. Scoping (local vs global variable)
   - ```
     bar = 42
     def foo():
         print(bar)
         bar = 0
     foo()
     ```
4. Copying vs referencing (mutable types)
   - ```
     a    = [1, 2 ,3]
     b    = a
     a[1] = 4

     print(b)
     ```
     ```

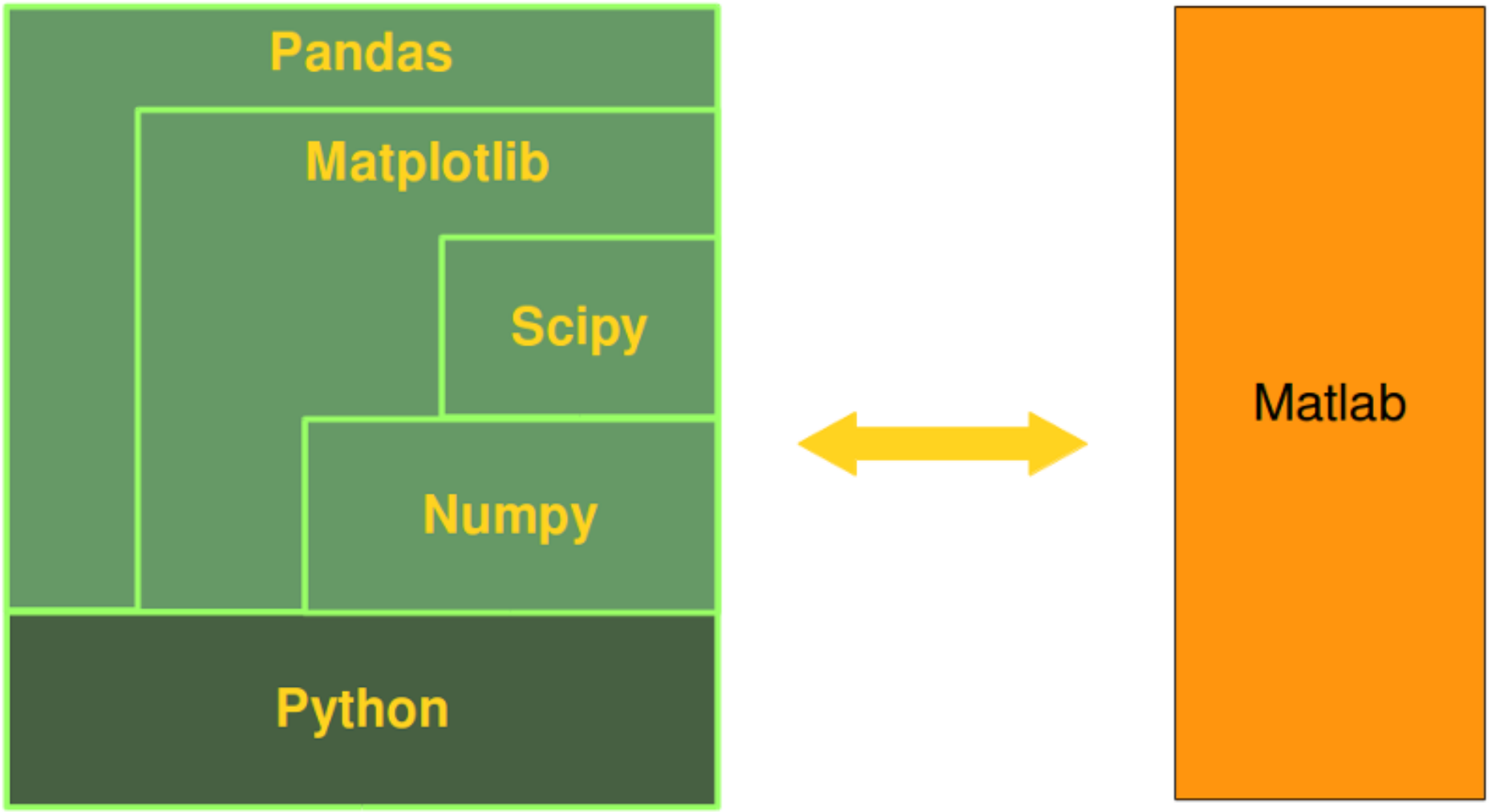
A few exercises in Python

- Open the **DSLab Week 1-1** Jupyter notebook
  ./notebooks/DSLab_week1_1.ipynb

1. Generators
2. List comprehension
3. Lambda Operator and the functions map() and reduce()
4. Lists of characters and the functions join() and append()

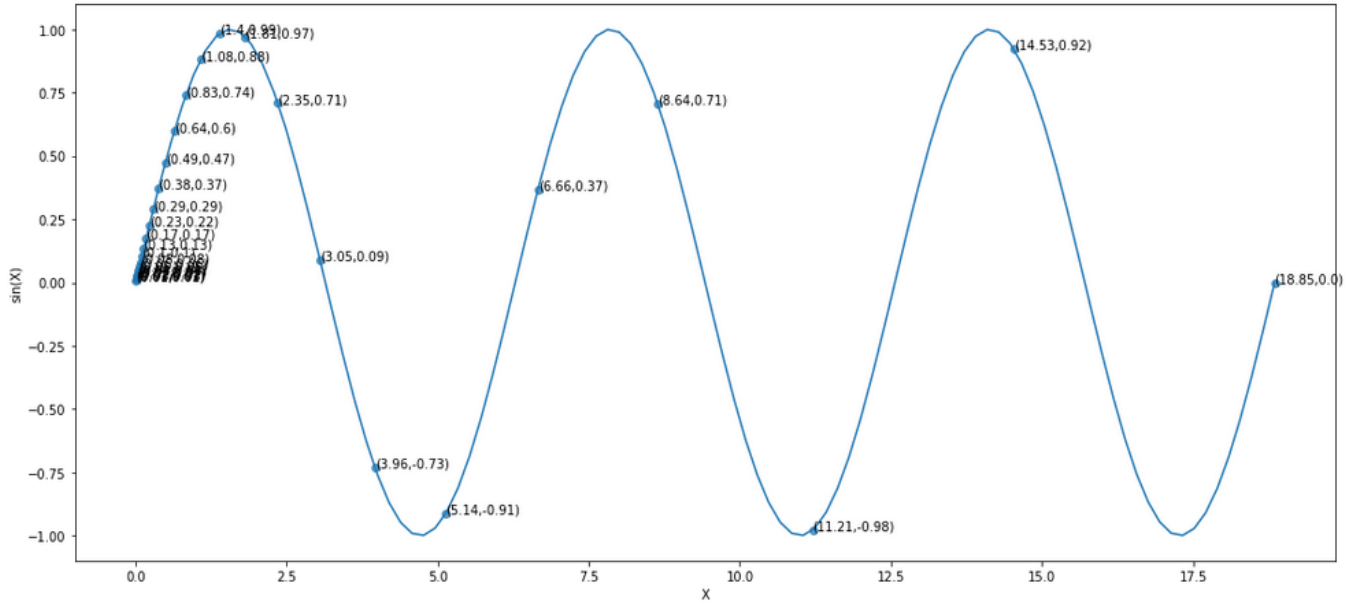
NumPy, Pandas, scikit-learn & Matplotlib

Python alternative to Matlab



Python libraries for (aspiring) data scientists

- **NumPy**: Work with large multidimensional arrays and matrices
- **Pandas**: Do data wrangling
- **Matplotlib**: Make line graphs, pie charts, histograms, etc
- **Scikit-learn**: Build machine learning models



NumPy & Data Types

- Core library for scientific computing in Python
- Provides a high-performance multidimensional array object, and tools for working with these arrays
- A **NumPy array** (ndarray) is a grid of values, all of the same type
  - indexed by a tuple of nonnegative integers
  - the *shape* of an array is the size of the array along each dimension

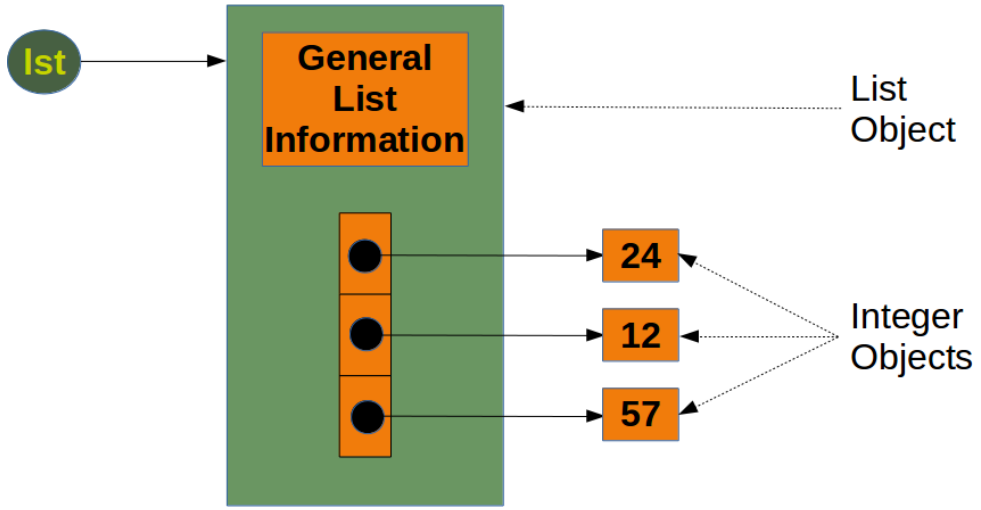
```
1 import numpy as np
2 a = np.array([[1,2,3], [4,5,6]])
3 print("Shape of matrix a: ", a.shape)
4 print("Value of a[0,2]:", a[0,2])
```

```
Shape of matrix a:  (2, 3)
Value of a[0,2]: 3
```

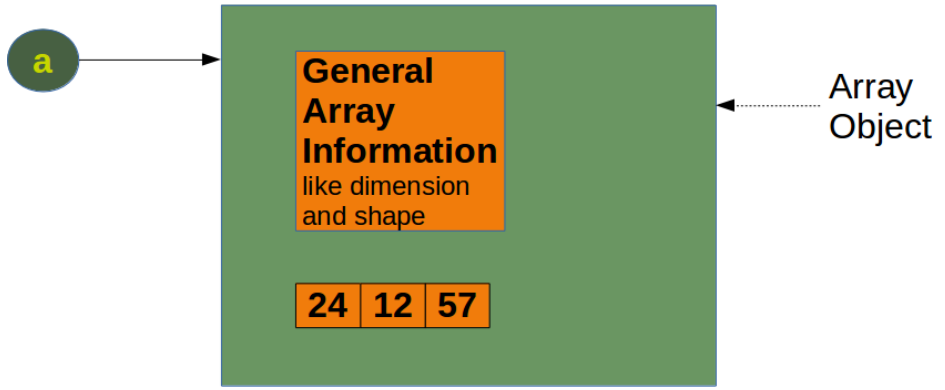
Python lists vs NumPy arrays

1. **Functionality**: SciPy and NumPy have optimized functions such as linear algebra operations built in
2. **Performance**: need for speed and are faster than lists
3. **Size**: Numpy data structures take up less space
   a. list: 64 + n*8 + n*28 bytes
   b. ndarray: 96 + n*8 bytes

a.



b.



Relevant NumPy functions

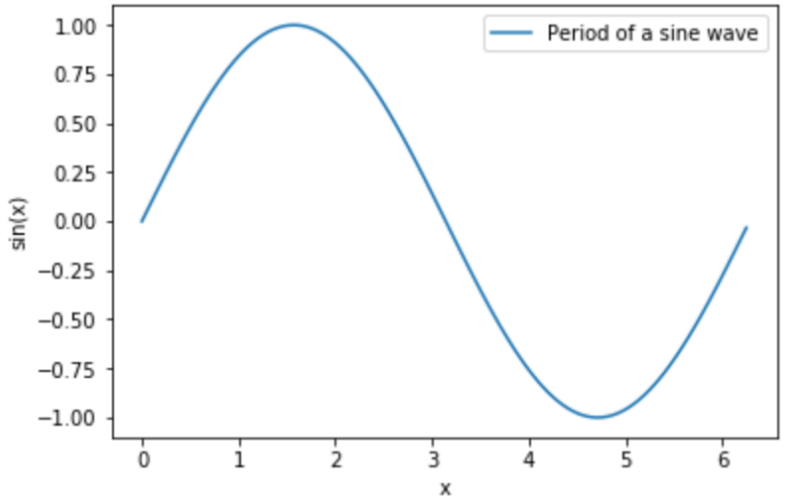
- **arange**([start,] stop[, step], [, dtype=None])
- **linspace**(start, stop, num=50, endpoint=True, retstep=False)
  - Checkout logspace & geomspace
- **reshape**(array, newshape, order='C')
- **copy**(obj, order='K')

+ Indexing and slicing arrays

What is Matplotlib?

- Plotting library

```
1  import numpy as np
2  from matplotlib import pyplot as plt
3
4  %matplotlib inline
5
6  x = np.arange(0, 2*np.pi, 0.05, np.float32)
7  y = np.sin(x)
8
9  plt.plot(x,y)
10
11 plt.xlabel("x")
12 plt.ylabel("sin(x)")
13 plt.legend(['Period of a sine wave'])
14 plt.show()
15
```



Relevant Matplotlib functions

- **Functions**: plot, subplot, scatter and annotate

- %matplotlib {inline, notebook}
- matplotlib.get_backend()

Other visualization libraries

1. **Seaborn**: Python's Statistical Data Visualization Library
   - high-level interface to draw statistical graphics
   - https://seaborn.pydata.org/

2. **Bokeh**: Python interactive visualization library
   - interactive plots, dashboards, and data applications
   - https://bokeh.pydata.org/en/latest/

Pandas & Pandas Data Frames

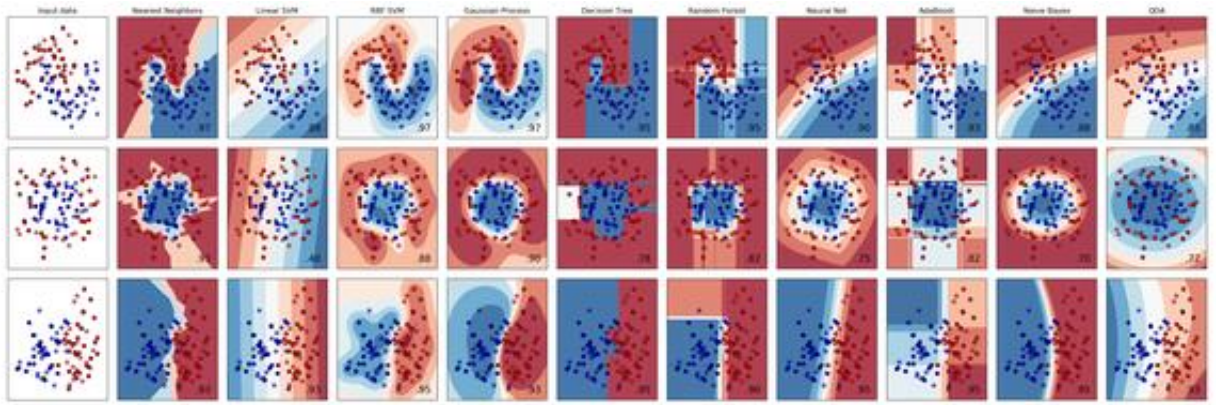
- Powerful & flexible data munging library
- Pandas was built on NumPy
  - NumPy stores your data in arrays
  - Pandas takes the NumPy Array…

    … and gives you a labeled index to it
- Pandas DataFrame is a 2-D labeled data structure with columns of potentially different types
  - Basically, dictionary-based NumPy arrays
- Recommended reading (before doing the exercises)
  - https://chrisalbon.com/python/data_wrangling/pandas_apply_operations_to_groups/

Scikit-learn: Machine Learning in Python

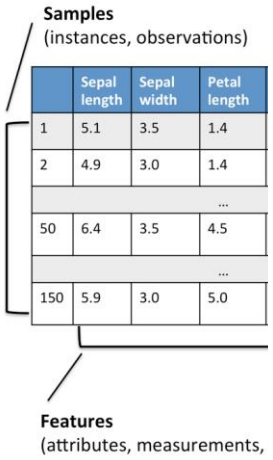
- http://scikit-learn.org/stable/index.html
- Open source, built on NumPy, SciPy, and matplotlib

1. Classification
2. Regression (Logistic Regression)
3. Clustering (KMeans)
4. Dimensionality reduction (PCA)
5. Model selection
6. Preprocessing

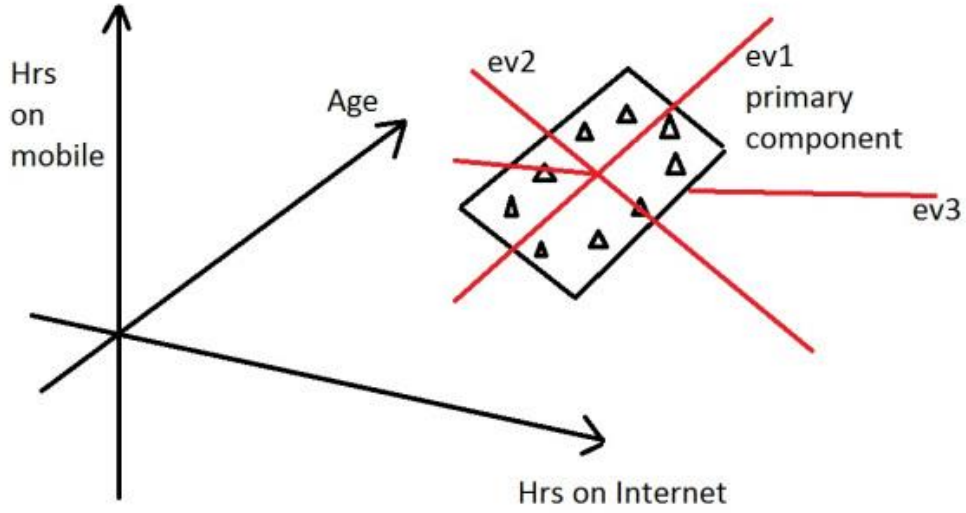


Principal Component Analysis (PCA)

- sklearn.decomposition.PCA()
- (Linear) dimensionality reduction using SVD of the data to project it to a lower dimensional space
- Maximize the variance in the low-dimensional representation
- Take e.g. the Iris dat
  - Example

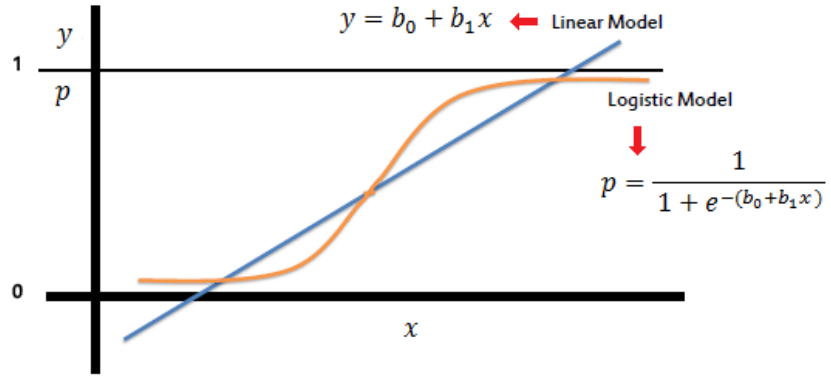


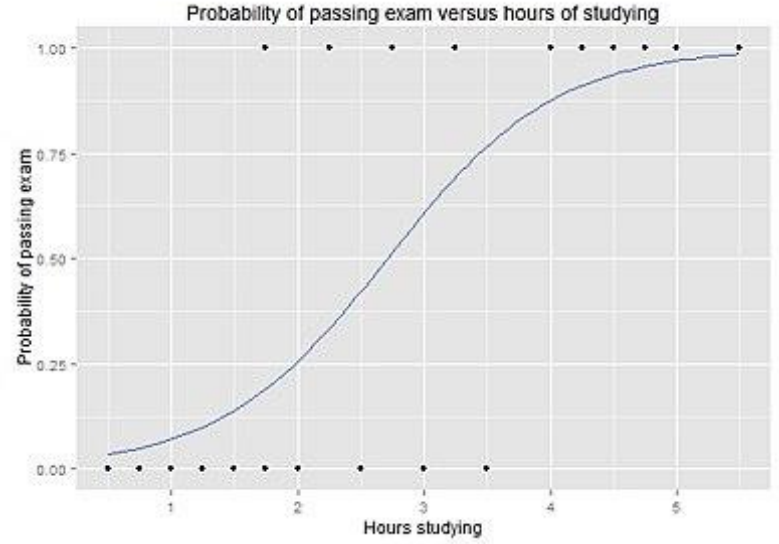
	Sepal length	Sepal width	Petal length
1	5.1	3.5	1.4
2	4.9	3.0	1.4
...			
50	6.4	3.5	4.5
...			
150	5.9	3.0	5.0



Logistic Regression

- sklearn.linear_model.LogisticRegression()
- Model used for prediction of the probability of occurrence of an event by fitting data to a logistic curve
- Standard industry workhorse!

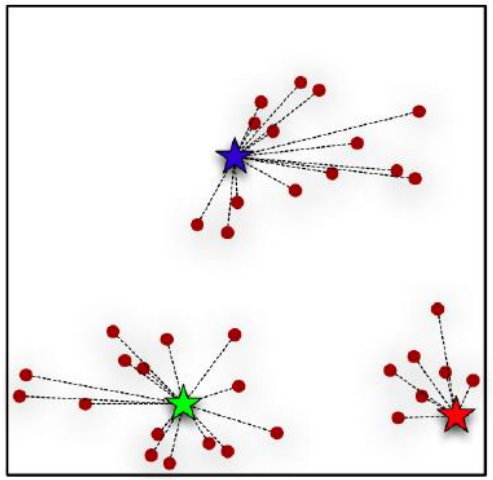


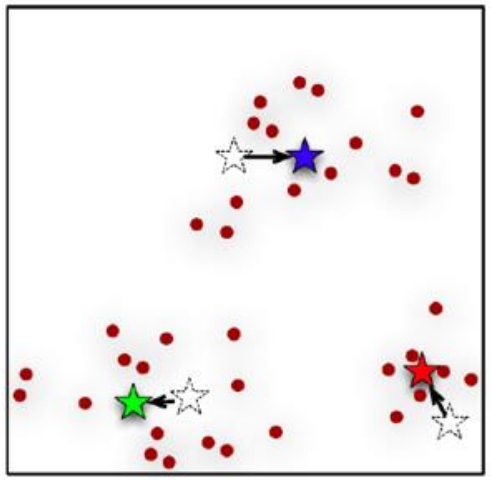


- Chaining a PCA and a logistic regression

Kmeans – Clustering algorithm

- sklearn.cluster.KMeans()
- Find similarity groups in a data, called clusters
- Randomize K points, then two-step iterative algorithm:
  - 1. Cluster assignment step
  - 2. Move centroid step.





Exercises … a bit harder/longer

Open **DSLab Week 1** Jupyter notebooks in Renku

1. ./notebooks/DSLab_week1-2.ipynb
   a. NumPy arrays & Matplotlib
2. ./notebooks/DSLab_week1-3.ipynb
   a. Getting familiar with Pandas
   b. Simple Machine Learning problems

Thank you!