Introduction to Machine Learning

Jiří Materna

About me

- Ph.D. in Natural Language Processing and Artificial Intelligence at Masaryk University
- 10 years at Seznam.cz (last 8 years as Head Of Research)
- Founder and lecturer at ML College
- Founder and co-organizer of ML Prague
- ML Freelance and consultant

www.mlguru.com **www.mlprague.com** **www.mlcollege.com**

Outline

Day 1

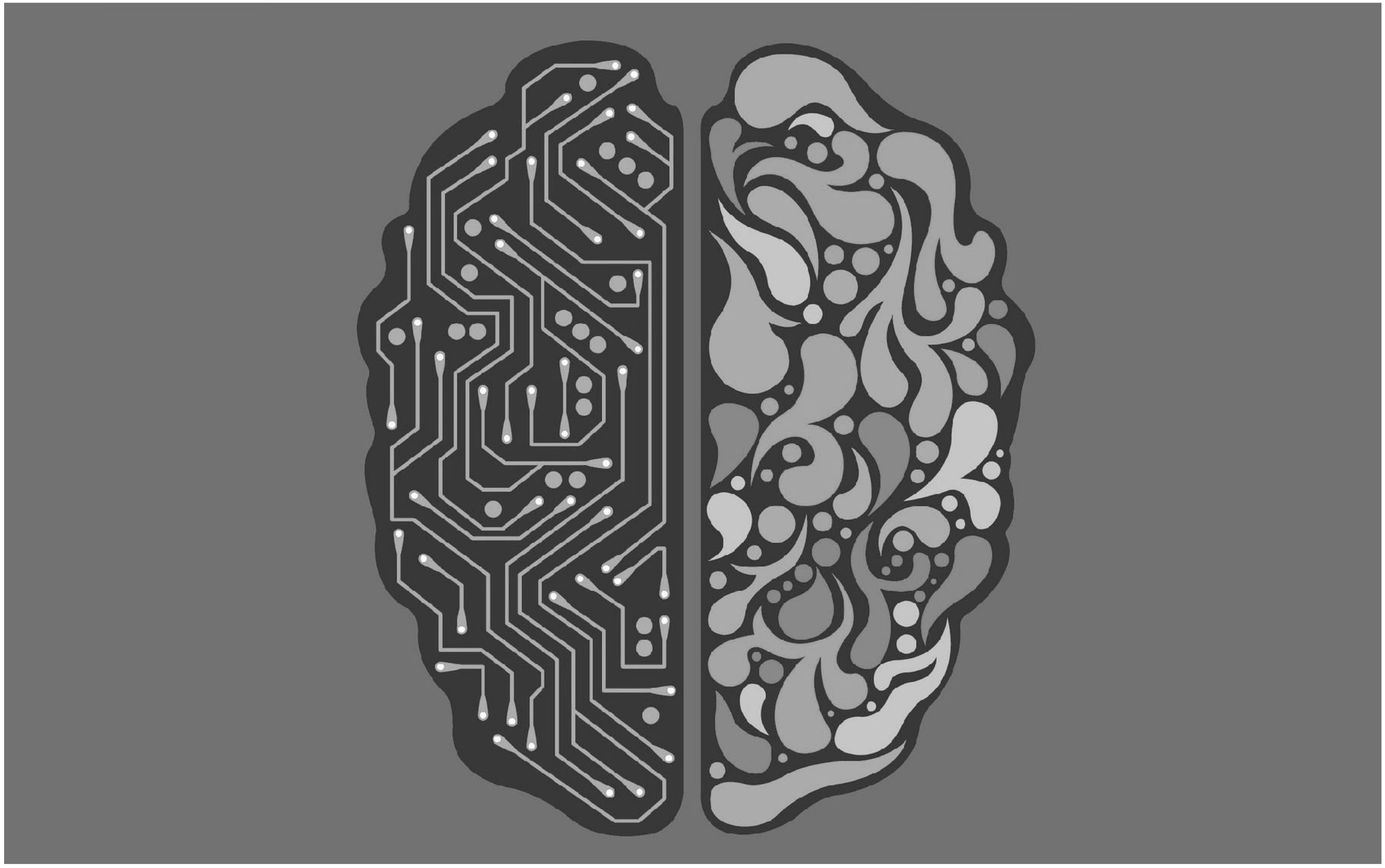
- Introduction to machine learning
- Types of ML tasks
- Data preparation
- Model evaluation
- Basic classification algorithms
- Scikit-learn tutorial
- Practical classification task
- Basic regression algorithms
- Regression model evaluation
- Practical regression task

Outline

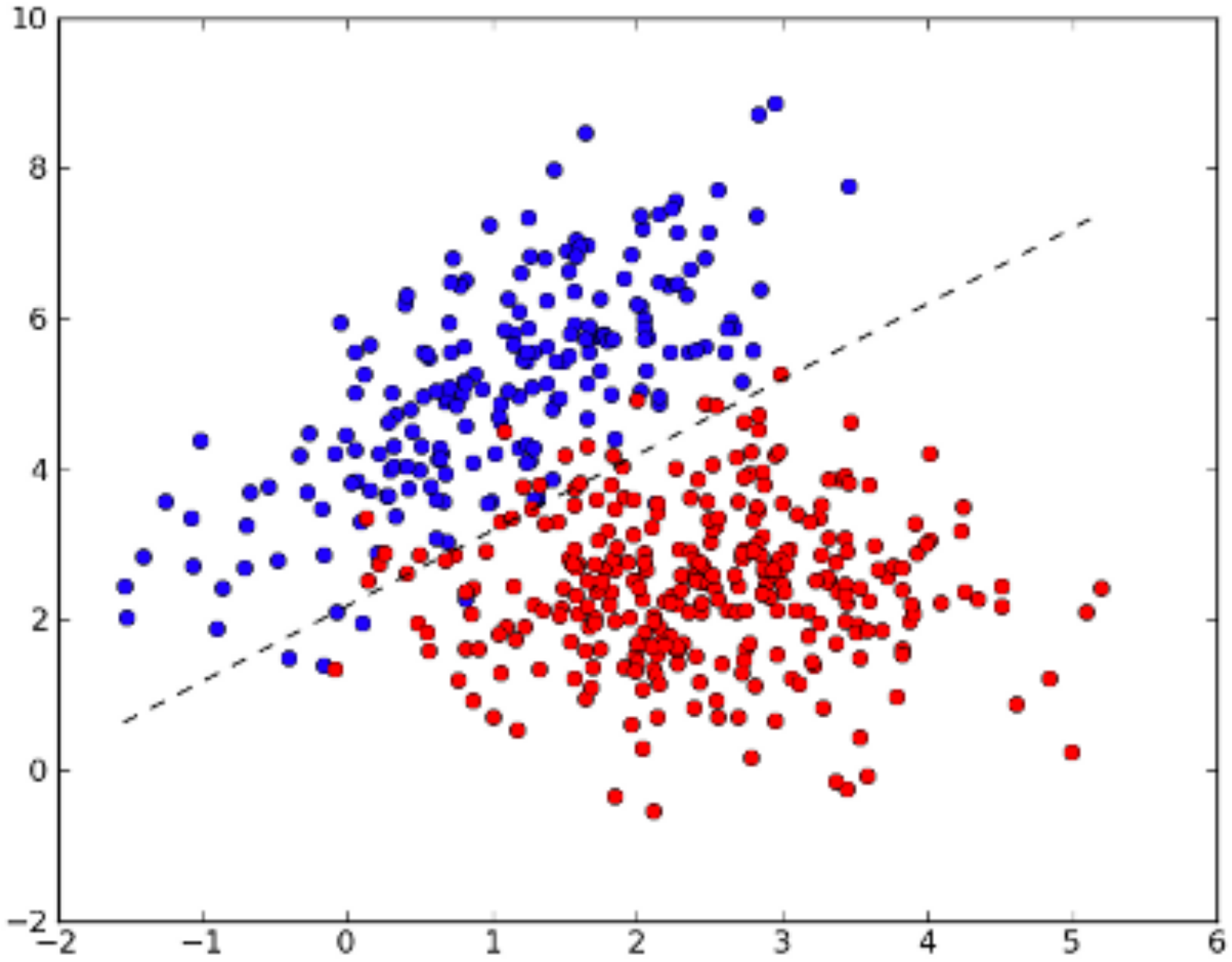
Day 2

- Dimensionality reduction
- Basic clustering algorithms
- Practical clustering task
- Introduction to neural networks
- Activation functions for neural networks
- Multilayered neural networks
- Methods for training neural networks
- Keras tutorial
- Practical classification and regression tasks solved using neural networks

What is (not) machine learning?

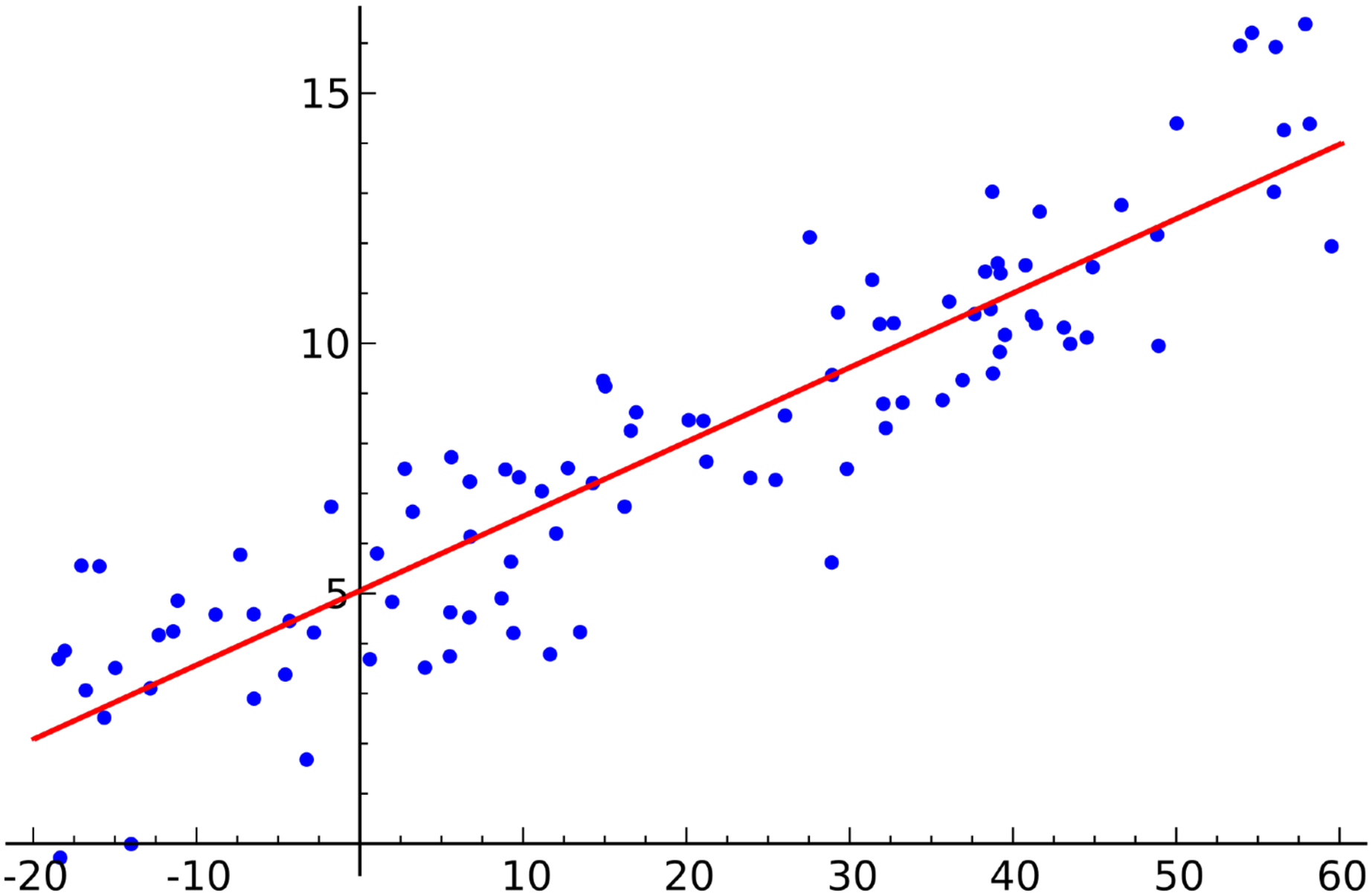


Classification



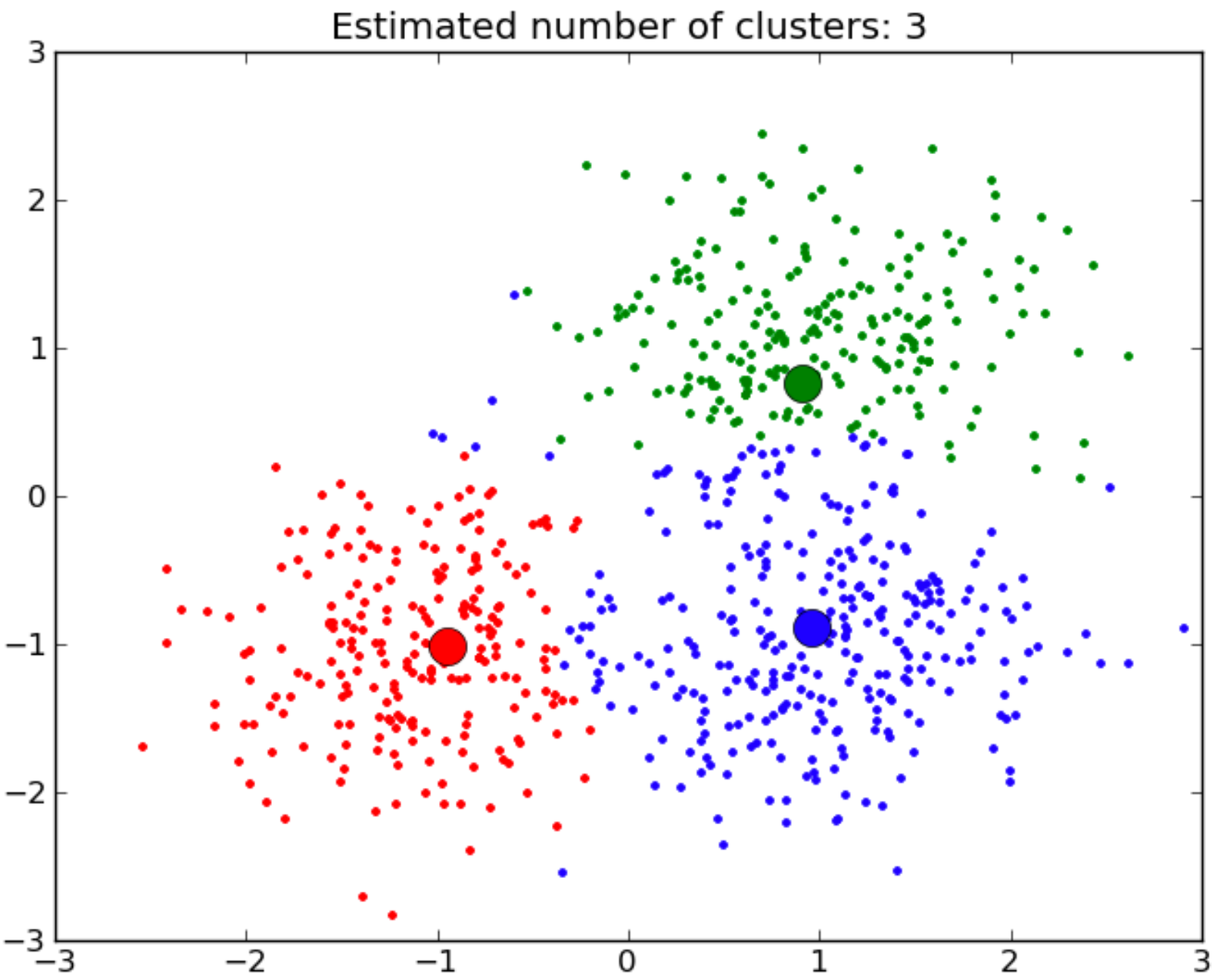
Source: http://mlpy.sourceforge.net

Regression



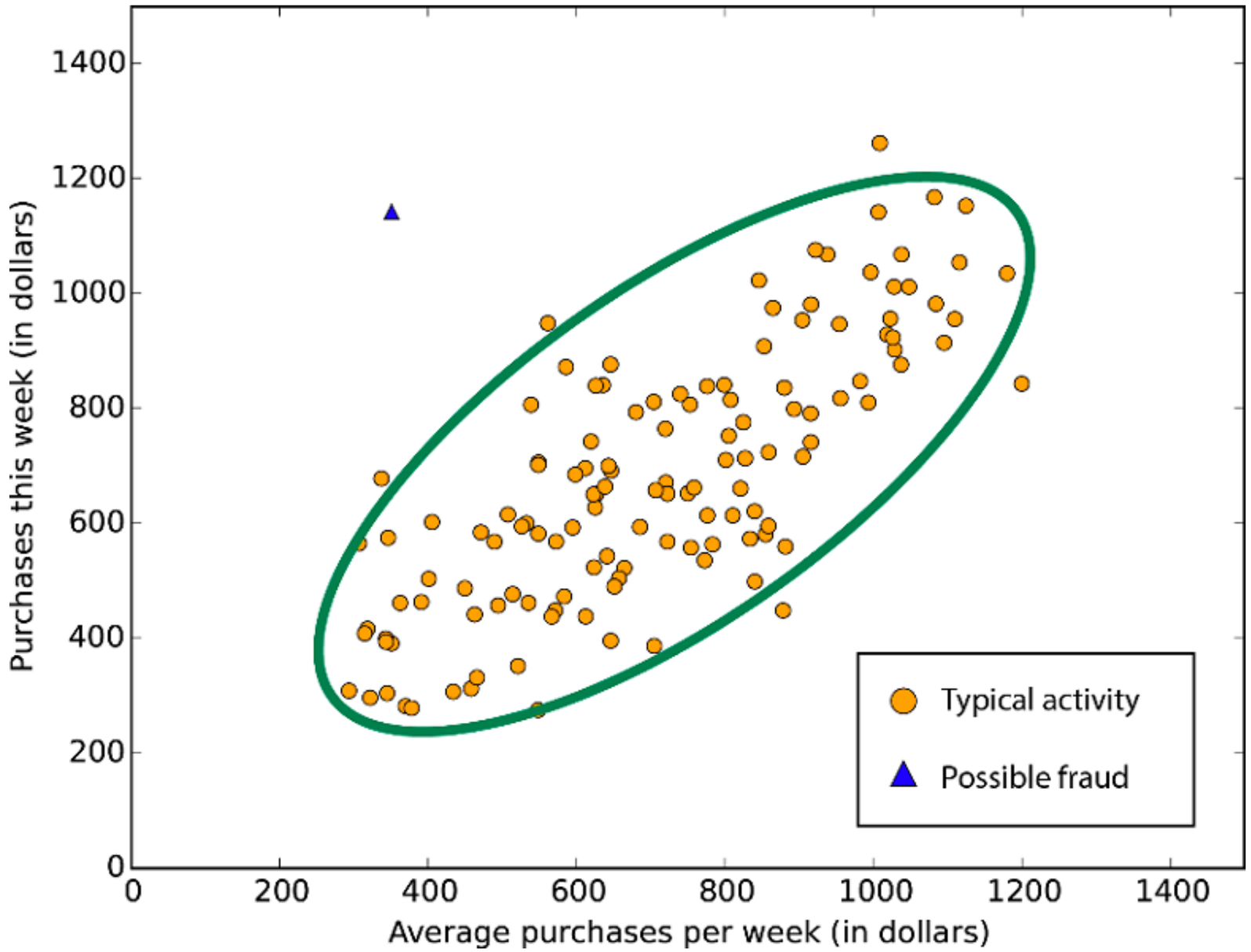
Source: www.wikipedia.org

Clustering



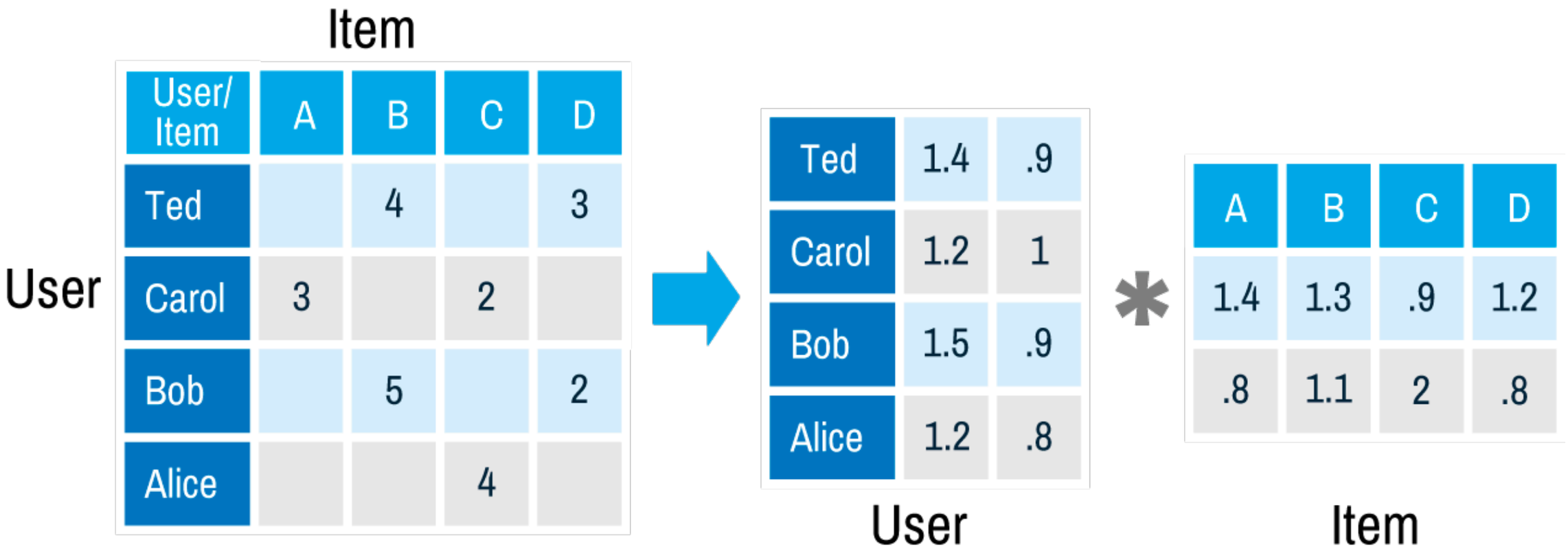
Source: http://scikit-learn.sourceforge.net

Anomaly detection



Source: https://docs.microsoft.com/en-us/azure

Recommendation

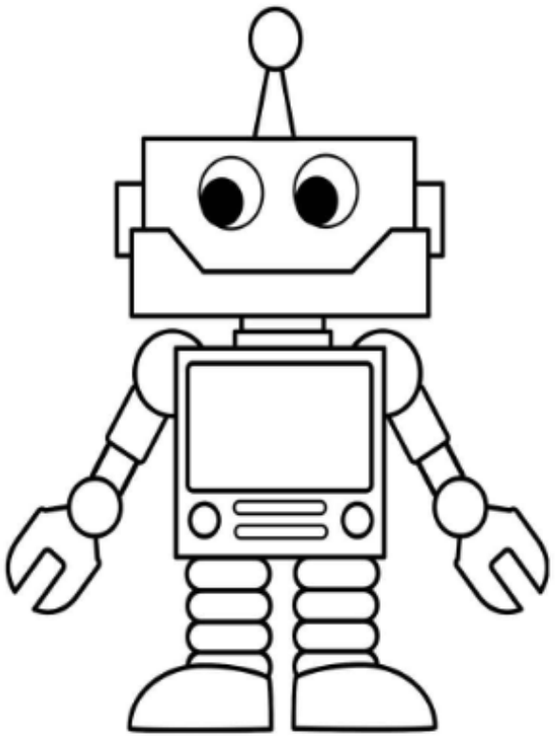


Source: https://mapr.com/ebooks/spark

Reinforcement learning

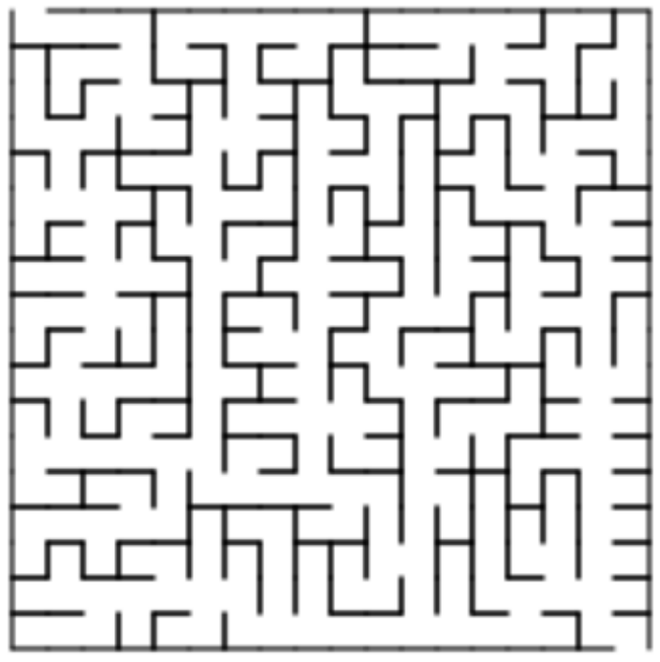
Agent

Environment



action

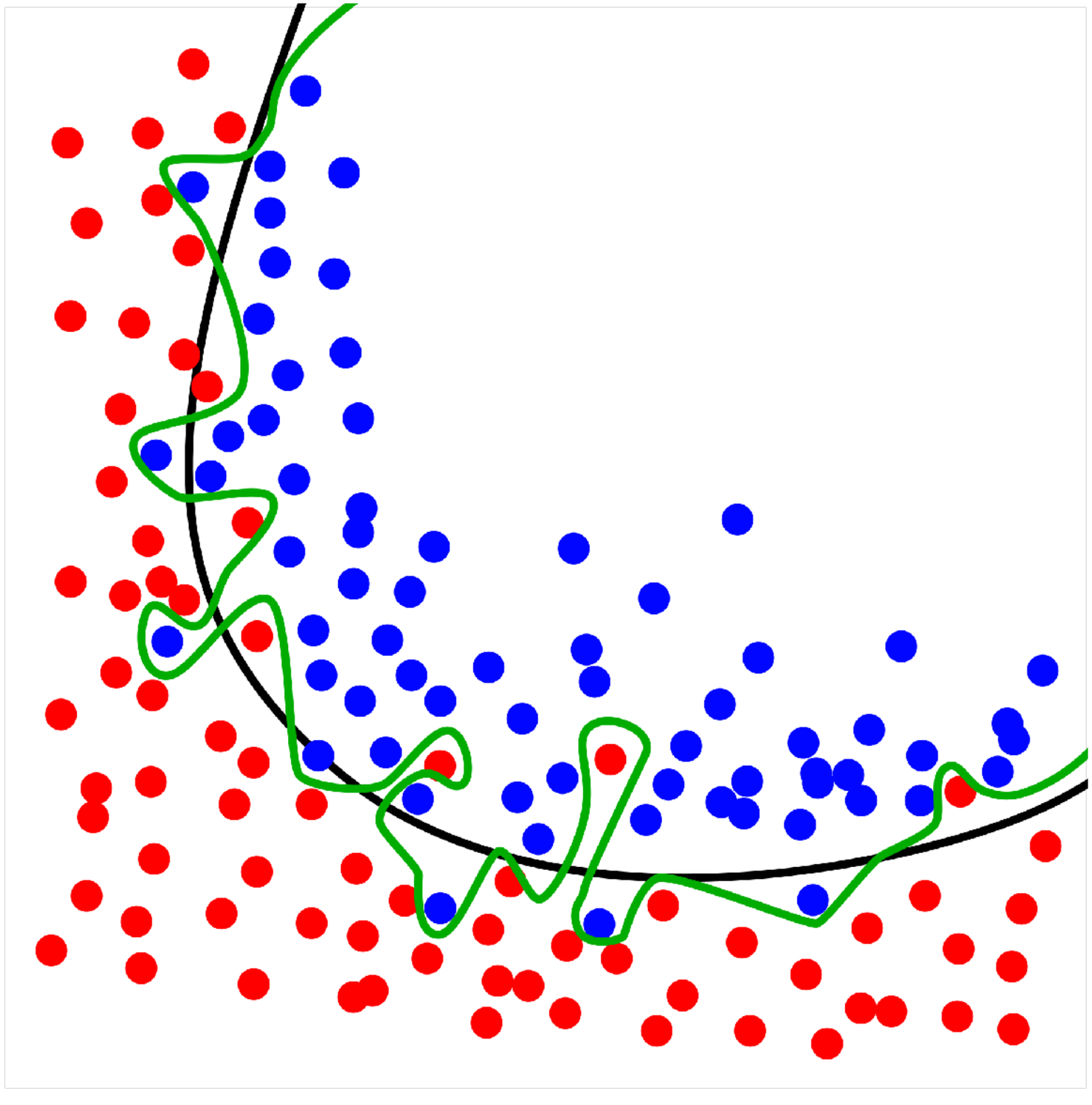
feedback



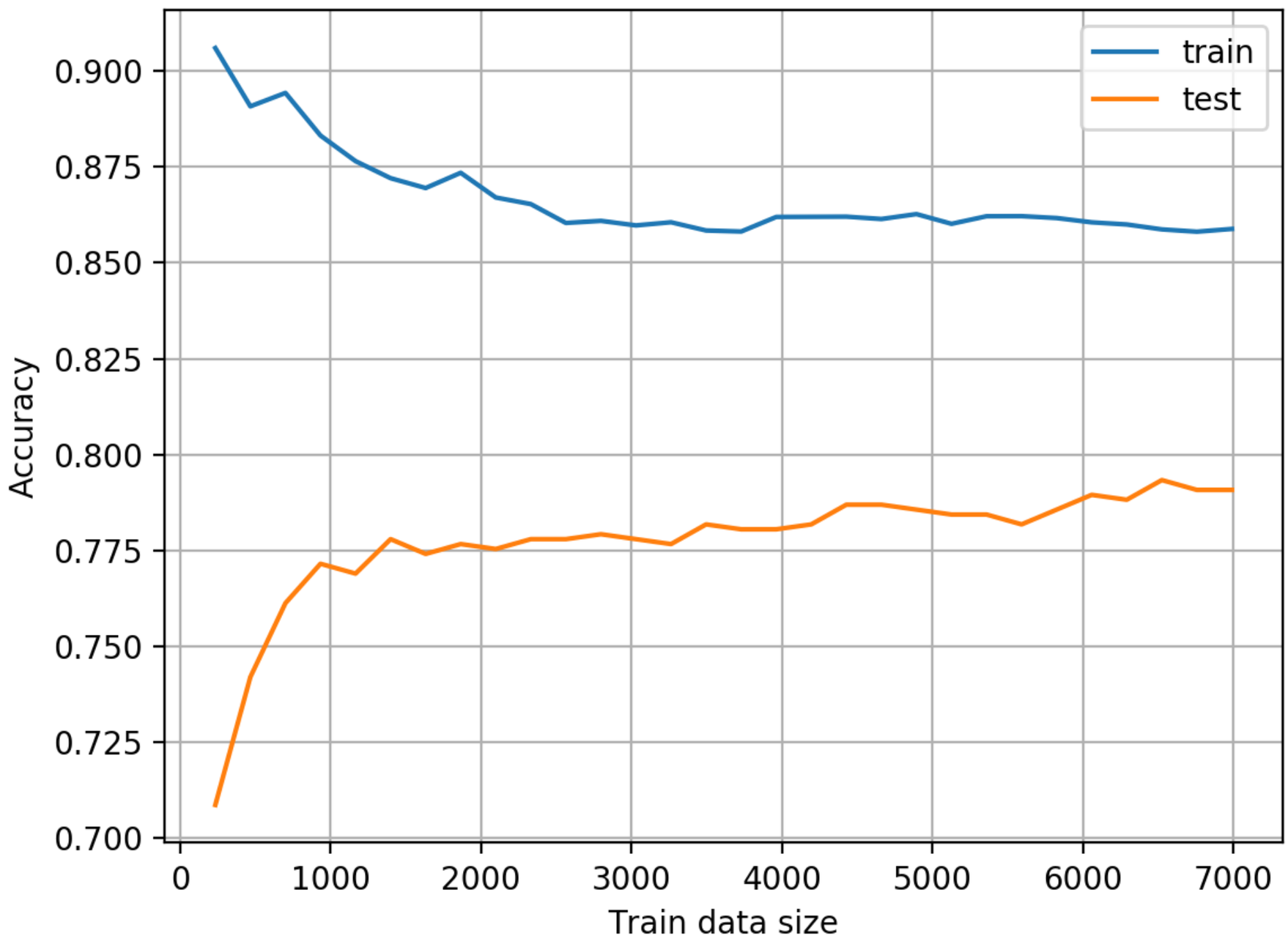
Data

- Train, validation, test data sets
- Cross-validation
- Imbalanced data sets
- Baseline models

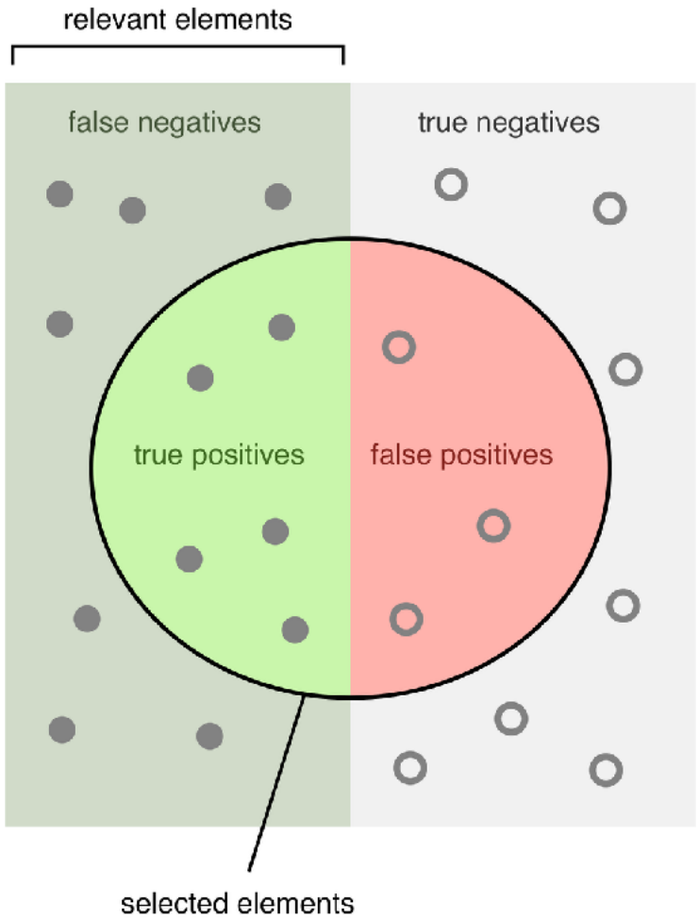
Overfitting

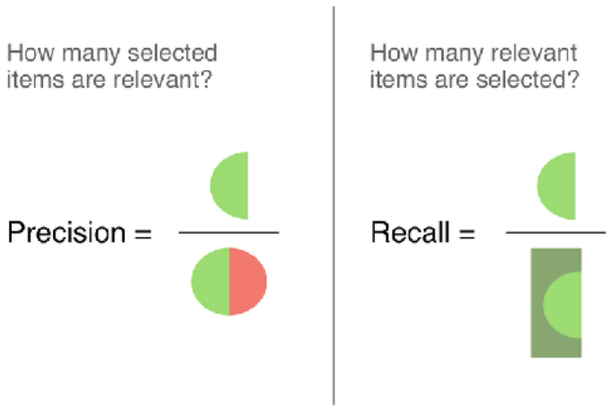


Overfitting detection



Classification Model evaluation





Source: https://www.wikipedia.org

$$\text{Accuracy} = \frac{tp + tn}{tp + tn + fp + fn}$$

$$\text{Precision} = \frac{tp}{tp + fp}$$

$$\text{Recall} = \frac{tp}{tp + fn}$$

$$\text{F} = 2 \cdot \frac{\text{precision} \cdot \text{recall}}{\text{precision} + \text{recall}}$$

Conditional probability

$$P(A|B) = \frac{P(A \cap B)}{P(B)} = \frac{P(A)P(B|A)}{P(B)}$$

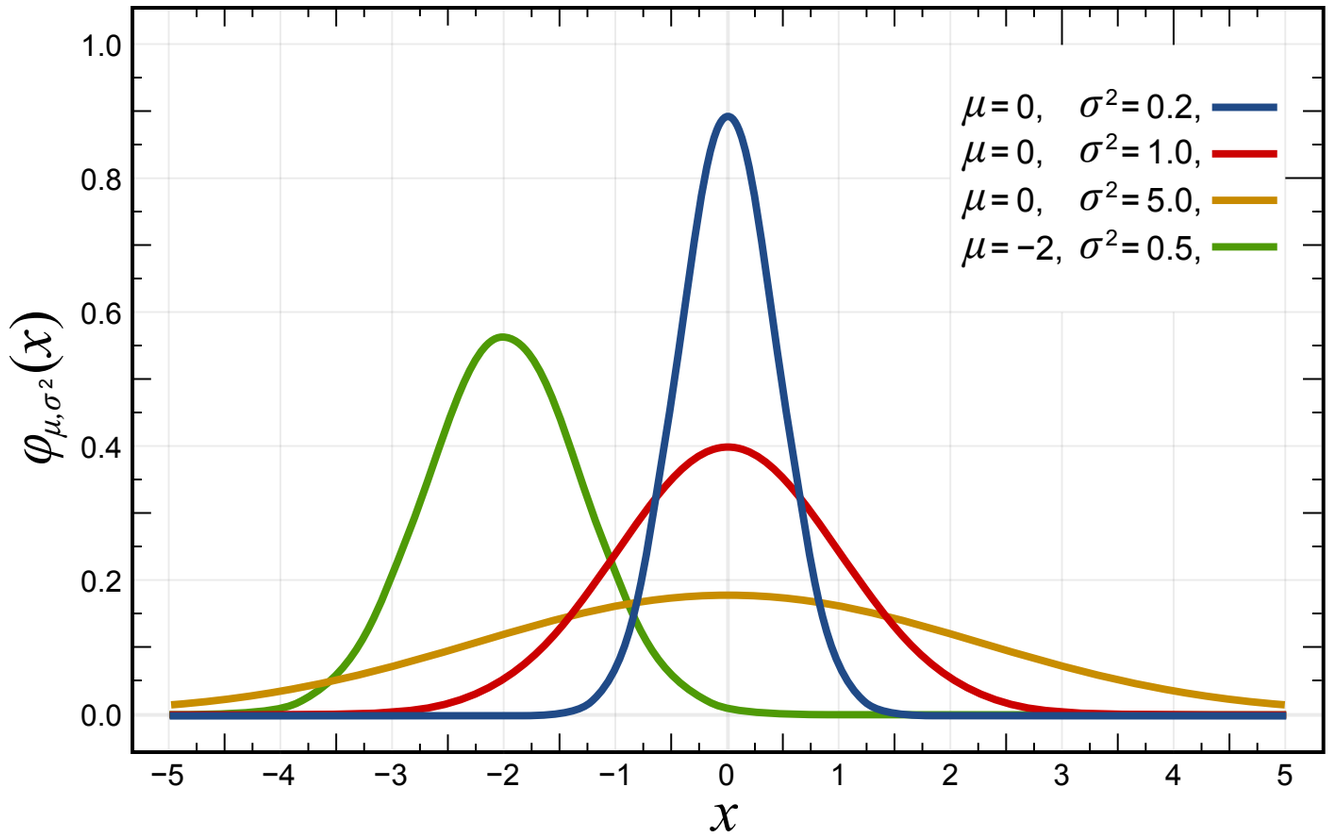
$$A \perp B \iff P(A \cap B) = P(A)P(B)$$

Naive Bayes Classifier

client	balance	income	sex	unemployed	loan
1	H	H	F	F	T
2	L	H	M	F	T
3	L	L	M	T	F
4	H	L	F	T	T
5	L	L	F	T	F
6	**H**	**L**	**M**	**F**	**?**

Gaussian Naive Bayes Classifier

$$p(x = v|C_k) = \frac{1}{\sqrt{2\pi\sigma_k^2}} e^{-\frac{(v-\mu_k)^2}{2\sigma_k^2}}$$



Source: https:/www.wikipedia.org

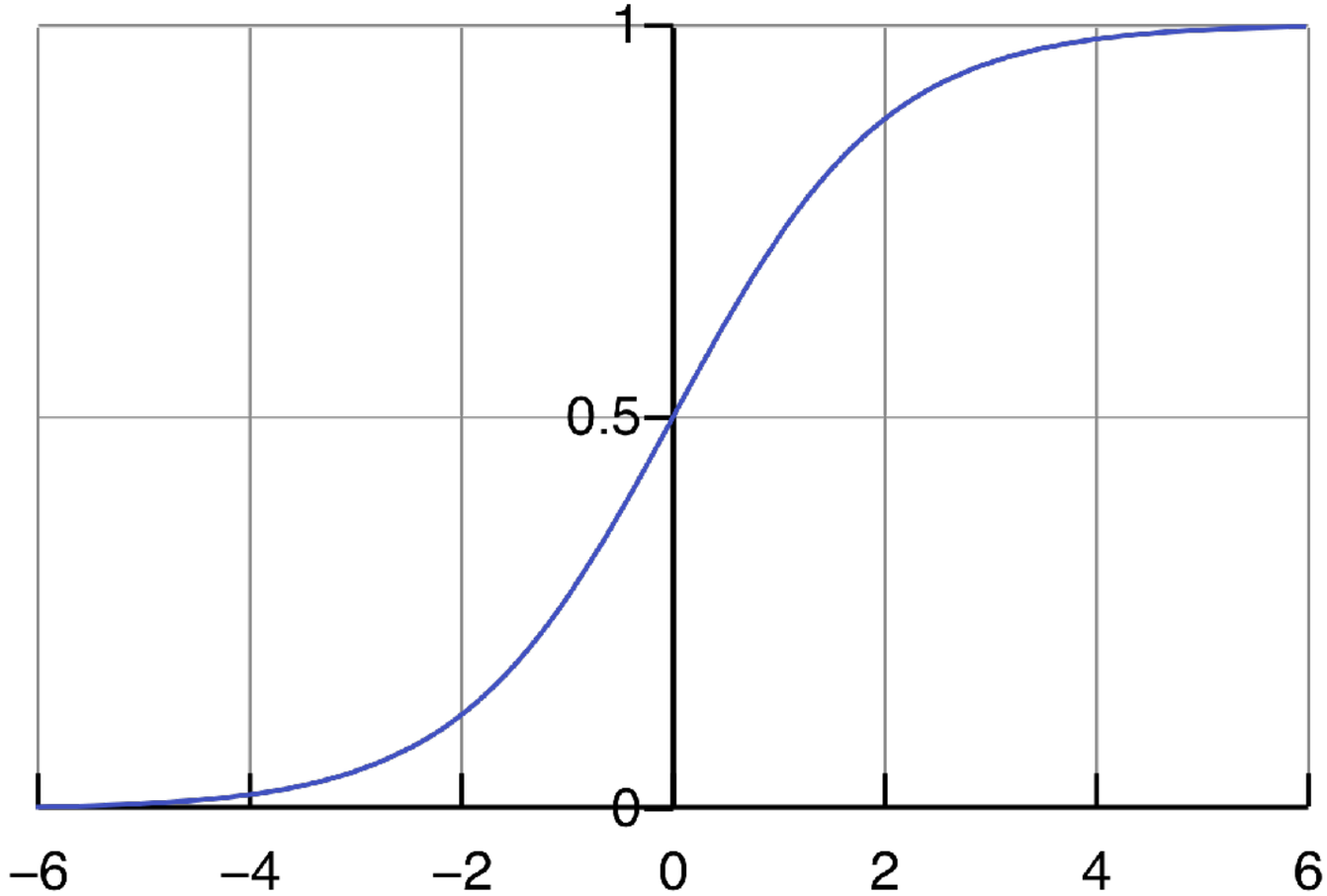
Scikit-learn tutorial

http://scikit-learn.org/stable/

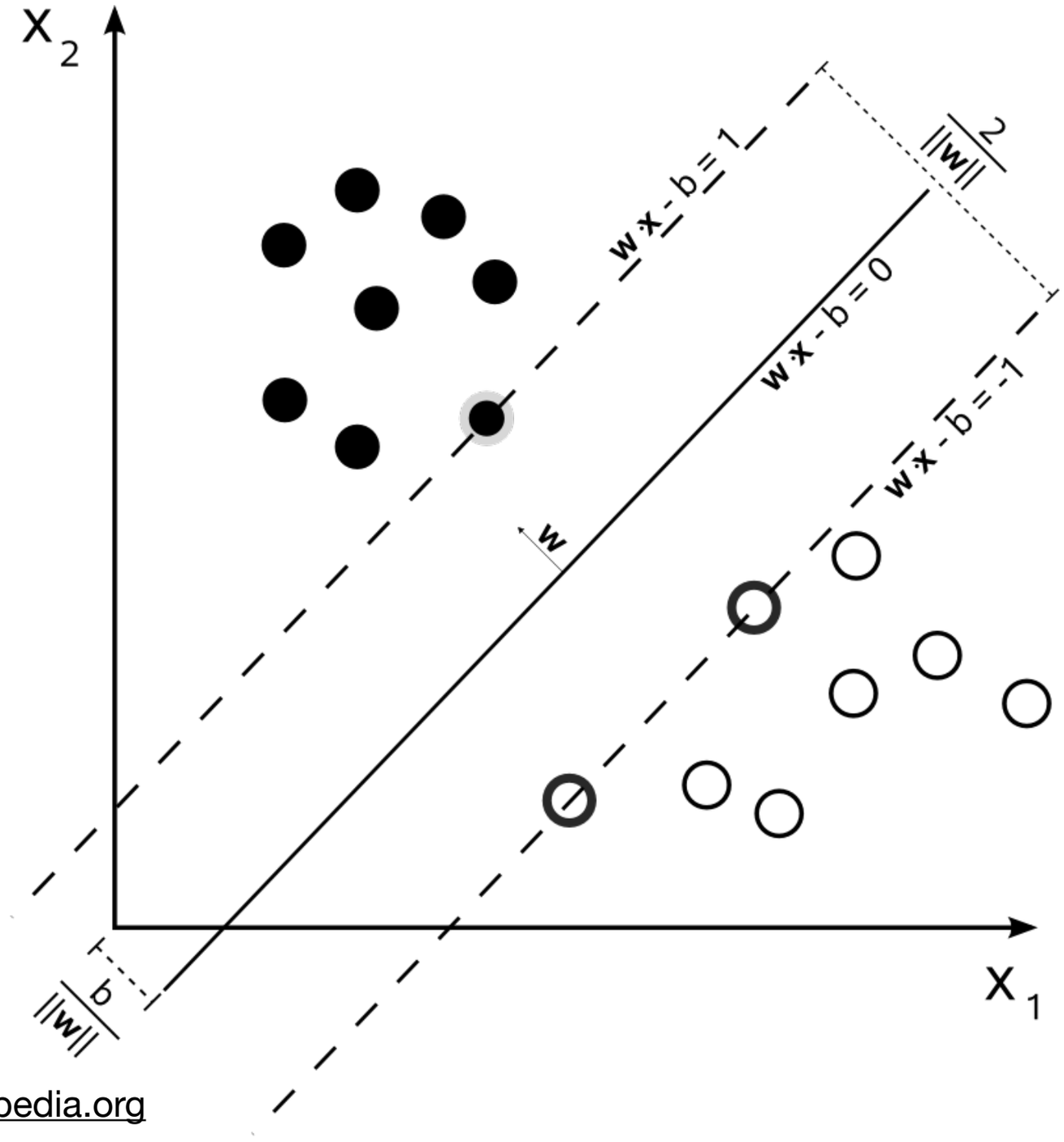
01-Scikit-introduction.ipynb

Logistic regression

$$P(y|\vec{x}) = \frac{1}{1 + e^{-(\vec{x}\vec{w} + w_0)}}$$

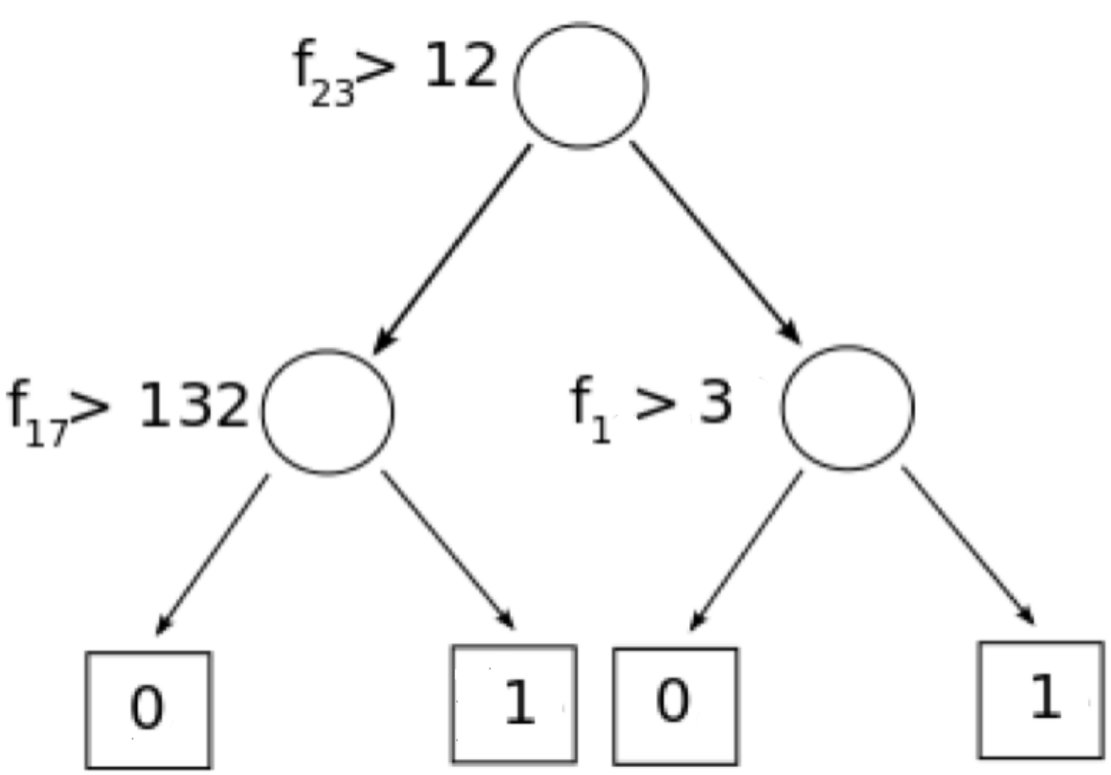


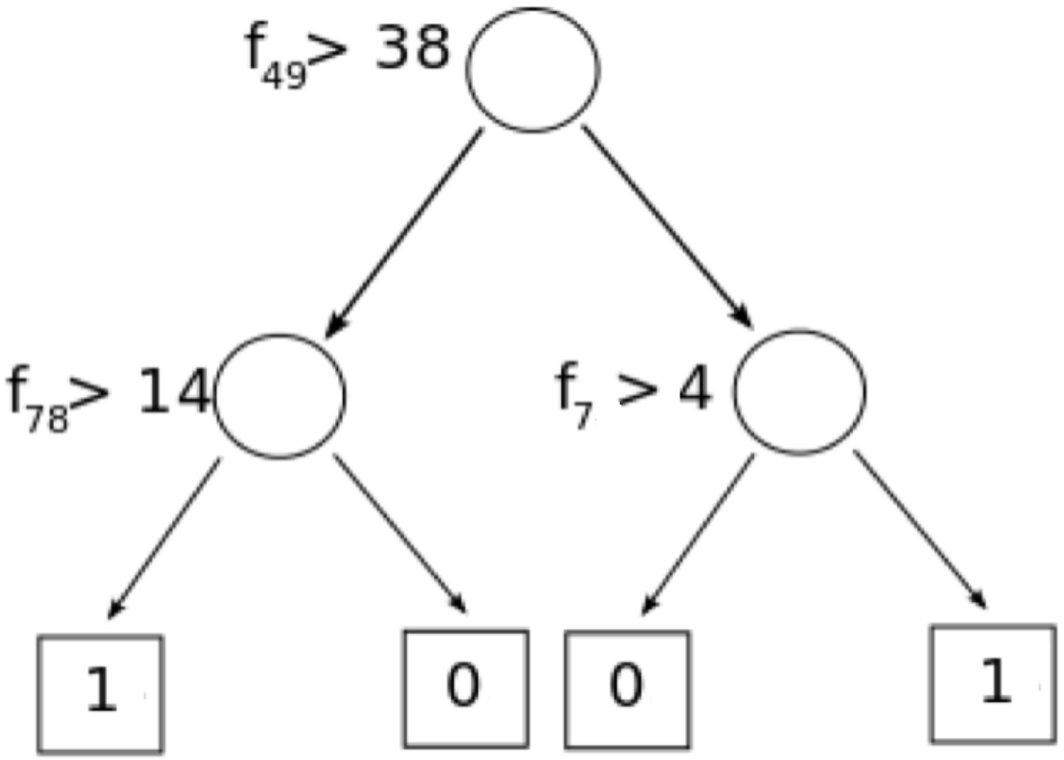
Support Vector Machines



Source: https:/www.wikipedia.org

Boosted Decision Trees



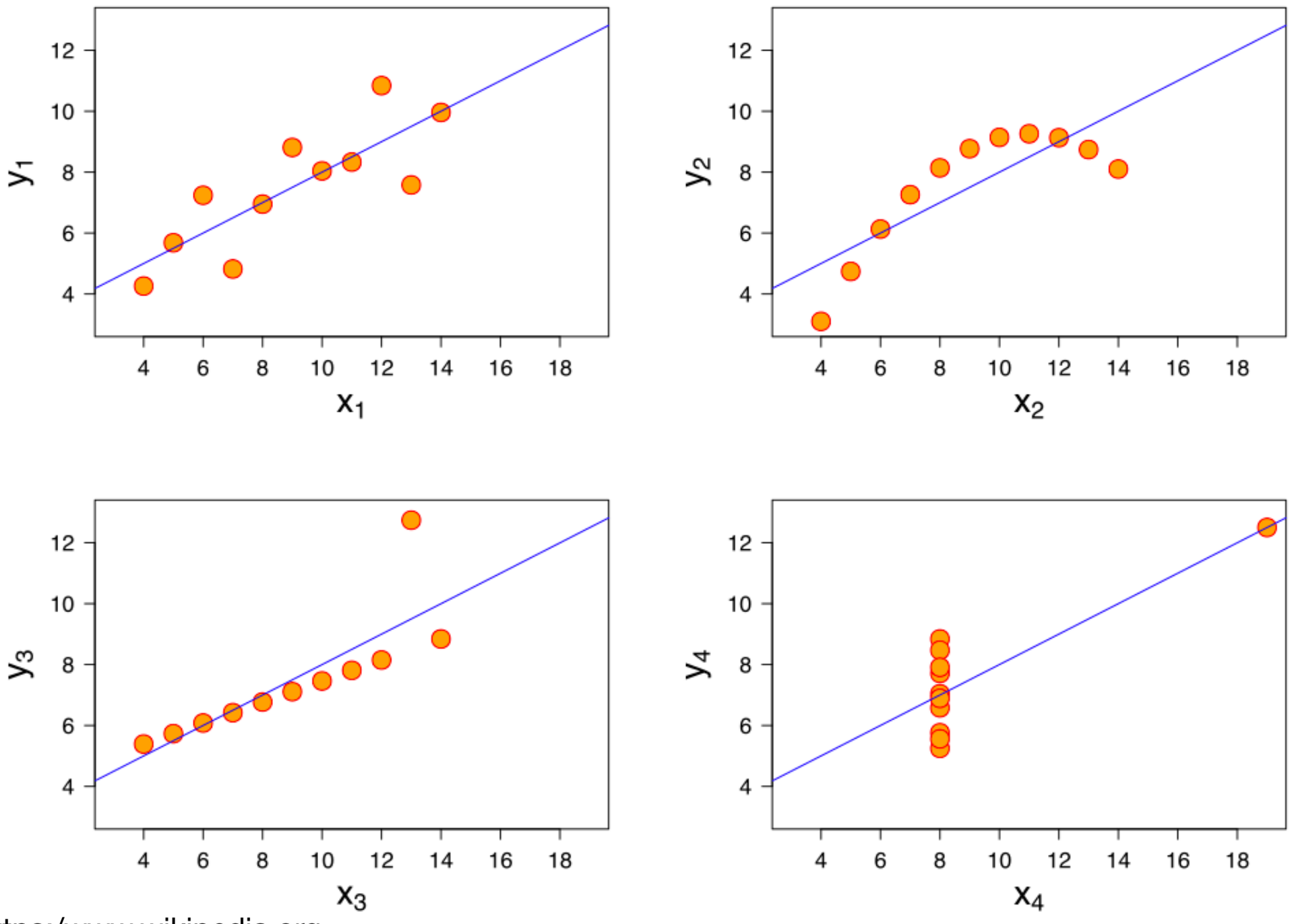


Classification task

02-Classification1-assignment.ipynb

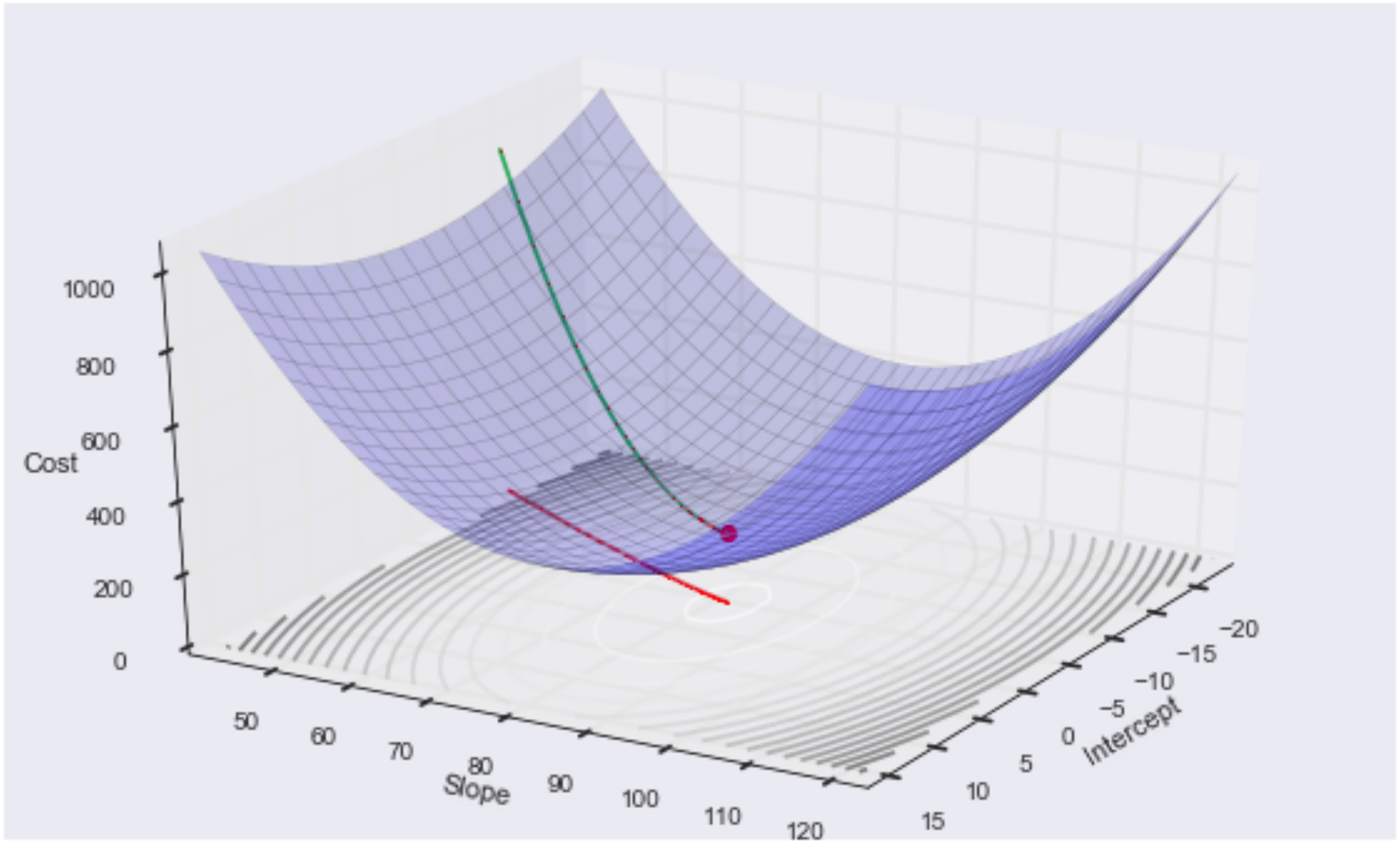
03-Classification2-assignment.ipynb

Regression



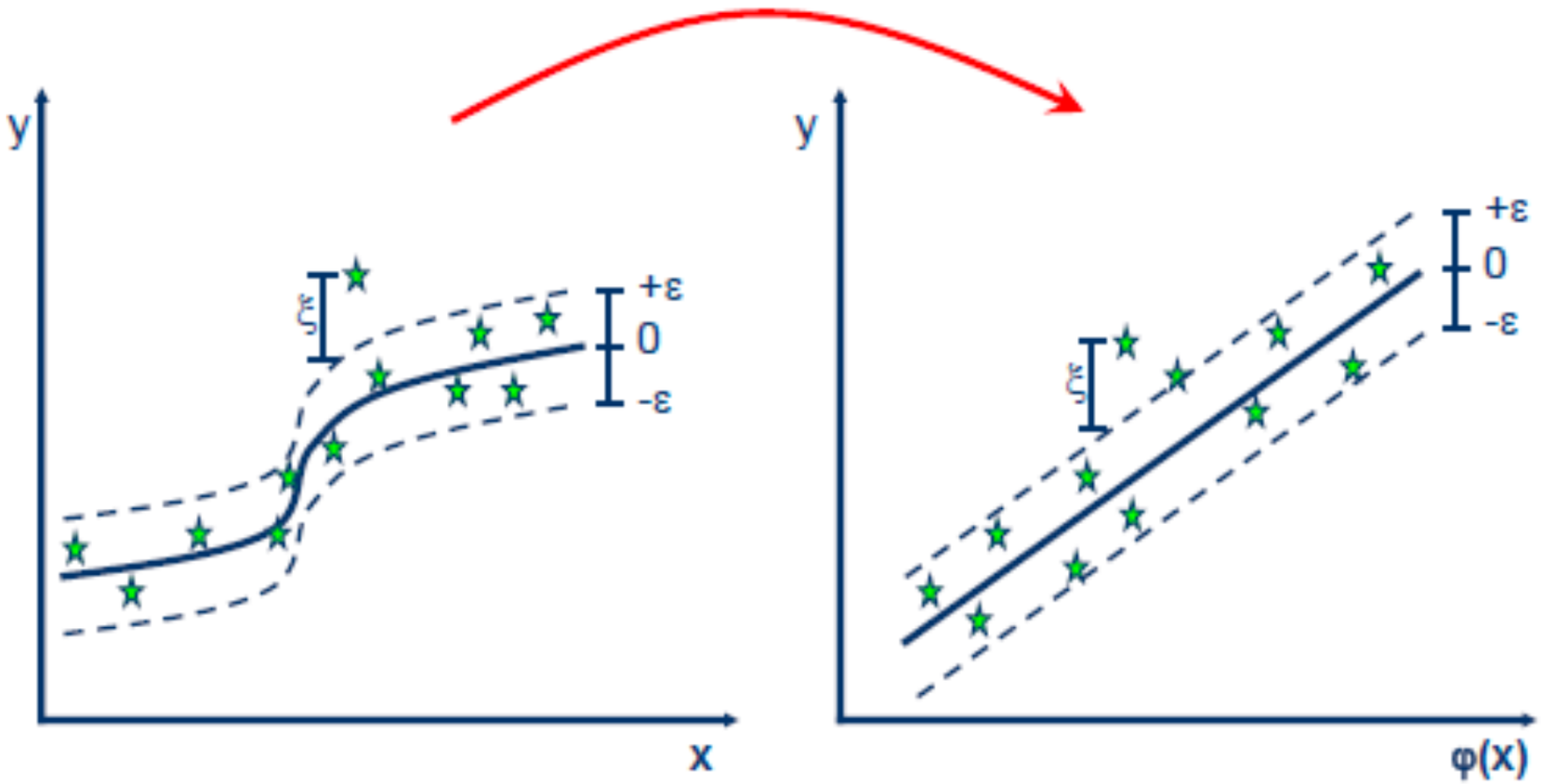
Source: https:/www.wikipedia.org

Linear regression with SGD



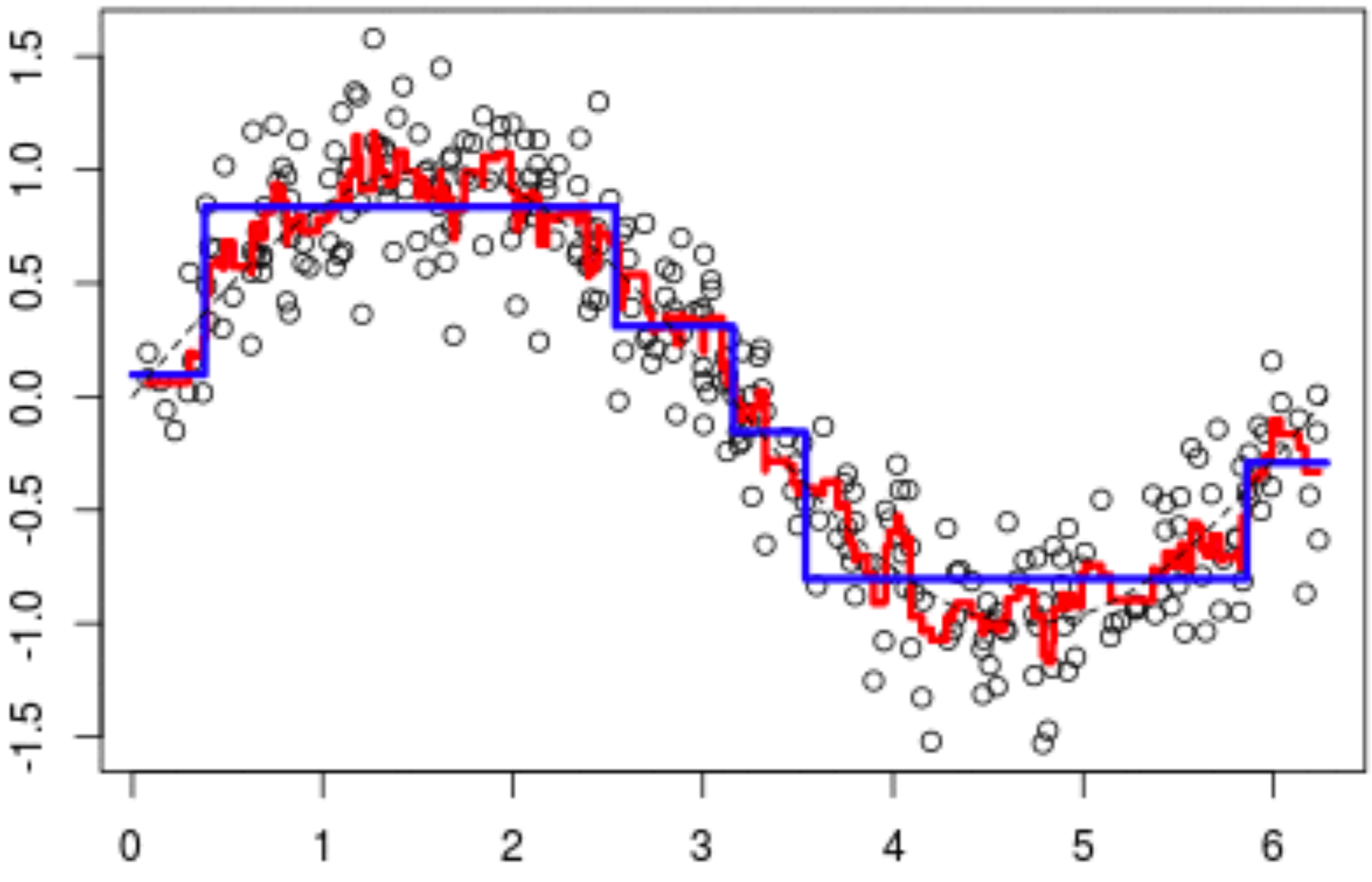
Source: https://am207.github.io/2017/wiki/gradientdescent.html

Support vector machines for Regression



Source: http://www.saedsayad.com/support_vector_machine_reg.htm

Boosted regression trees



Source: https://www.r-bloggers.com/an-attempt-to-understand-boosting-algorithms/

Evaluation of regression models

Root mean squared error

$$\mathrm{RMSE} = \sqrt{\frac{\sum_i (y_i - \hat{y}_i)^2}{n}}$$

Mean absolute error

$$\mathrm{MAE} = \frac{\sum_i |y_i - \hat{y}_i|}{n}$$

R Squared

$$\hat{R}^2 = 1 - \frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{\sum_{i=1}^{n} (y_i - \overline{y})^2}$$

Regression task

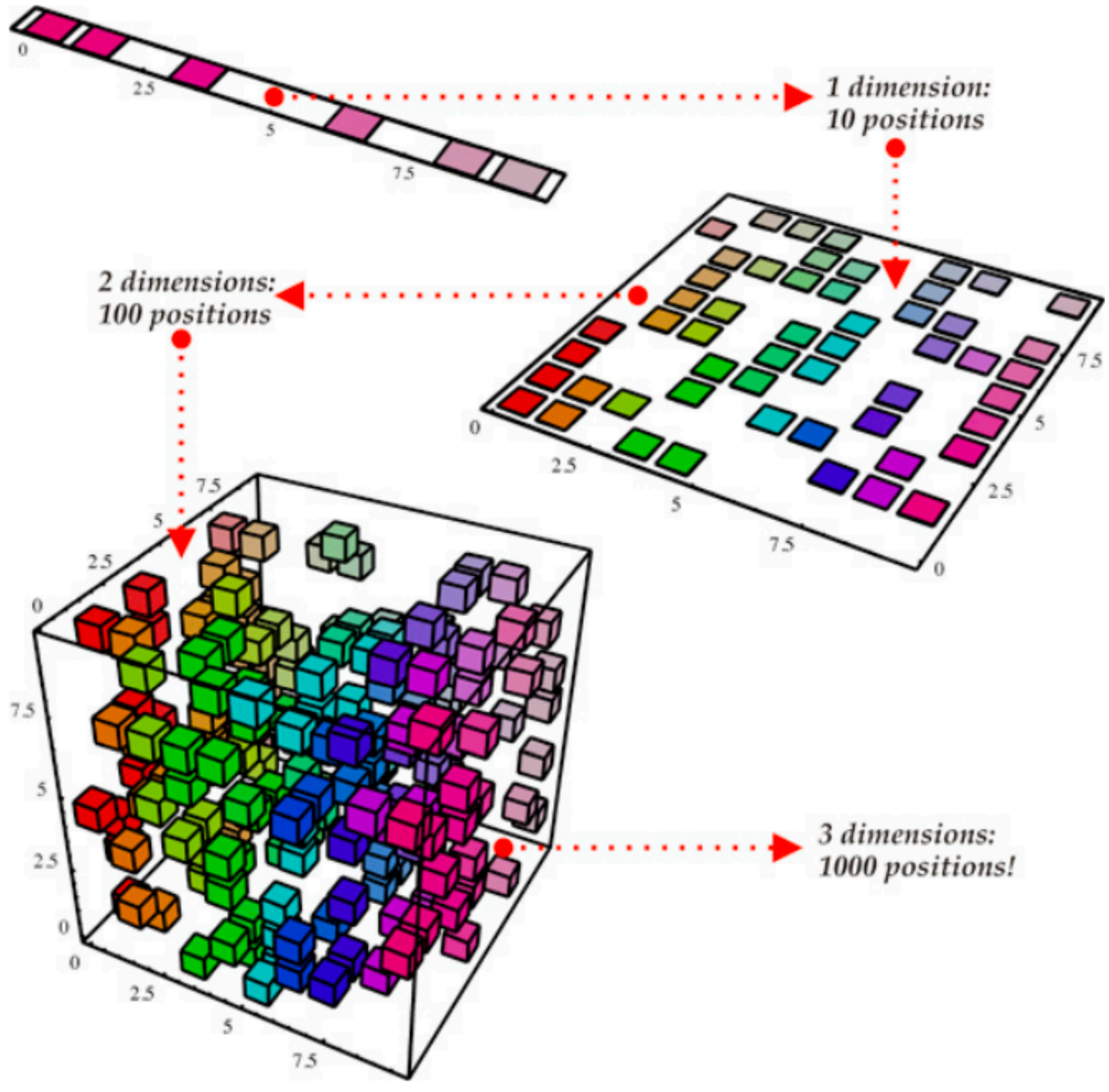
04-Regression1-assignment.ipynb

05-Regression2-assignment.ipynb

Unsupervised techniques

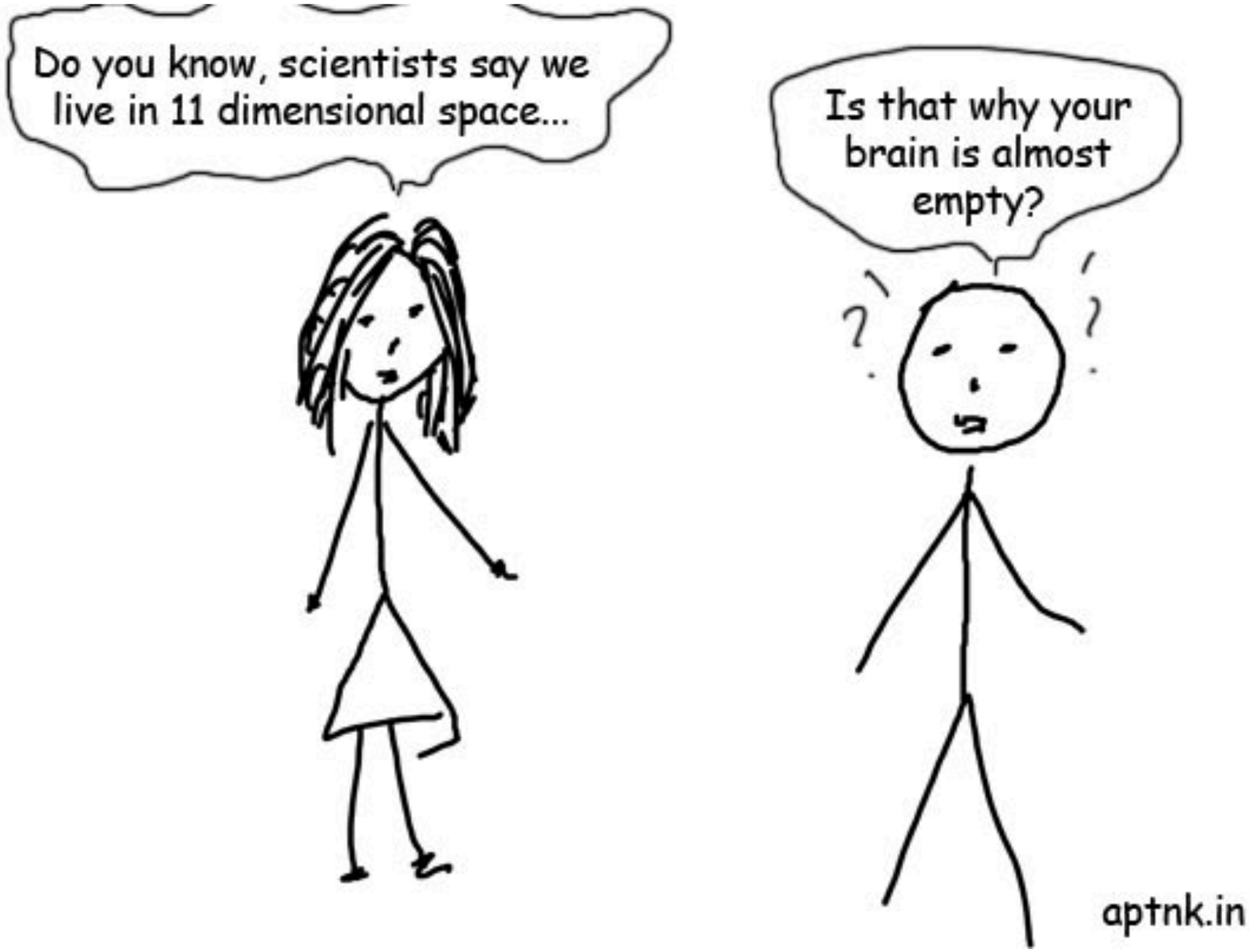
Source: tmdb.org

Dimensionality reduction

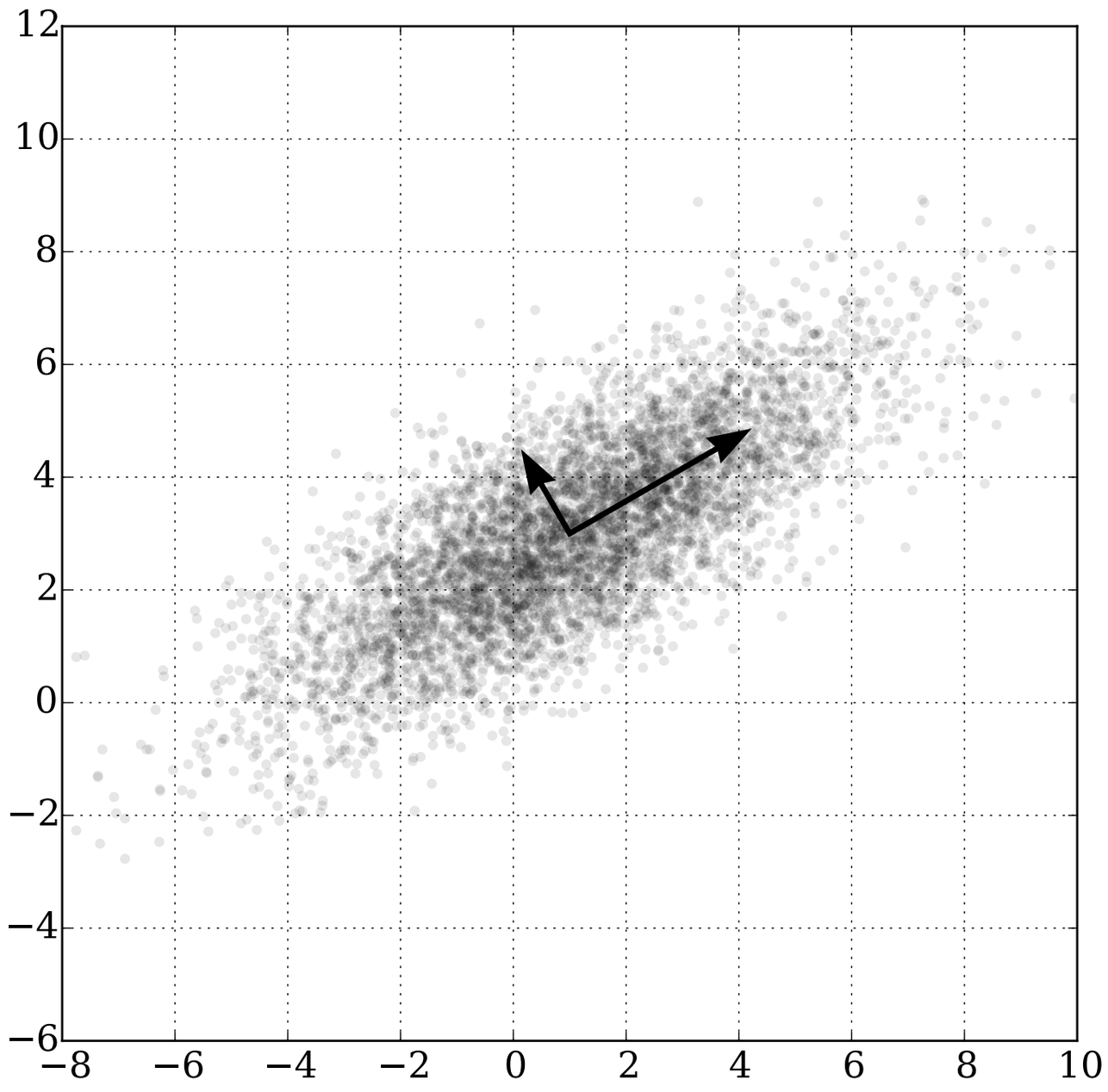


Source: https:/http://www.turingfinance.com/

Curse of dimensionality



Principal Component Analysis



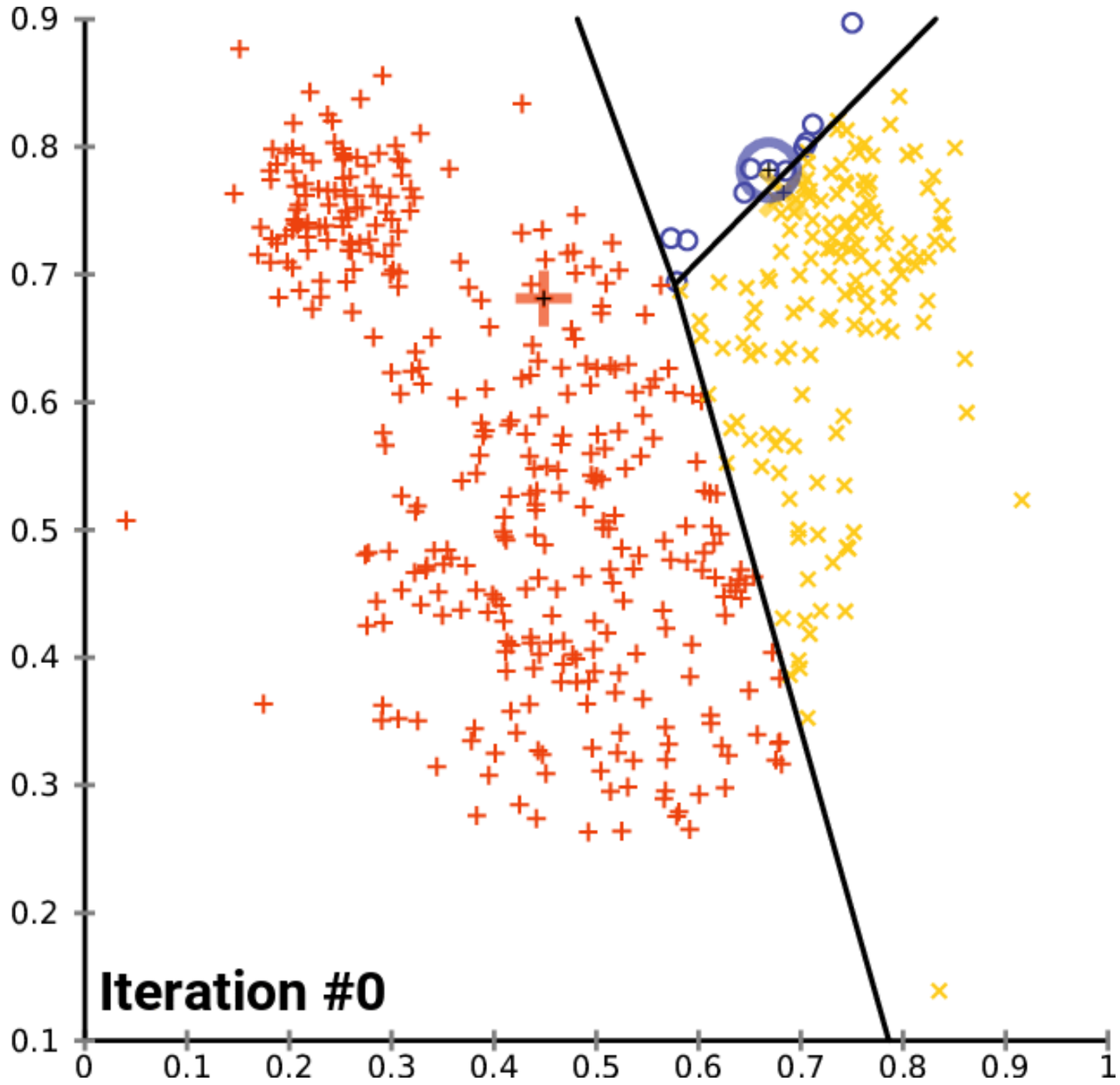
Source: https:/www.wikipedia.org

t-SNE and UMAP dimensionality reduction

Dimensionality reduction task

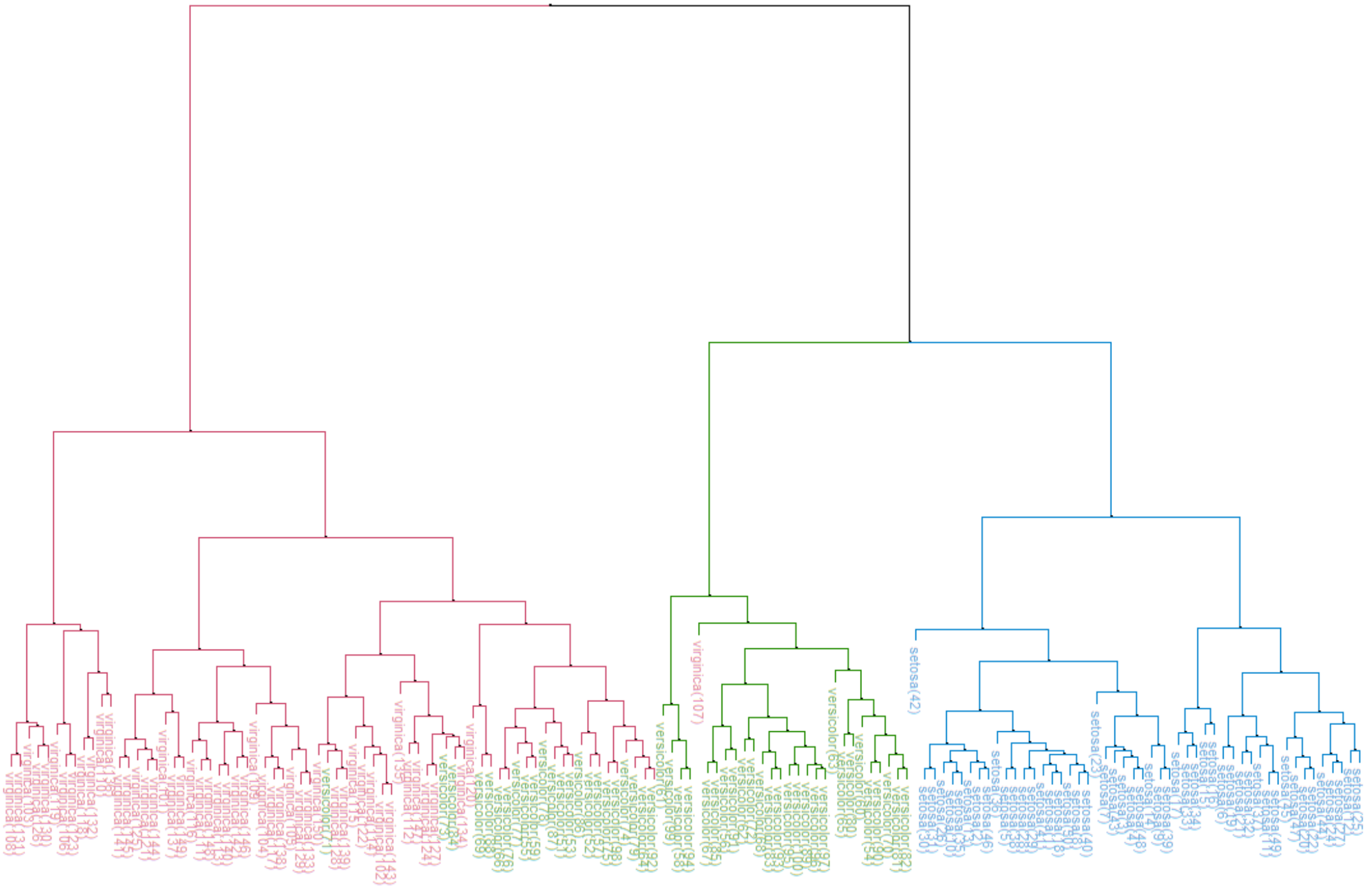
06-Dim-reduction-assignment.ipynb

k-means clustering



Source: https://wikipedia.org

Agglomerative clustering

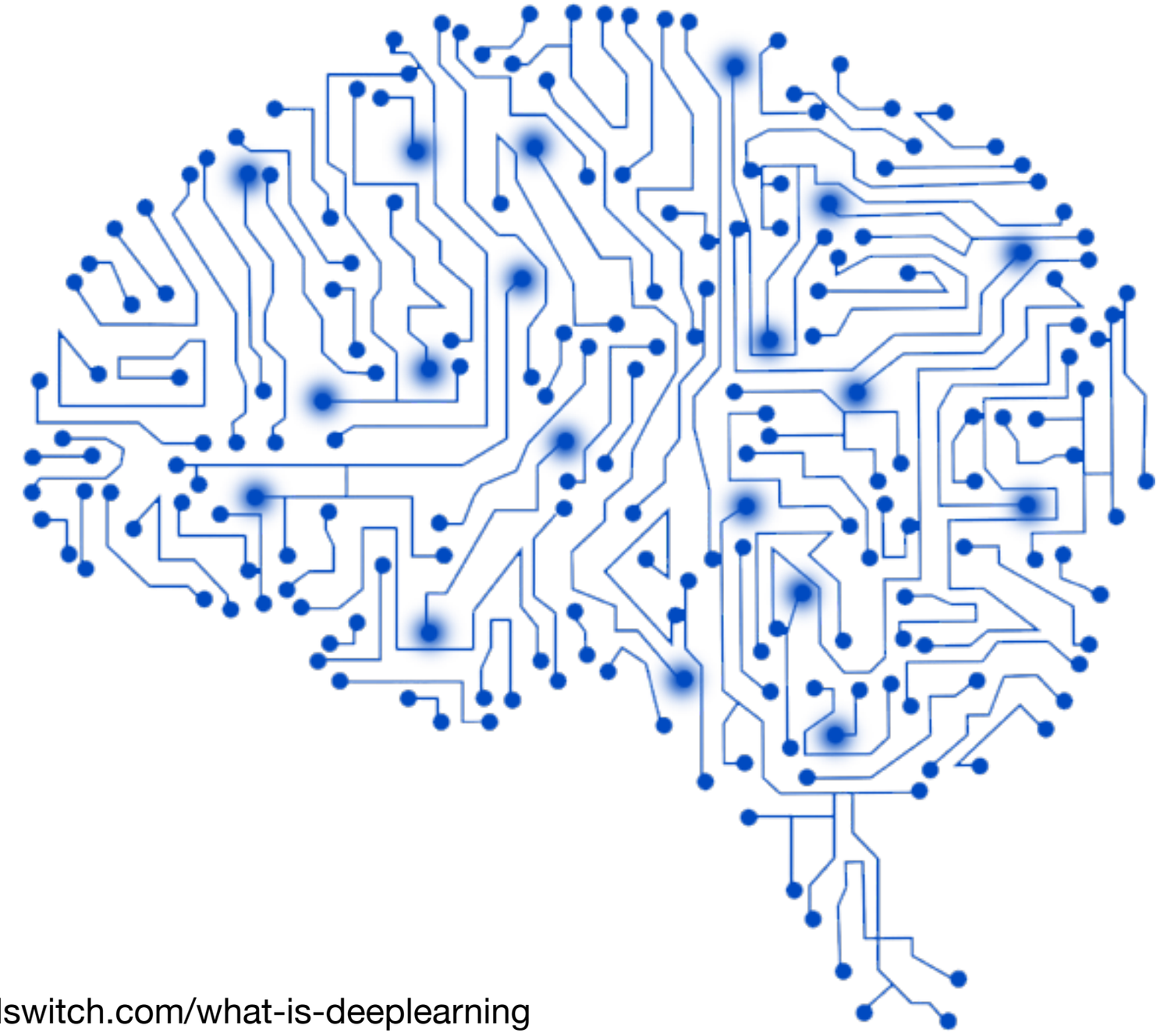


Source: https://wikipedia.org

Clustering task

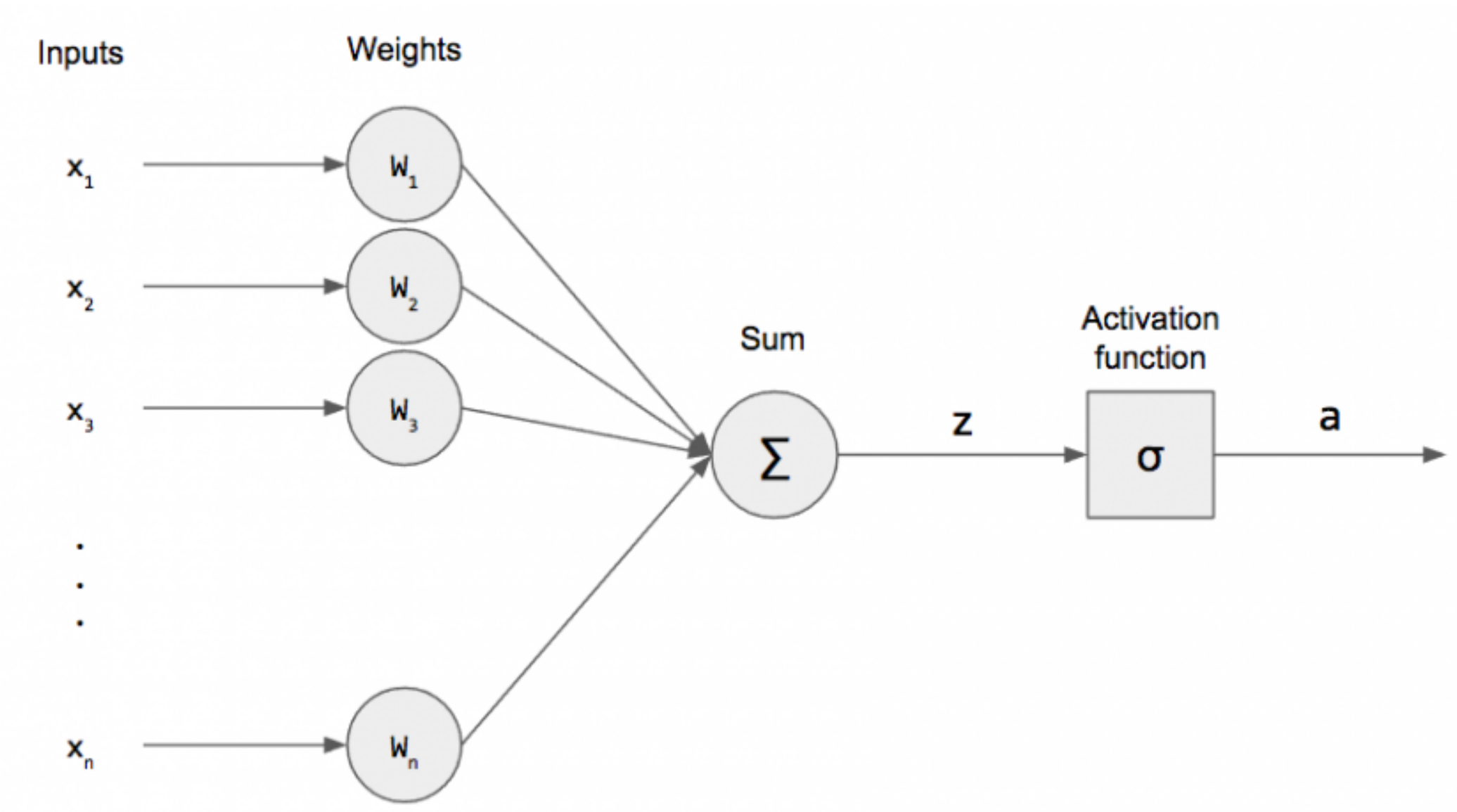
07-Clustering-assignment.ipynb

Neural networks and deep learning



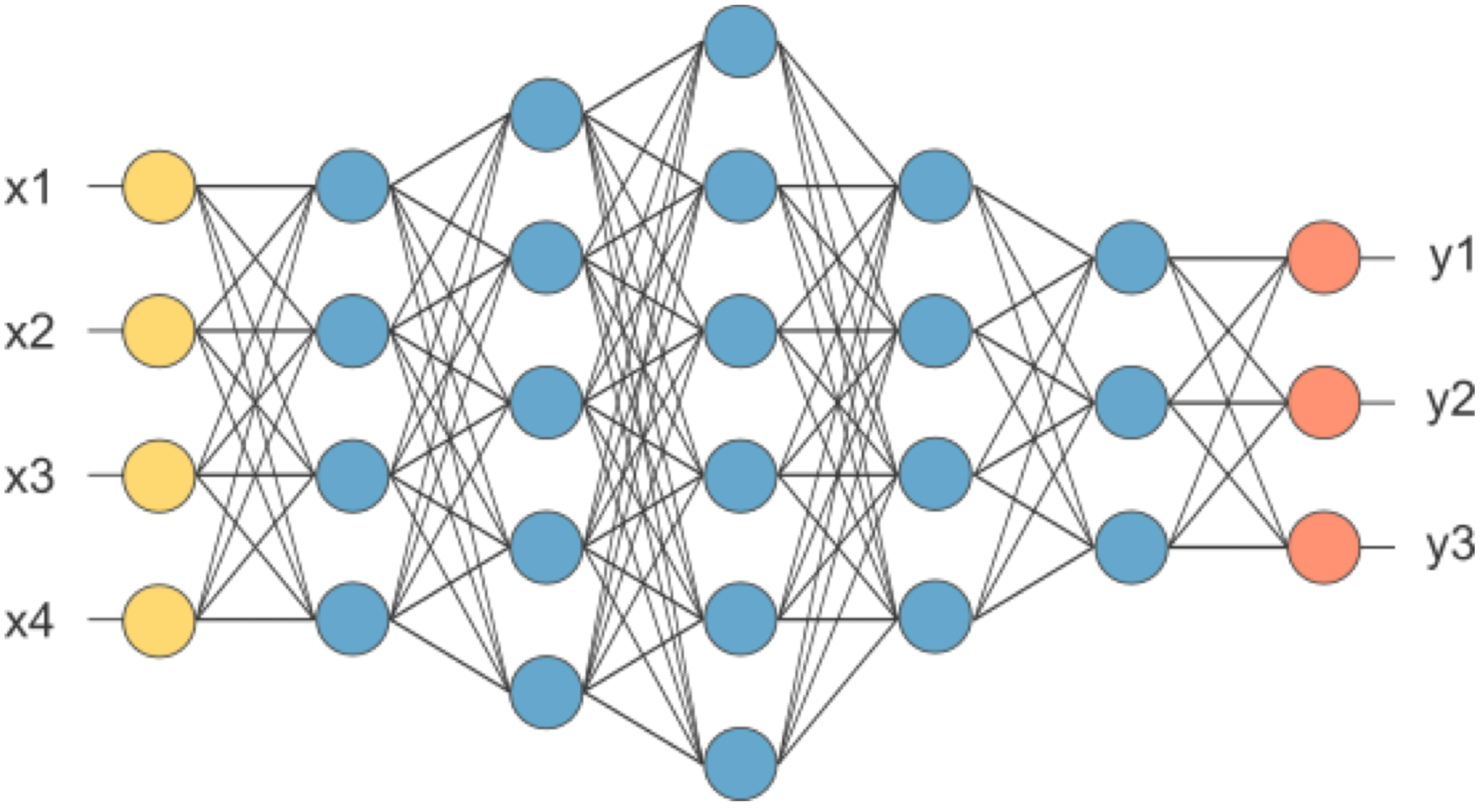
Source: http://www.rapidswitch.com/what-is-deeplearning

Perceptron

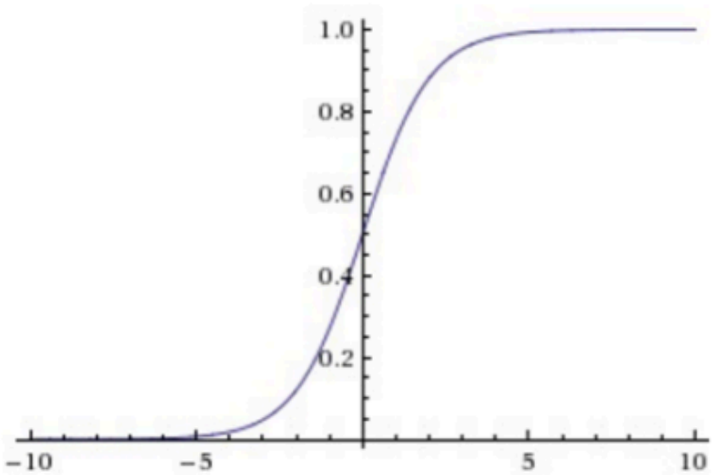


Source: https://pythonmachinelearning.pro

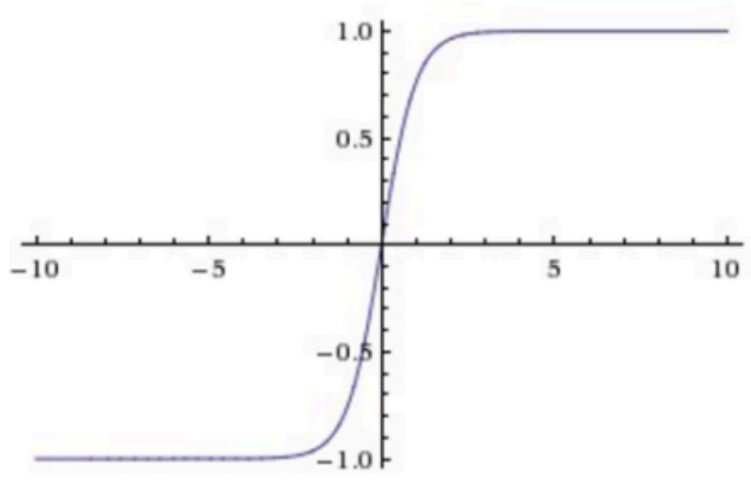
Multilayered Neural Networks



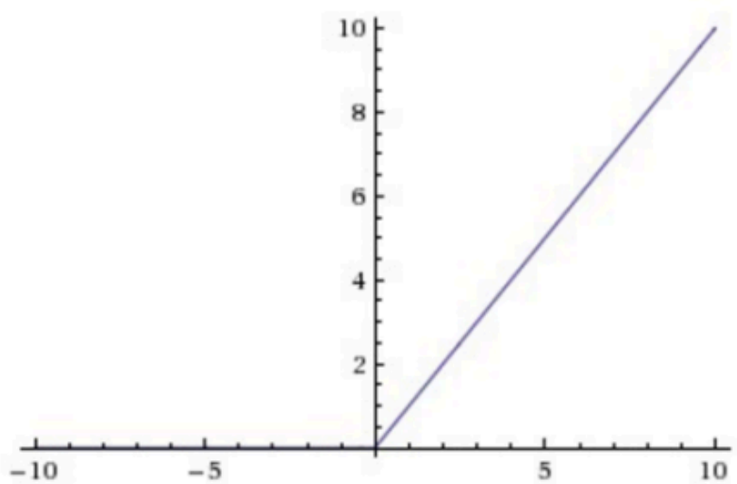
Activation functions



Sigmoid



tanh

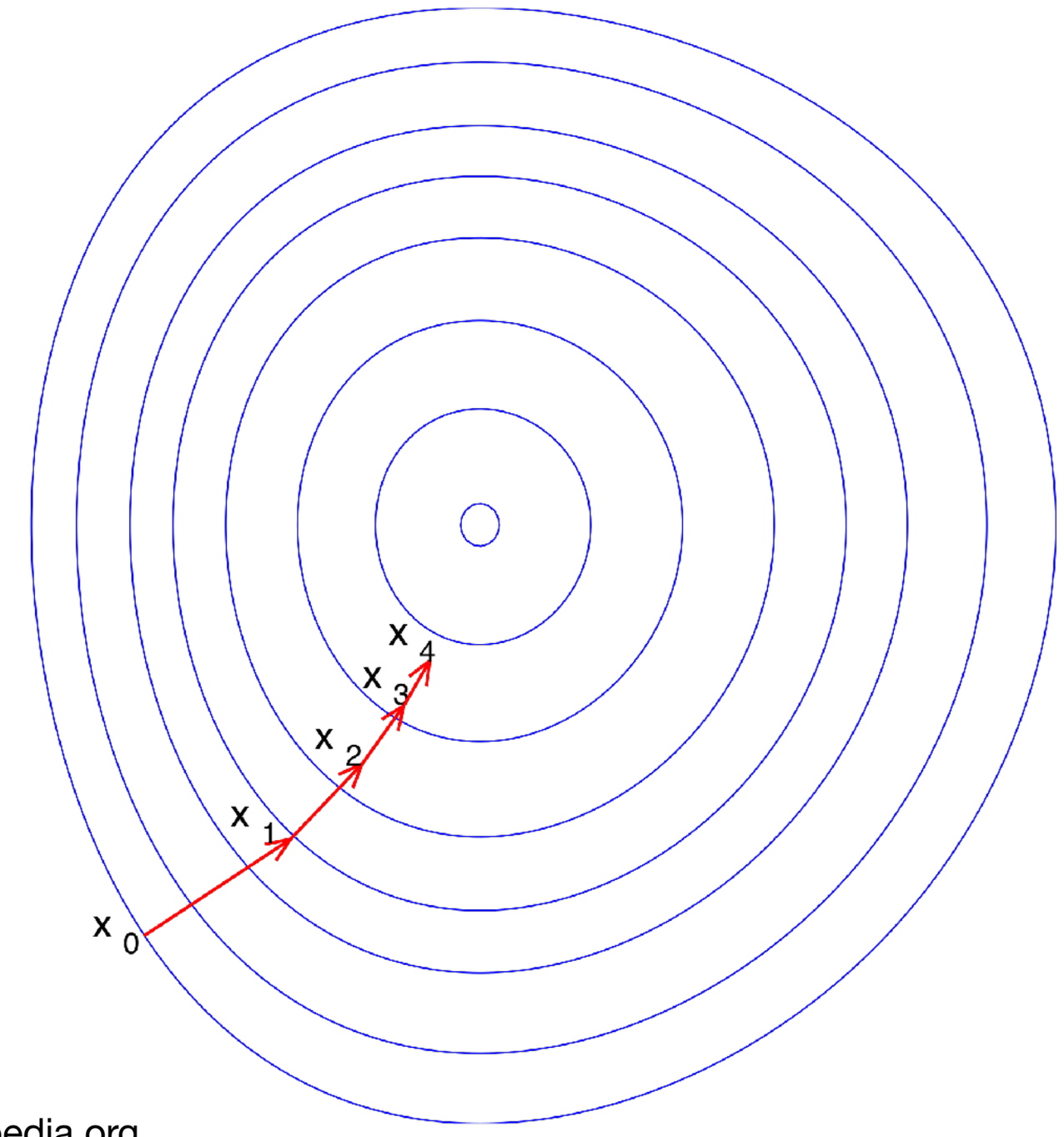


ReLU

Softmax:

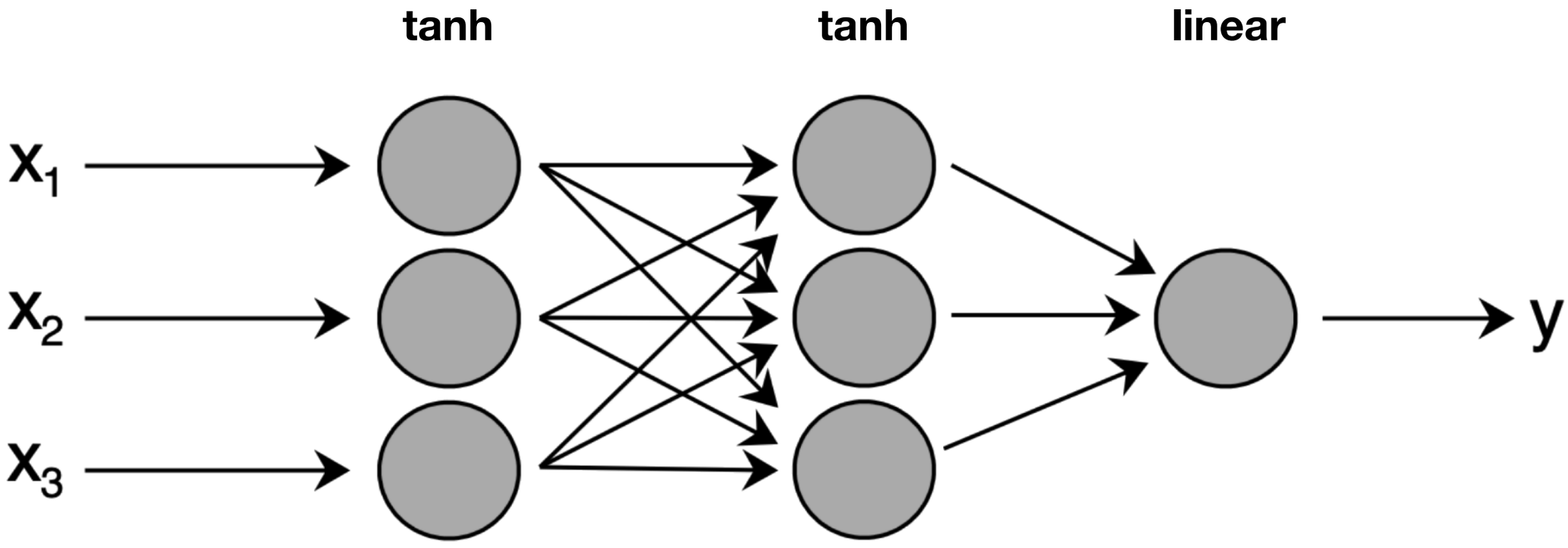
$$\sigma(\mathbf{z})_j = \frac{e^{z_j}}{\sum_{k=1}^{K} e^{z_k}}$$

Steepest gradient descent

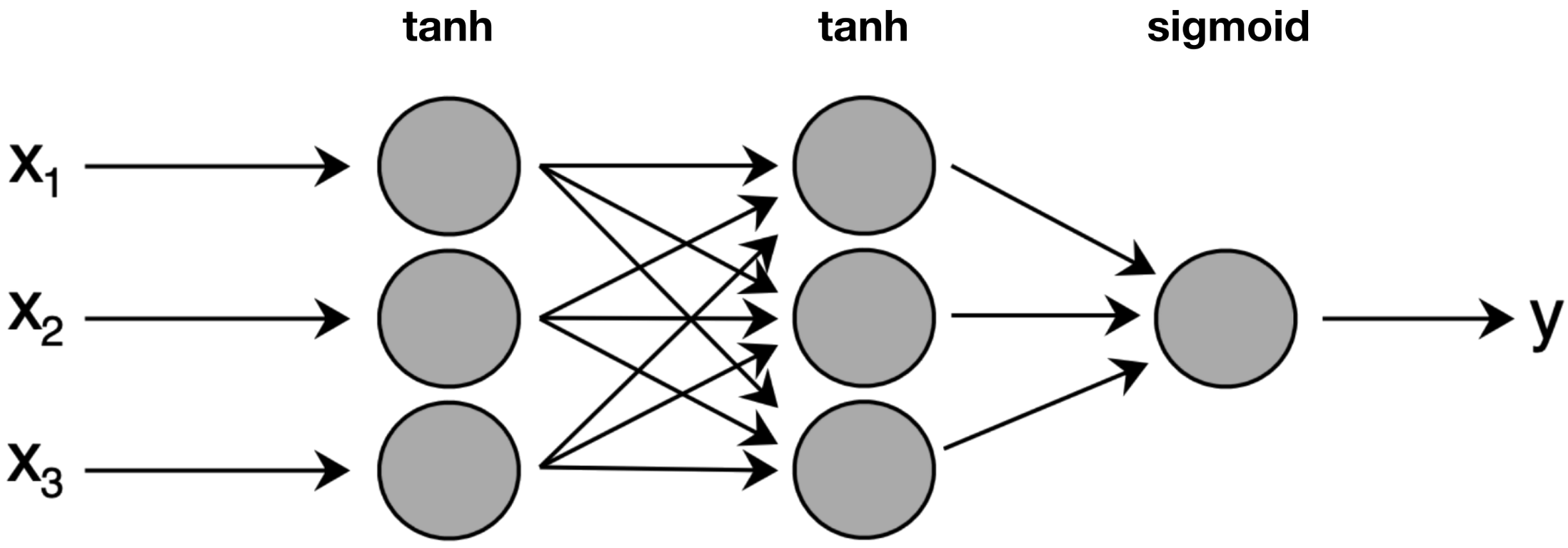


Source: https://www.wikipedia.org

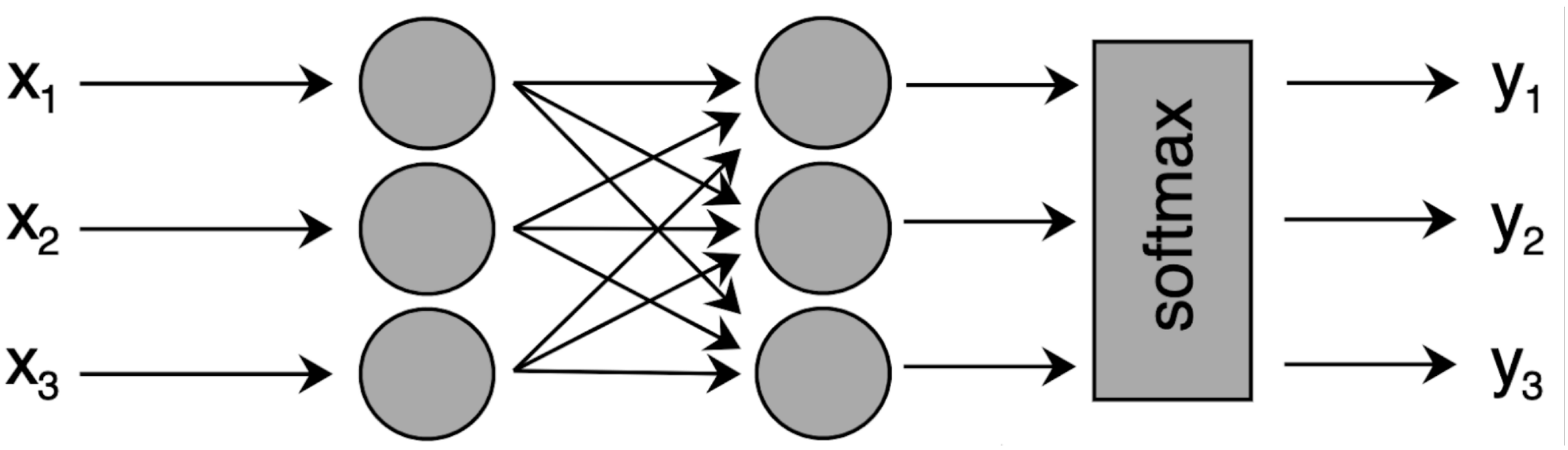
Example - NN for regression



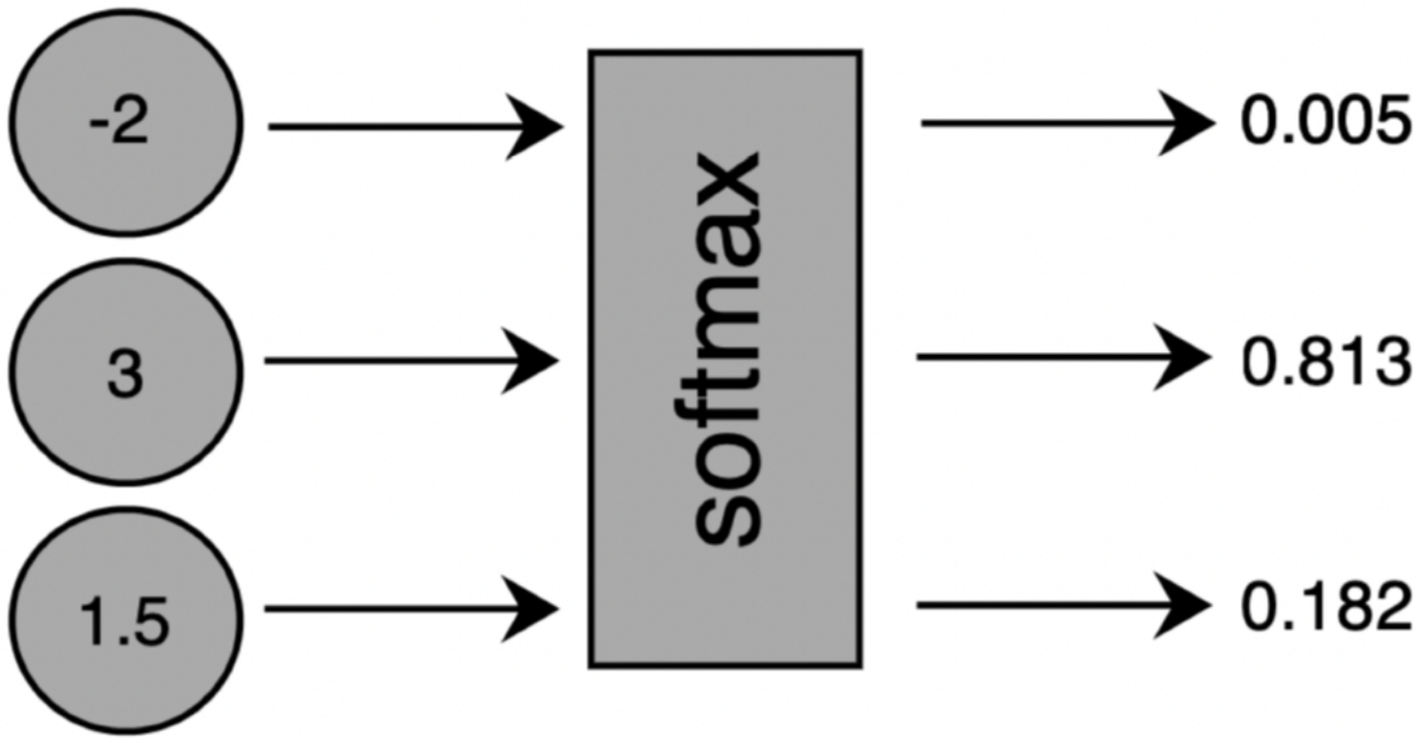
Example - NN for binary classification



Example - NN for multiclass classification



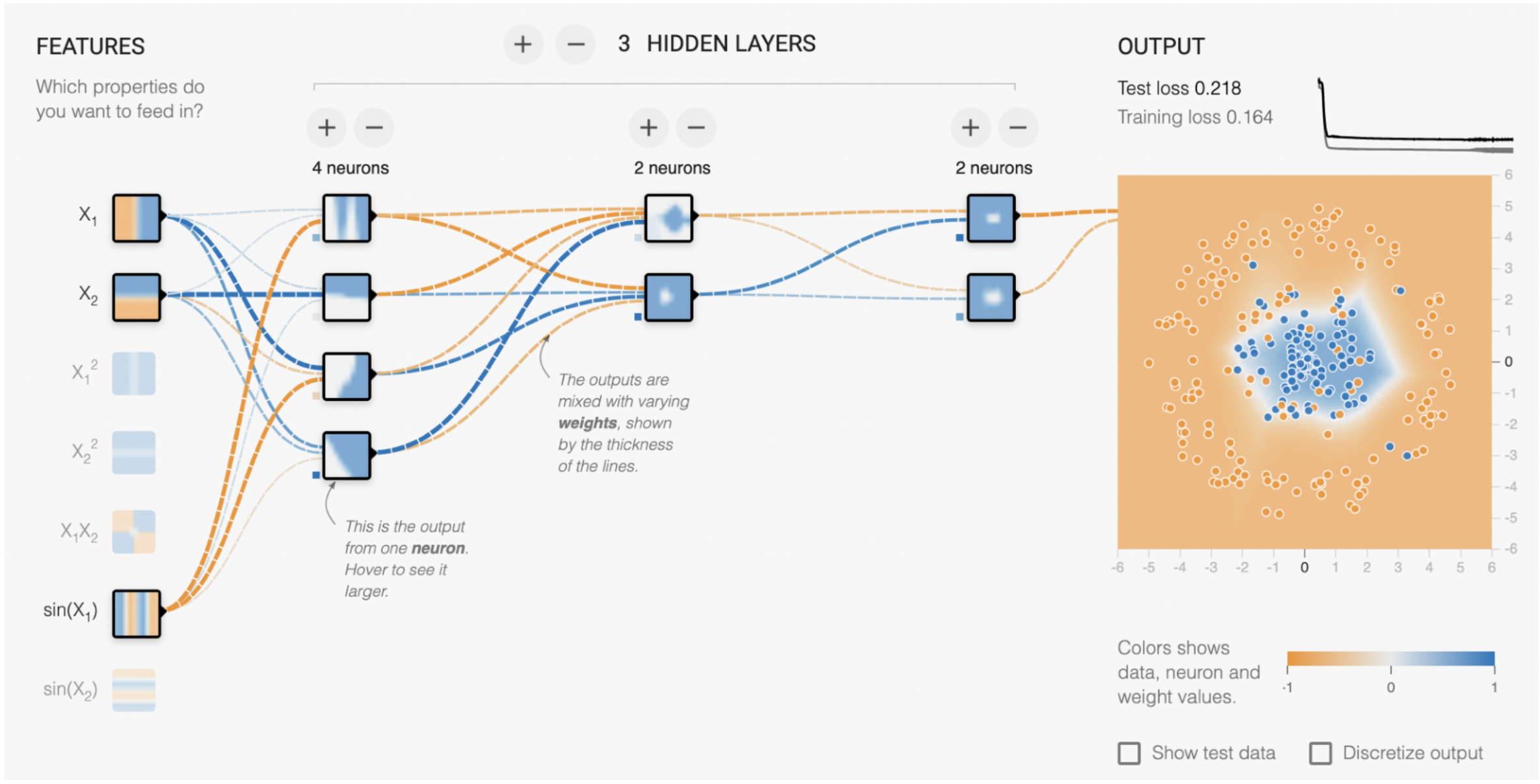
Softmax example



Important terms

- deep learning
- stochastic gradient descent
- batch and mini-batch learning
- epoch

Neural network playground



https://playground.tensorflow.org/

Keras tutorial

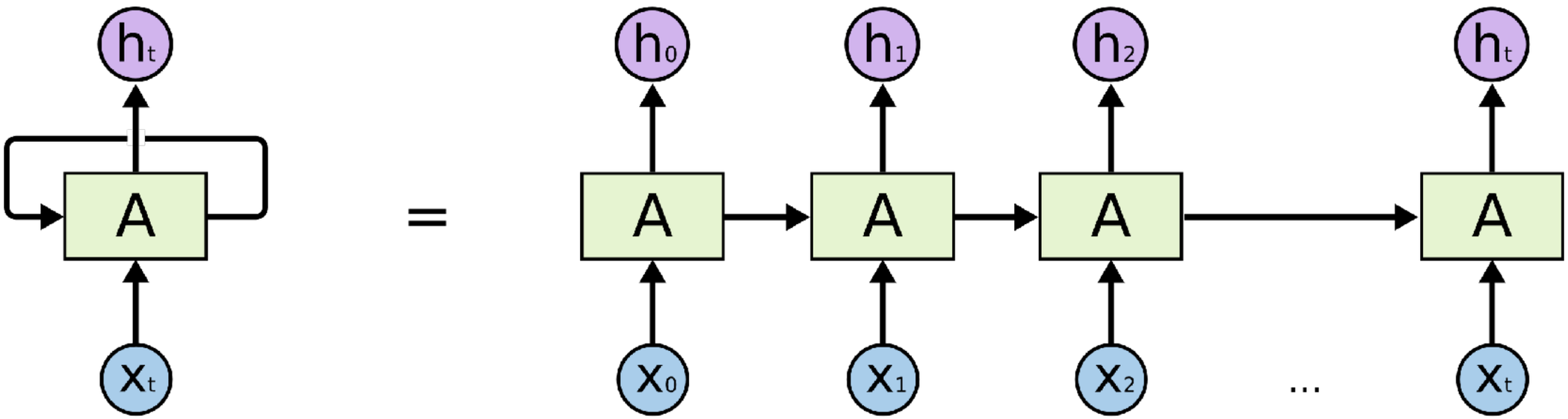
08-Keras-introduction.ipynb

Reimplemenation of the classification and regression task using NN

09-Classification-nn-assignment.ipynb

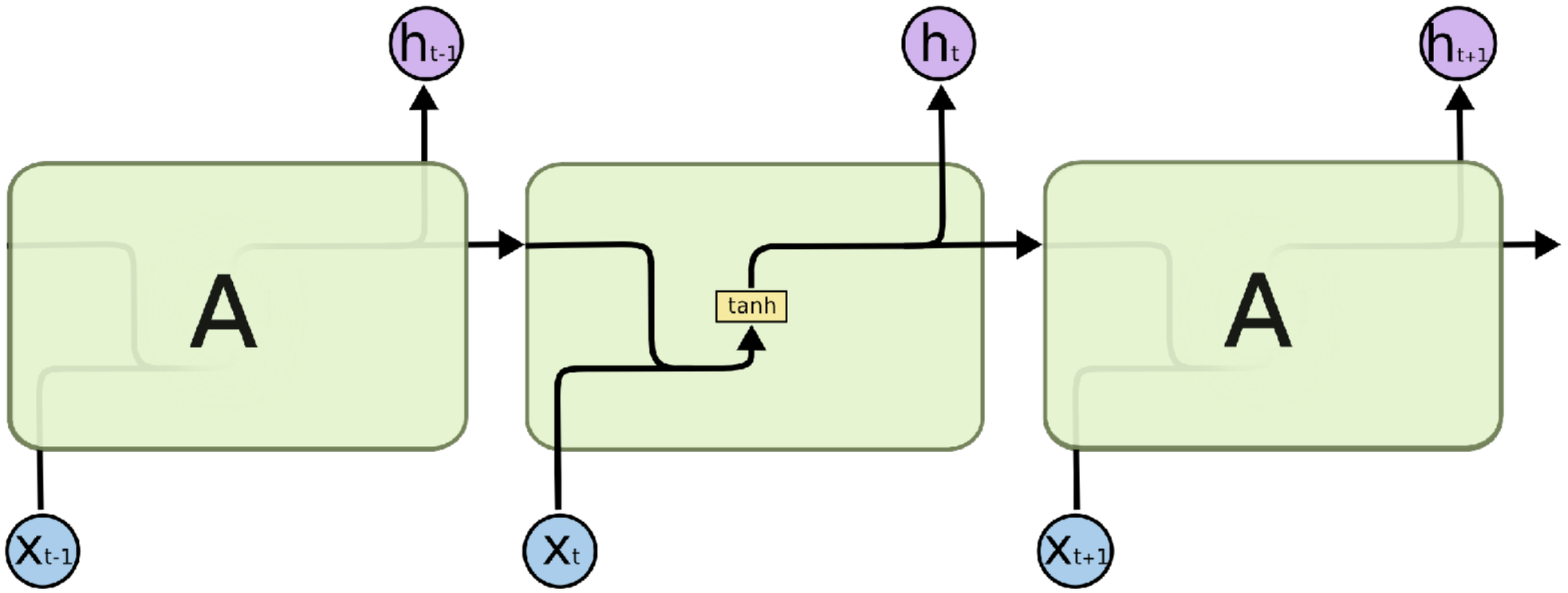
10-Regression-nn-assignment.ipynb

Recurrent Neural Networks 1/2 (bonus)



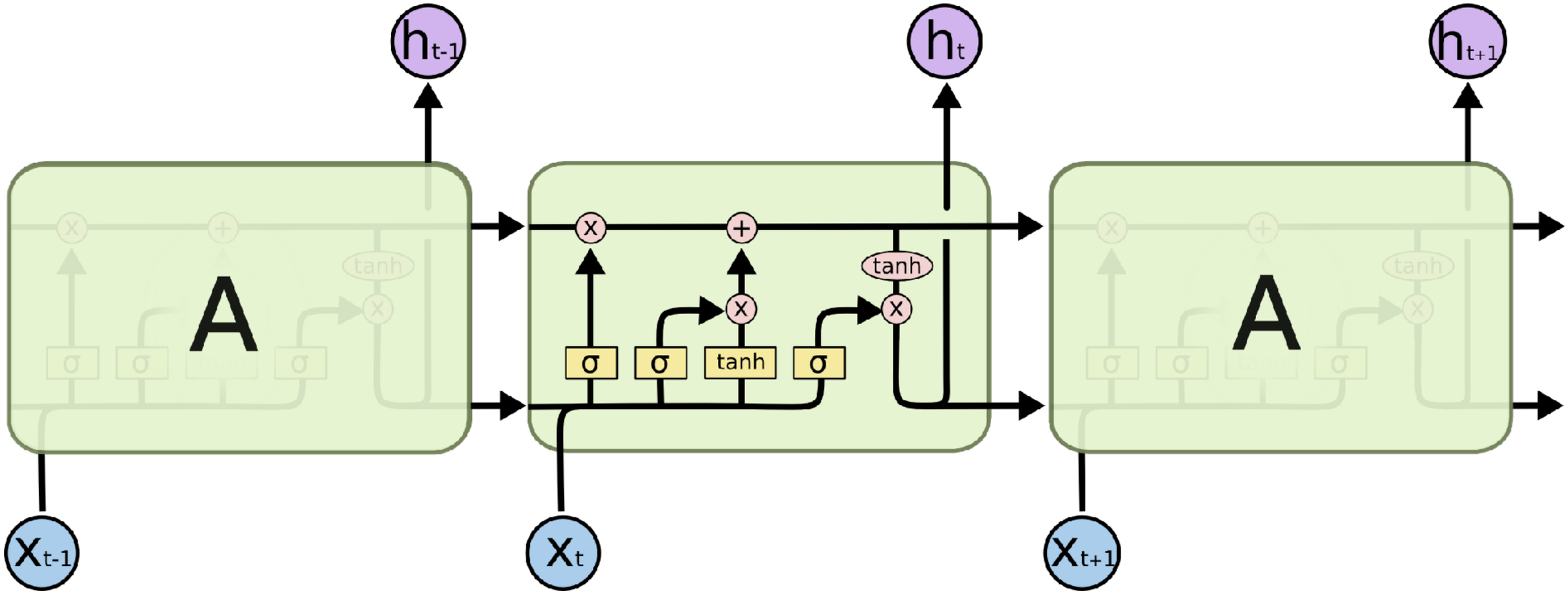
Source: https://www.tensorflow.org

Recurrent Neural Networks 2/2 (bonus)



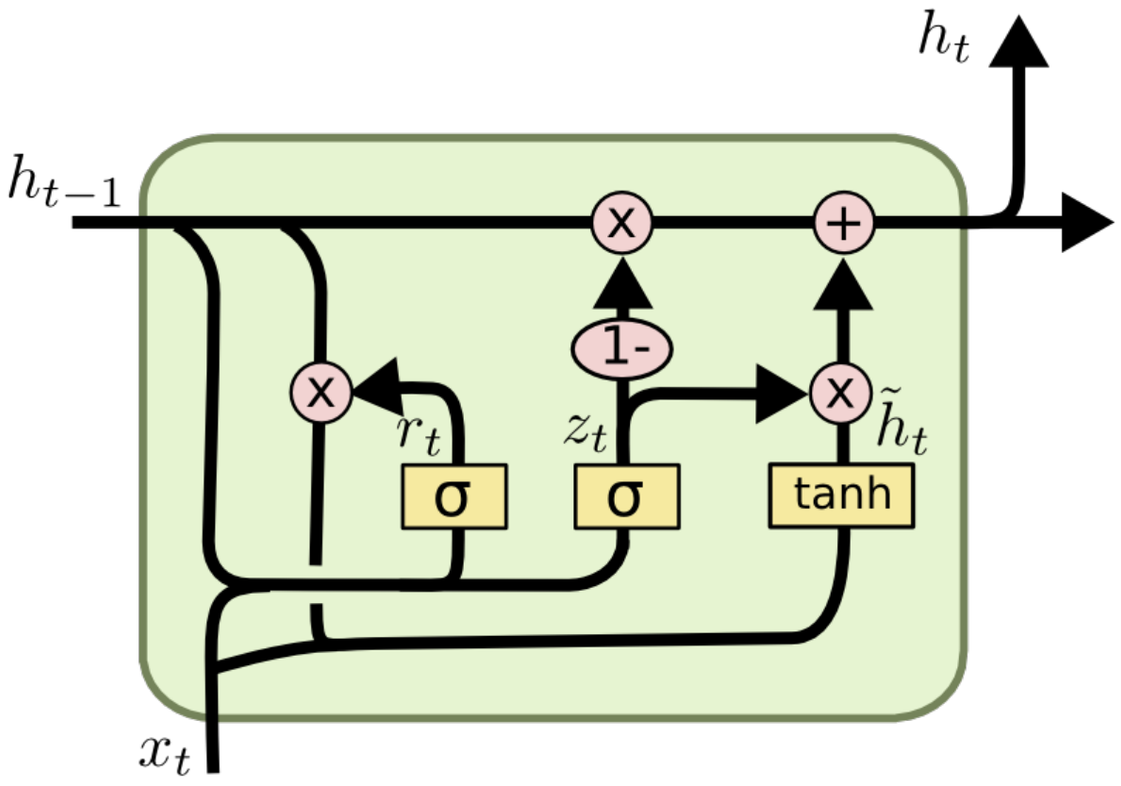
Source: https://www.tensorflow.org

Long Short-Term Memory (bonus)



Source: https://www.tensorflow.org

Gated Recurrent Unit (bonus)



$$z_t = \sigma\left(W_z \cdot [h_{t-1}, x_t]\right)$$

$$r_t = \sigma\left(W_r \cdot [h_{t-1}, x_t]\right)$$

$$\tilde{h}_t = \tanh\left(W \cdot [r_t * h_{t-1}, x_t]\right)$$

$$h_t = (1 - z_t) * h_{t-1} + z_t * \tilde{h}_t$$

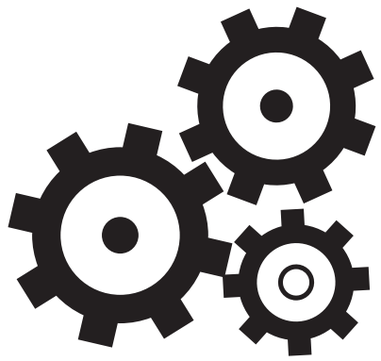
Source: https://www.tensorflow.org

Reimplemenation of the regression task using Recurrent neural network (bonus)

11-Regression-rnn.ipynb

What next?

https://www.mlcollege.com/en/#courses



Machine Learning Prague

MACHINE LEARNING
meetups

Thank you for your attention

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Facebook: https://www.facebook.com/maternajiri

LinkedIn: https://www.linkedin.com/in/jirimaterna/