EECS 510: SOCIAL MEDIA MINING
SPRING 2016

# Data Mining Essentials 2: Data Mining in Practice, with Python

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# Outline

- Why Python?
- Intro to Python
- Intro to Scikit-Learn
- Unsupervised Learning
  - Demo on PCA, K-Means
- Supervised Learning
  - Demo on Linear Regression, Logistic Regression

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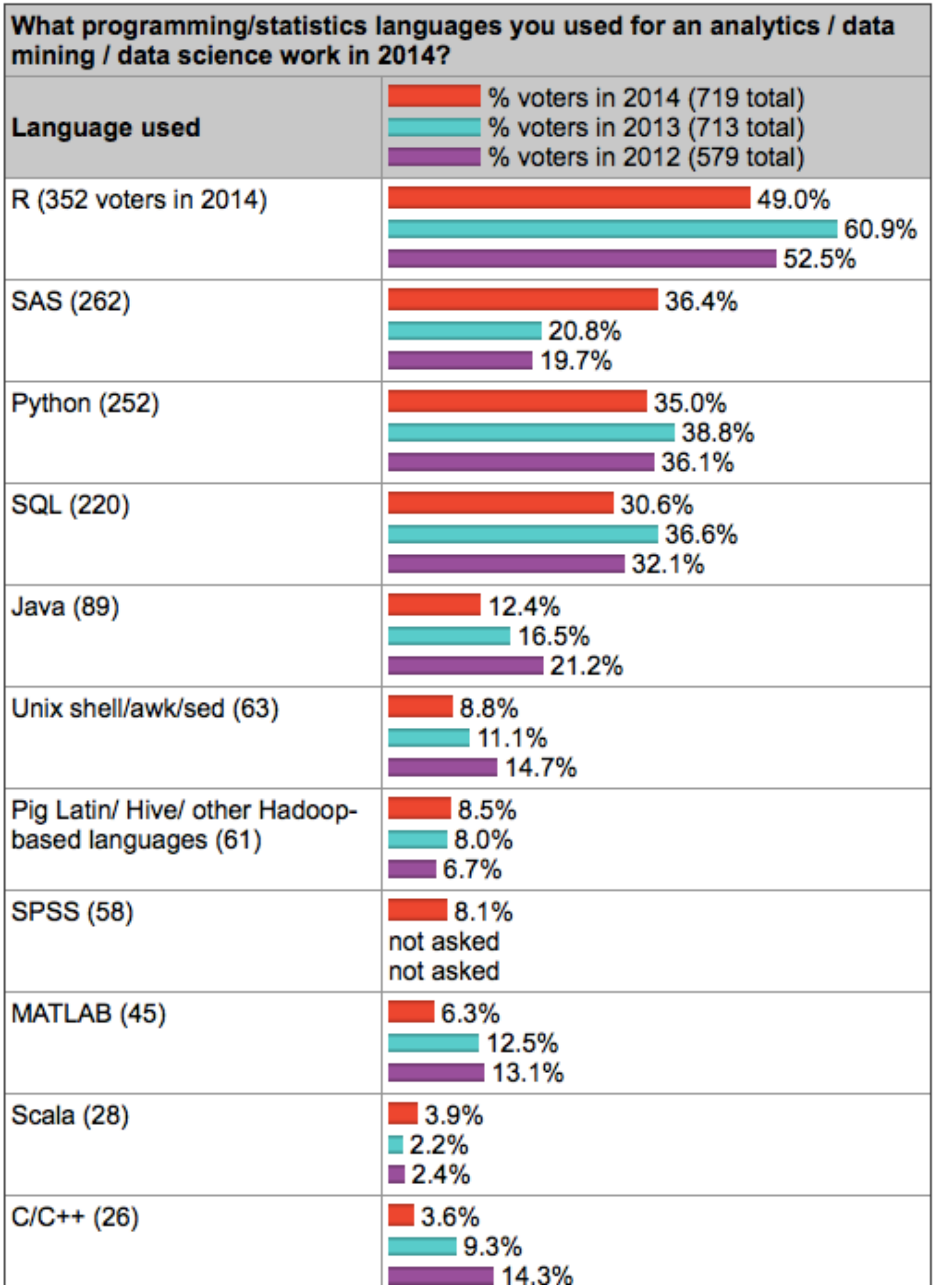
- **Why Python?**

**What programming language do you use for data mining?**



**What programming/statistics languages you used for an analytics / data mining / data science work in 2014?**

| Language used | 🟥 % voters in 2014 (719 total) | 🟦 % voters in 2013 (713 total) | 🟪 % voters in 2012 (579 total) |
|---|---|---|---|
| R (352 voters in 2014) | 49.0% | 60.9% | 52.5% |
| SAS (262) | 36.4% | 20.8% | 19.7% |
| Python (252) | 35.0% | 38.8% | 36.1% |
| SQL (220) | 30.6% | 36.6% | 32.1% |
| Java (89) | 12.4% | 16.5% | 21.2% |
| Unix shell/awk/sed (63) | 8.8% | 11.1% | 14.7% |
| Pig Latin/ Hive/ other Hadoop-based languages (61) | 8.5% | 8.0% | 6.7% |
| SPSS (58) | 8.1% | not asked | not asked |
| MATLAB (45) | 6.3% | 12.5% | 13.1% |
| Scala (28) | 3.9% | 2.2% | 2.4% |
| C/C++ (26) | 3.6% | 9.3% | 14.3% |

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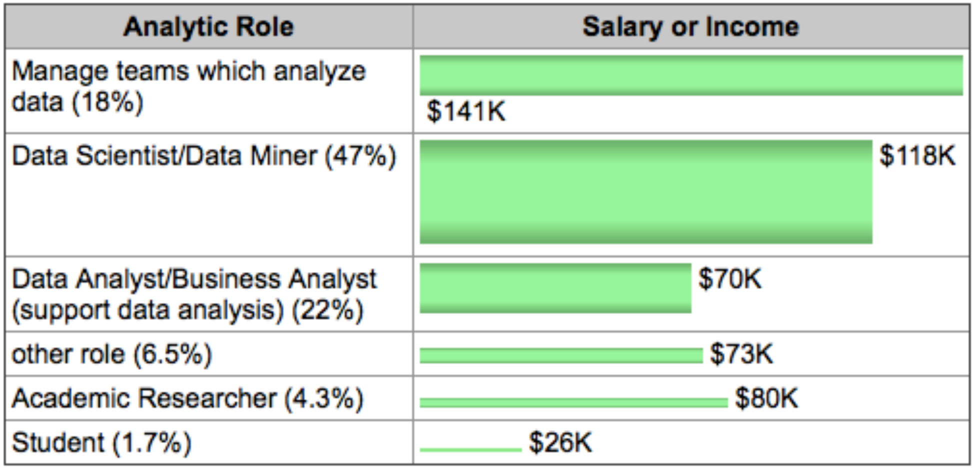
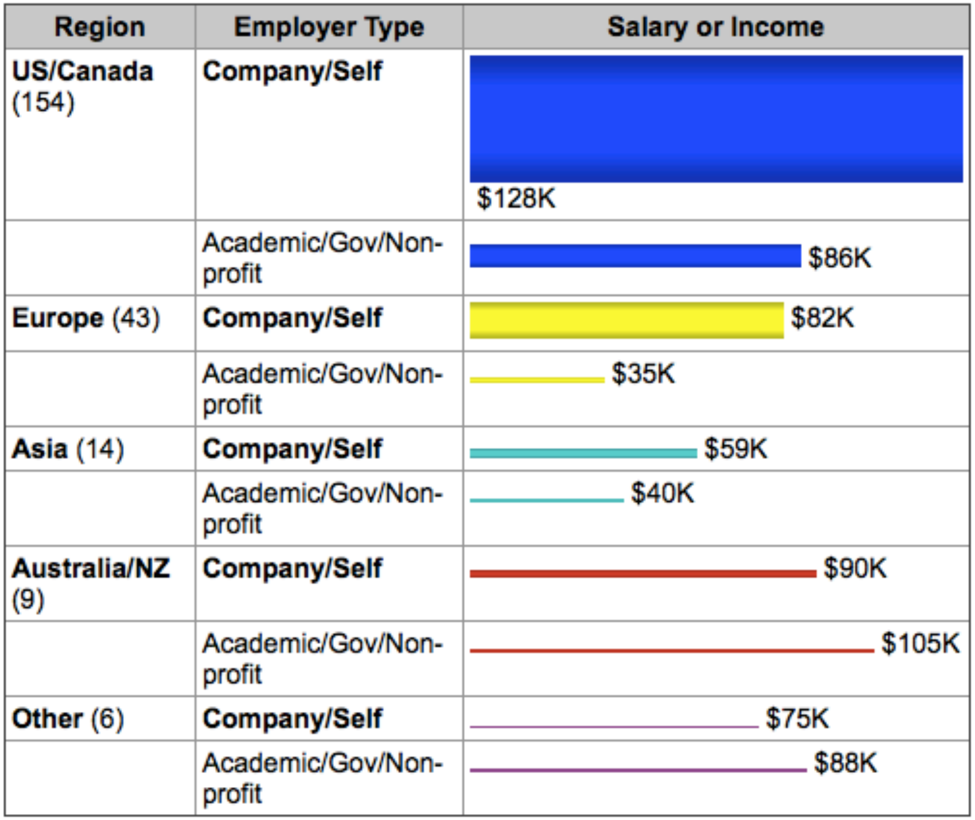
Source from: http://www.kdnuggets.com/polls/index.html

## How much is your salary as analytics, data mining, data science professionals?



| Analytic Role | Salary or Income |
|---|---|
| Manage teams which analyze data (18%) | $141K |
| Data Scientist/Data Miner (47%) | $118K |
| Data Analyst/Business Analyst (support data analysis) (22%) | $70K |
| other role (6.5%) | $73K |
| Academic Researcher (4.3%) | $80K |
| Student (1.7%) | $26K |



| Region | Employer Type | Salary or Income |
|---|---|---|
| **US/Canada** (154) | **Company/Self** | $128K |
| | Academic/Gov/Non-profit | $86K |
| **Europe** (43) | **Company/Self** | $82K |
| | Academic/Gov/Non-profit | $35K |
| **Asia** (14) | **Company/Self** | $59K |
| | Academic/Gov/Non-profit | $40K |
| **Australia/NZ** (9) | **Company/Self** | $90K |
| | Academic/Gov/Non-profit | $105K |
| **Other** (6) | **Company/Self** | $75K |
| | Academic/Gov/Non-profit | $88K |

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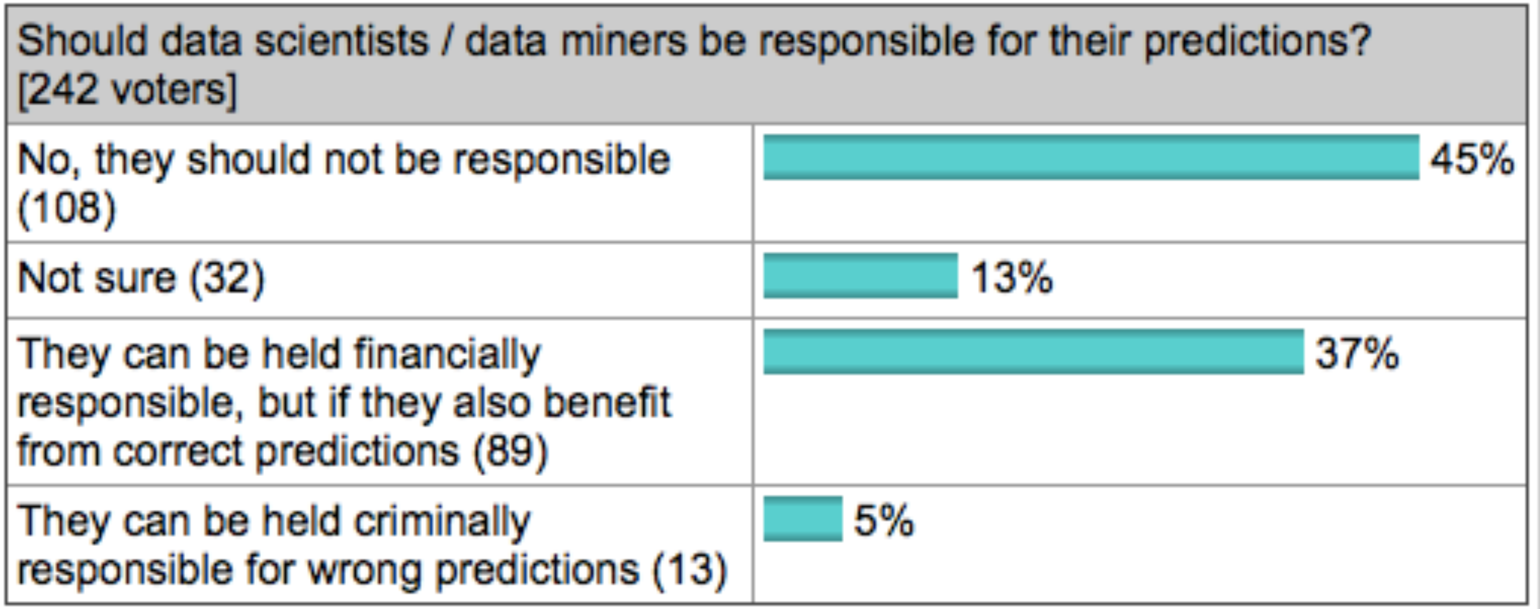
Source from: http://www.kdnuggets.com/polls/index.html

## Should data scientist / data miners be responsible for their predictions?



Should data scientists / data miners be responsible for their predictions? [242 voters]

| | |
|---|---|
| No, they should not be responsible (108) | 45% |
| Not sure (32) | 13% |
| They can be held financially responsible, but if they also benefit from correct predictions (89) | 37% |
| They can be held criminally responsible for wrong predictions (13) | 5% |

Source from: http://www.kdnuggets.com/polls/index.html

# Why Python?

- **Why Python?**

  **Not**

**Think about the scientist's needs:**

- Get data (simulation, experiment control)
- Manipulate and process data.
- Visualize results... to understand what we are doing!
- Communicate results: produce figures for reports or publications, write presentations.

# Why Python?

- **Why Python?**

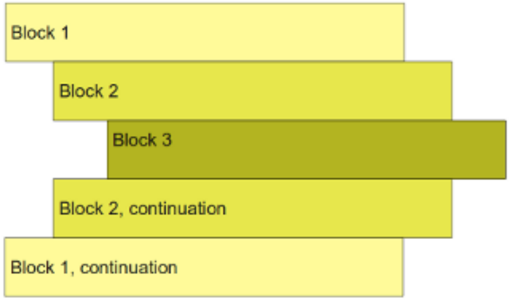
  **Not**

  – Easy
    - Easy to learn, easily readable
    - Scientists first, programmers second
  – Efficient
    - Managing memory is easy – if you just don't care
  – A single Language for everything
    - Avoid learning a new software for each new problem

# More to Take Away

- Free distribution from [http://www.python.org](http://www.python.org)
- Known for it’s “batteries included” philosophy

  Similar to R, Python has a fantastic community around it and, luckily for you, this community can write
- Two popular versions, 2.7 or 3.x
- A single-click installer: Enthought Canopy
- Prepare yourself for code indentation heaven



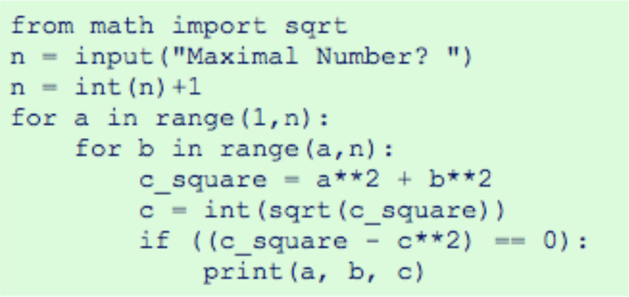
Block 1

Block 2

Block 3

Block 2, continuation

Block 1, continuation



```
from math import sqrt
n = input("Maximal Number? ")
n = int(n)+1
for a in range(1,n):
    for b in range(a,n):
        c_square = a**2 + b**2
        c = int(sqrt(c_square))
        if ((c_square - c**2) == 0):
            print(a, b, c)
```

# All the Good Modules

- **numpy, scipy**: basics for almost everything
- **Matplotlib**, a Python 2D plotting library http://matplotlib.org
- **NLTK**, Natual Language Toolkit http://www.nltk.org
- **Pandas**, Python Data Analysis Library http://pandas.pydata.org
- **mrjob**, route to writing MapReduce jobs https://pythonhosted.org/mrjob/
- **IPython,** Interactive console with IDE-like features http://ipython.org
- **Scikit-Learn**, ML resource and library http://scikit-learn.org/dev/index.html
- **Theano/Pylearn2**, deep learning

  http://deeplearning.net/software/theano/

  http://deeplearning.net/software/pylearn2/
- More: mlpy, PyBrain, Orange, Scrapy, …

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# The Use of Python: Simple demos

0 – Python Intro.ipynb

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# What is Scikit-learn

- A Python Machine Learning Library
- Focused on modeling data
- Developed by David Cournapeau as a Google summer of code project in 2007.
- First public release (v0.1 beta) published in late January 2010.
- Now has more than 30 active contributors and has had paid sponsorship from INRIA, Google, Tinyclues and the Python Software Foundation.
- The library is built upon the SciPy that must be installed before you can use scikit-learn.

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# The use of Scikit-Learn: unsupervised learning demos

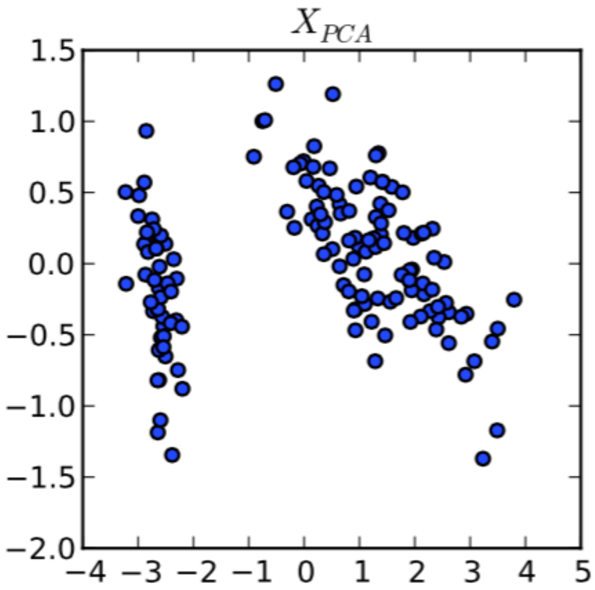
# PCA Summary

- PCA projects to axis with greatest variance
- Often provides good first insight into dataset

$$\bar{X} \leftarrow X - \mathrm{mean}(X) \qquad \bar{X} \in \mathbb{R}^{n \times N}$$

$$W \leftarrow \mathrm{PCA}(\bar{X}, 2) \qquad W \in \mathbb{R}^{N \times M}$$

$$X_{\mathrm{PCA}} \leftarrow \bar{X} \cdot W \qquad X_{\mathrm{PCA}} \in \mathbb{R}^{n \times M}$$

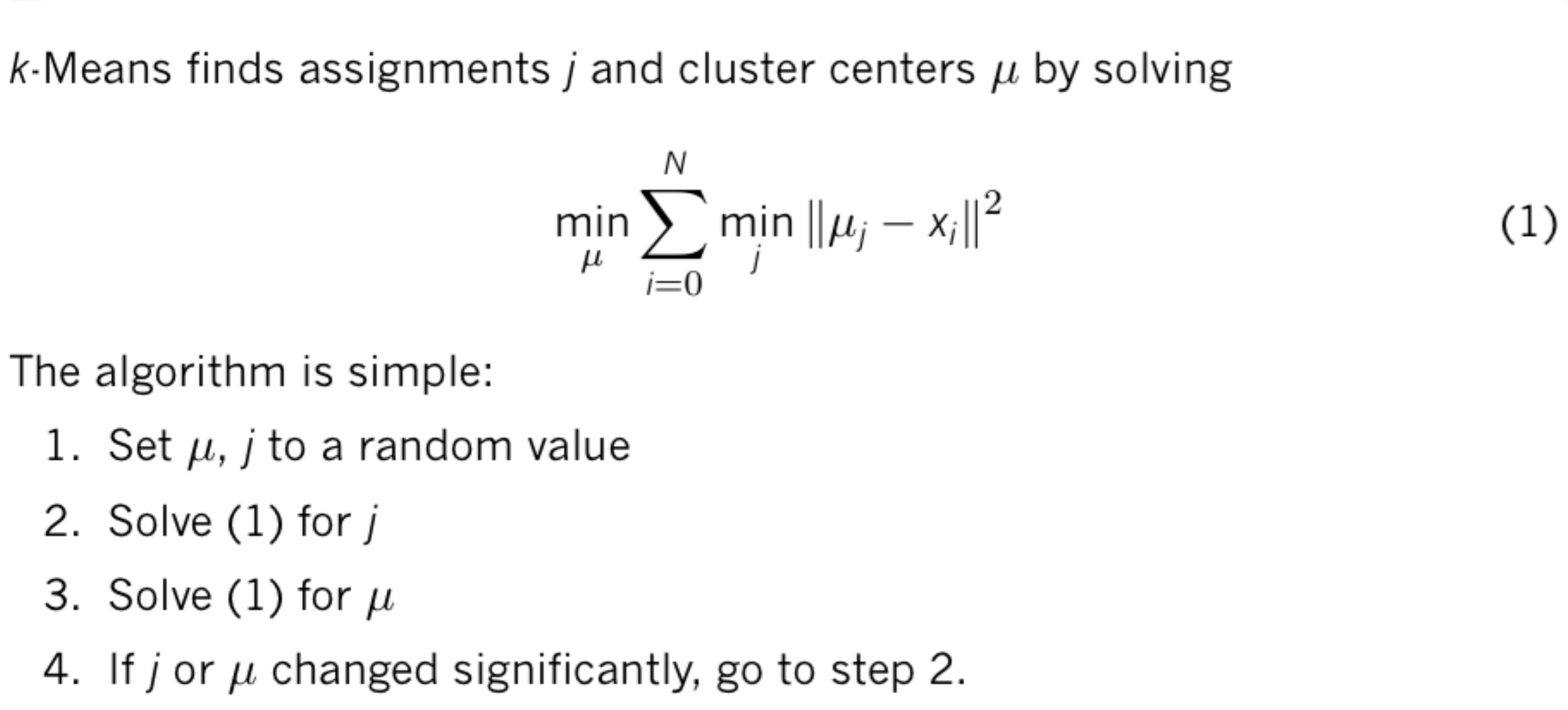


- Identify important variables in projection matrix *W*:

```
W = [[ 0.36 -0.08 0.85 0.35]
     [-0.65 -0.72 0.17 0.07]]
```

1 – PCA.ipynb

# K-Means Algorithm



*k*-Means finds assignments *j* and cluster centers $\mu$ by solving

$$\min_{\mu} \sum_{i=0}^{N} \min_{j} \|\mu_j - x_i\|^2 \tag{1}$$

The algorithm is simple:

1. Set $\mu$, *j* to a random value
2. Solve (1) for *j*
3. Solve (1) for $\mu$
4. If *j* or $\mu$ changed significantly, go to step 2.

2 – k means.ipynb

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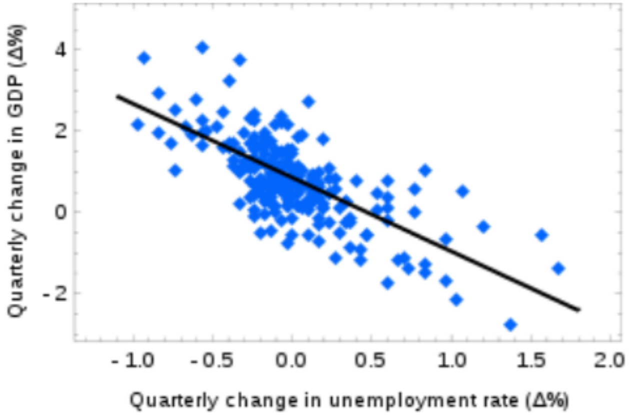
The use of Scikit-Learn: supervised learning demos

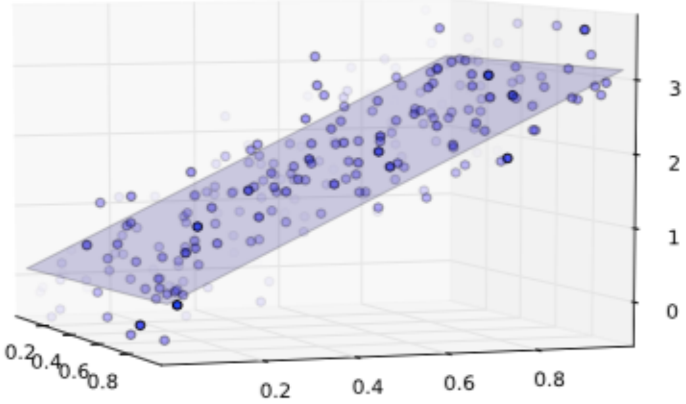
# Linear Regression

$$y = w_1 x_1 + b$$

$$y = w_2 x_2 + w_1 x_1 + b$$



1D



2D

To find w and b, minimize the error:

$$E = \sum_{i=0}^{N} (y_i - (w_i x_i + b))^2$$

3 – LinearRegression1.ipynb

3 – LinearRegression2.ipynb

# Logistic Regression

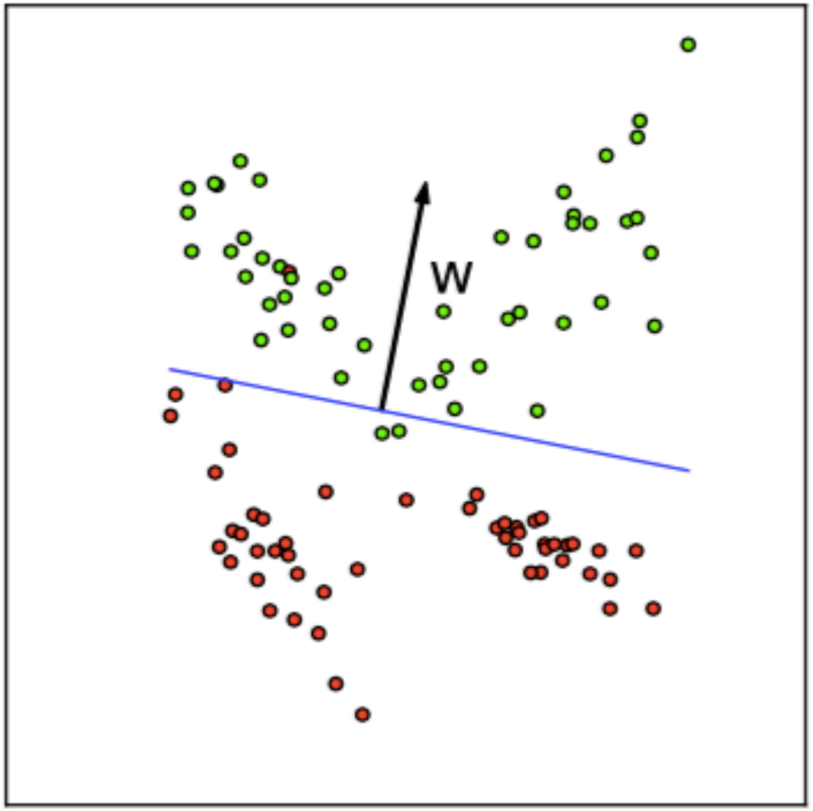
For two classes $-1, +1$.

Decision boundary given by hyperplane.

Hyperplane defined by normal vector and offset:

$$y = \operatorname{sign}(\langle w, x \rangle + b)$$

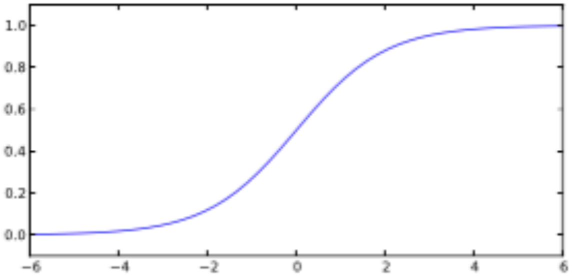
$$w \in \mathbb{R}^n, b \in \mathbb{R}$$



# Logistic Regression

Relation to regression:

$$p(y = +1 \,|\, x) = \text{logistic}(\langle w, x \rangle + b)$$



As probabilities are between $0$ and $1$, the logistic function squashes the regression result:

$$p(y = +1 \,|\, x) > 0.5 \Leftrightarrow \langle w, x \rangle + b > 0$$

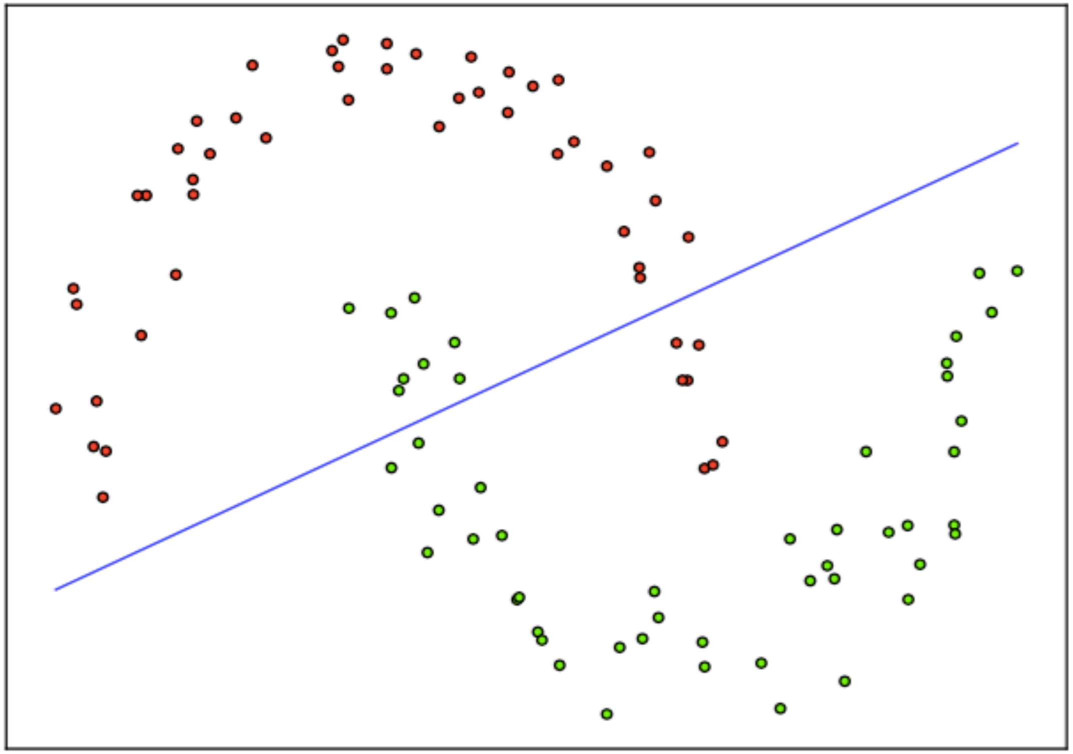
Need to solve:

$$\max_{w} \sum_{i=0}^{n} \log(p(Y = y_i | x_i))$$

4 – LogisticRegression.ipynb

# Nonlinear Problems

- Logistic regression works well if the data is linearly separable, but…



# K Nearest Neighbors

- Classification: same setup as logistic regression.
- Very simple but powerful idea: Do as your neighbors do.
- For a new point *x* look at the nearest (or the two nearest or three nearest, ...) point(s) in the training data for a label.
- Usual distance measure: Euclidean distance

# Simple Algorithm

- Pick a $k$, for example $k = 3$.
- Want to classify new example $x$.
- Compute $d_i = d(x_i, x)$, i.e. $d(x_i, x) = ||x_i - x||$.
- Sort $d_i$, take $k$ smallest: $d_{i0}$, $d_{i1}$, $d_{i2}$.
- Assign $y$ that appears most often among $y_{i0}$, $y_{i1}$, $y_{i2}$.

5 – kNN.ipynb