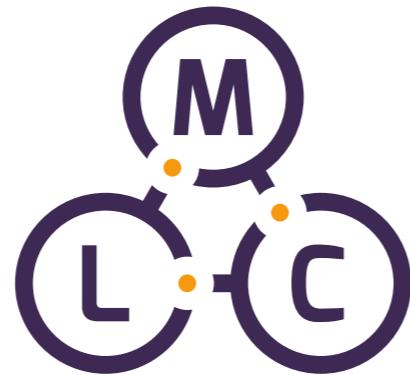


# Introduction to Machine Learning

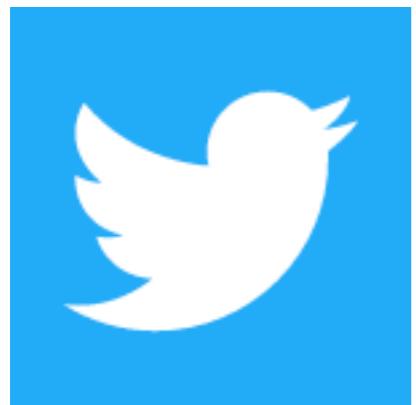
Jiří Materna



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Learning  
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# About me

- Ph.D. in Natural Language Processing and Artificial Intelligence at Masaryk University
- 10 years at [seznam.cz](http://seznam.cz) (last 8 years as Head Of Research)
- Founder and co-organiser of ML Prague
- Author of the ML Guru blog
- Mentor at StartupYard and Startup AI Incubator
- ML Freelancer and consultant

# Outline

## Day 1

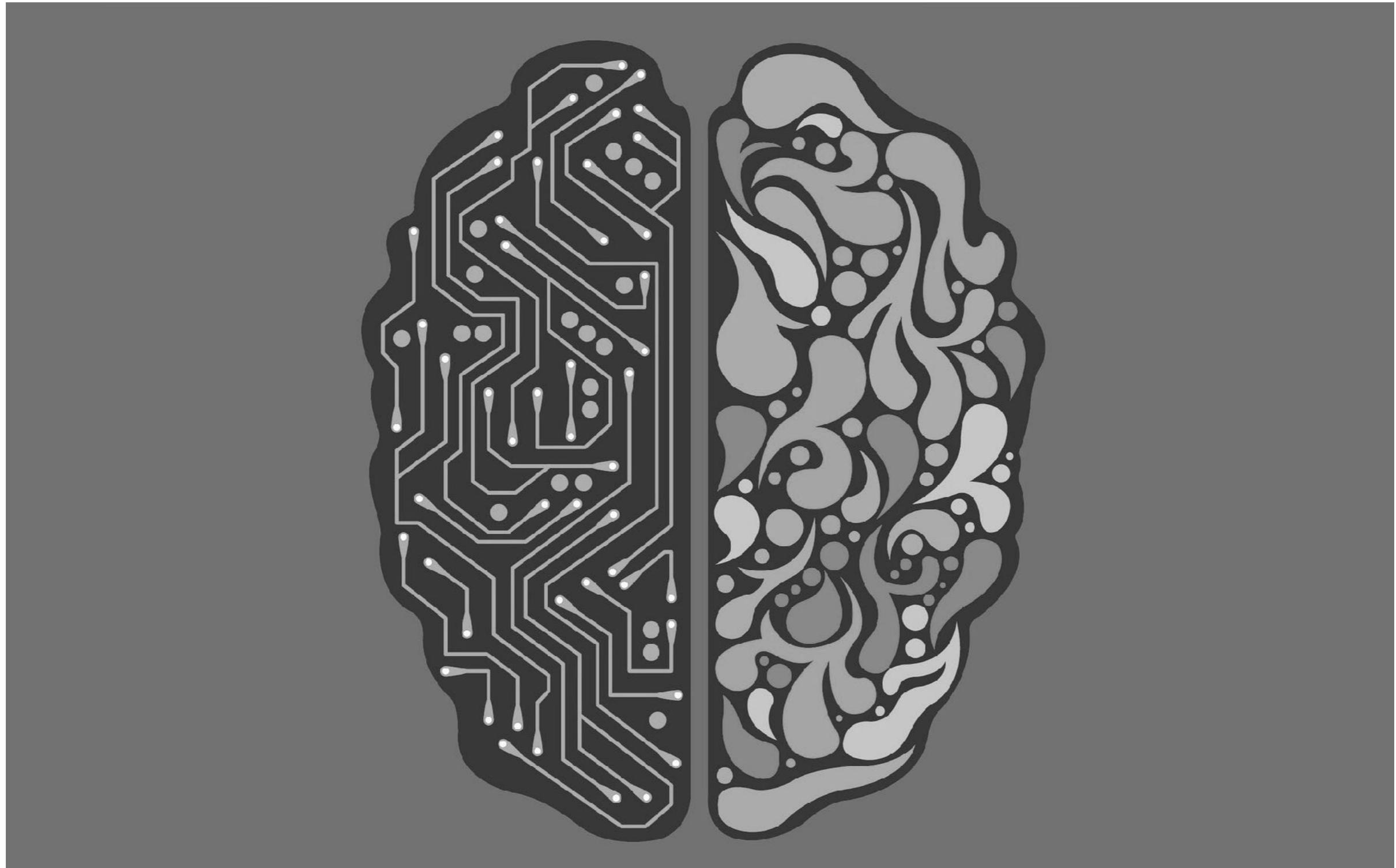
- Introduction to machine learning
- Types of ML tasks
- Data preparation
- Model evaluation
- Basic classification algorithms
- Scikit-learn tutorial
- Practical classification task
- Basic regression algorithms
- Regression model evaluation
- Practical regression task

# Outline

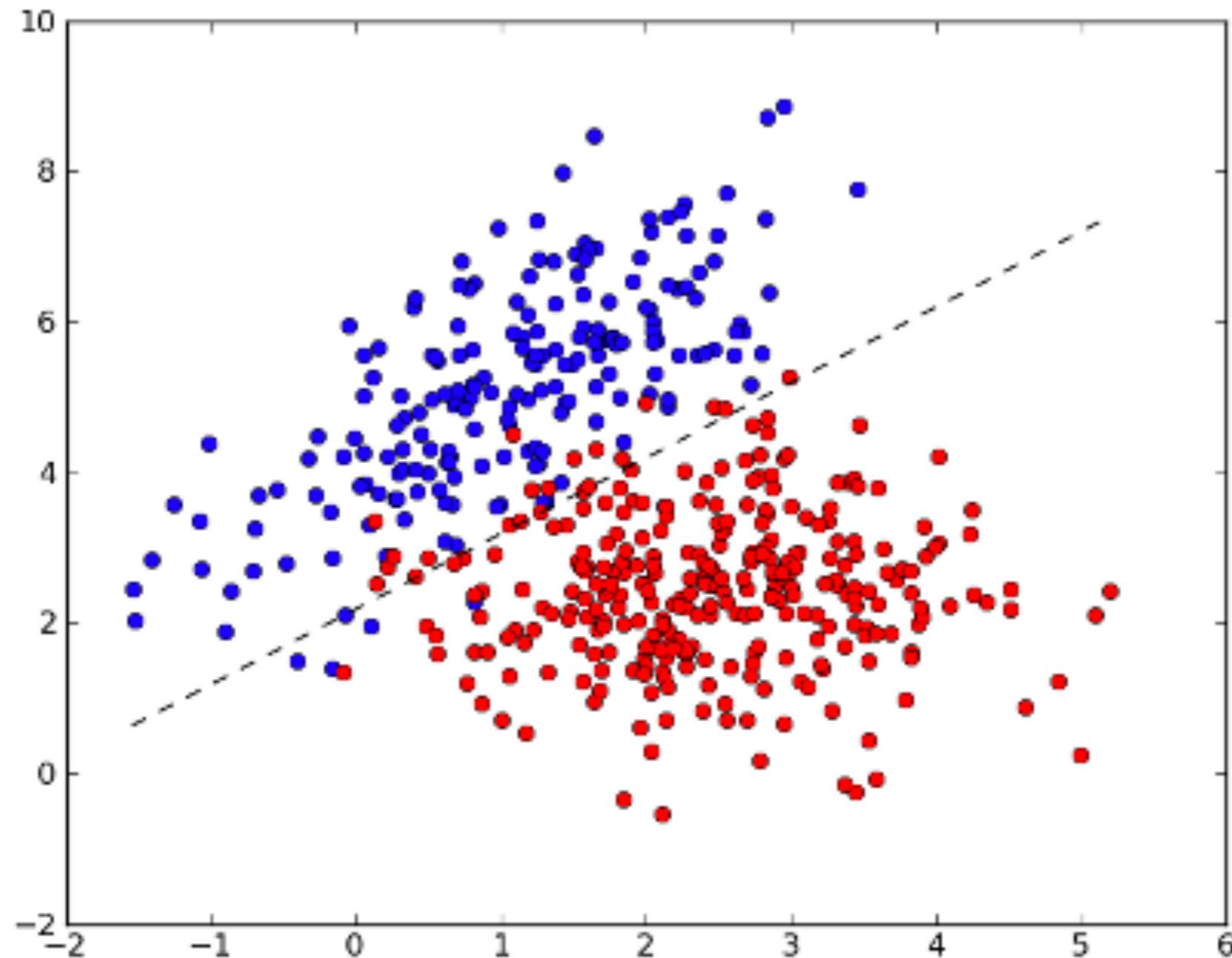
## Day 2

- 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

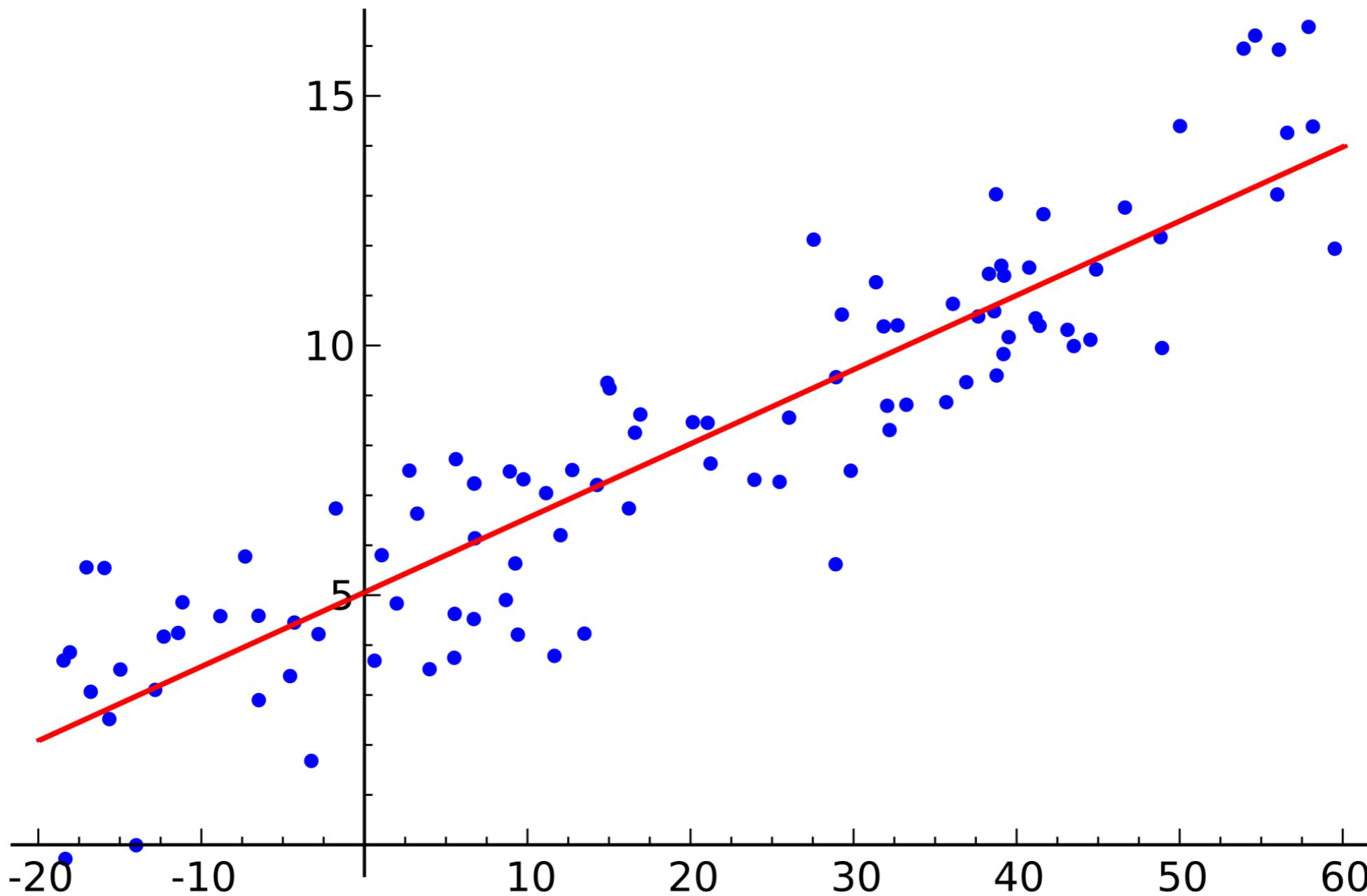
# What is (not) machine learning?



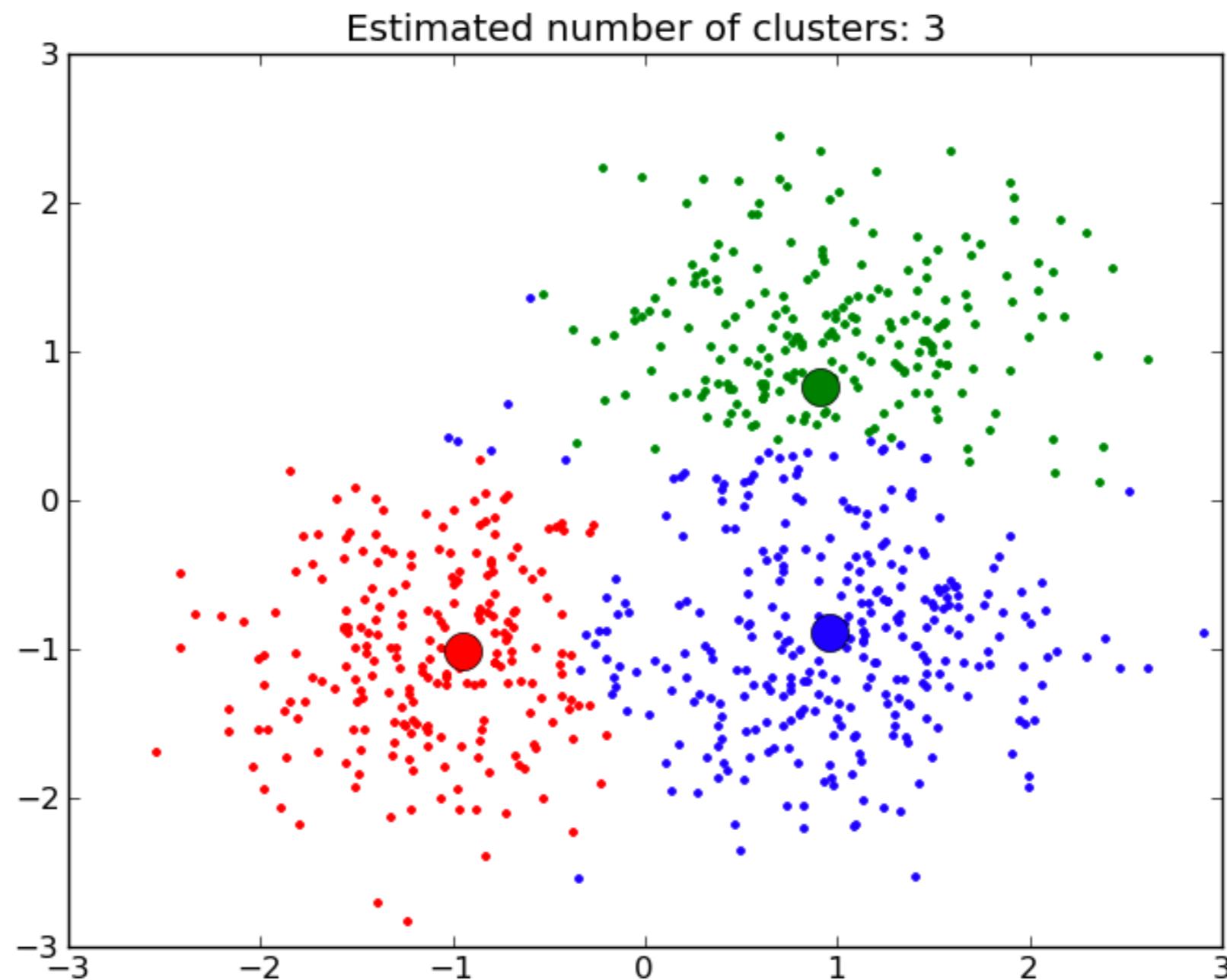
# Classification



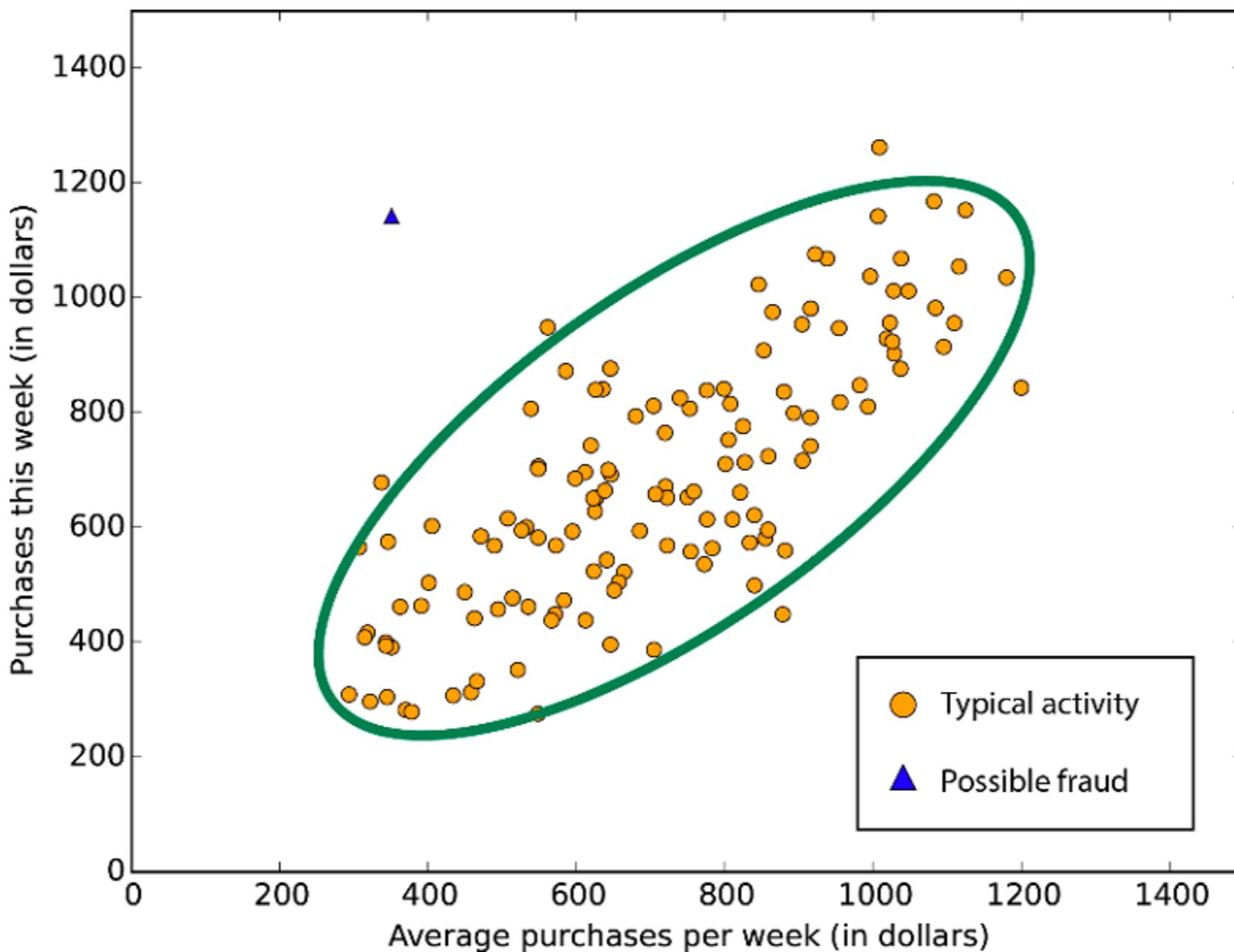
# Regression



# Clustering

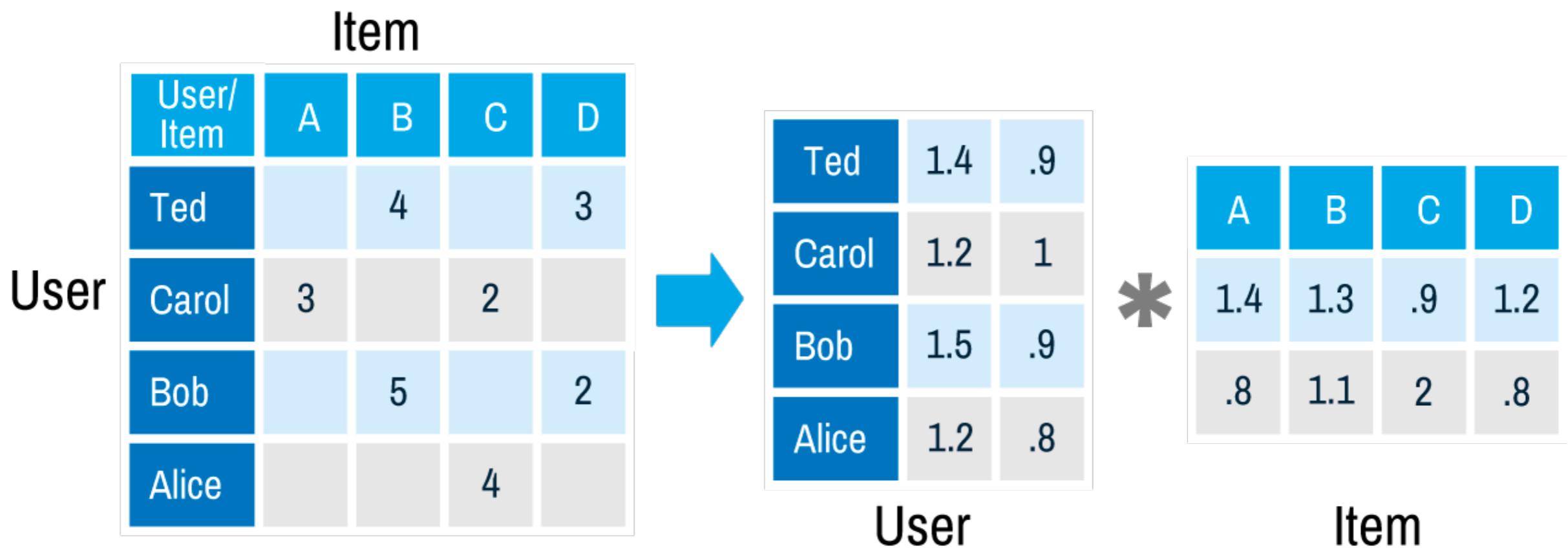


# Anomaly detection

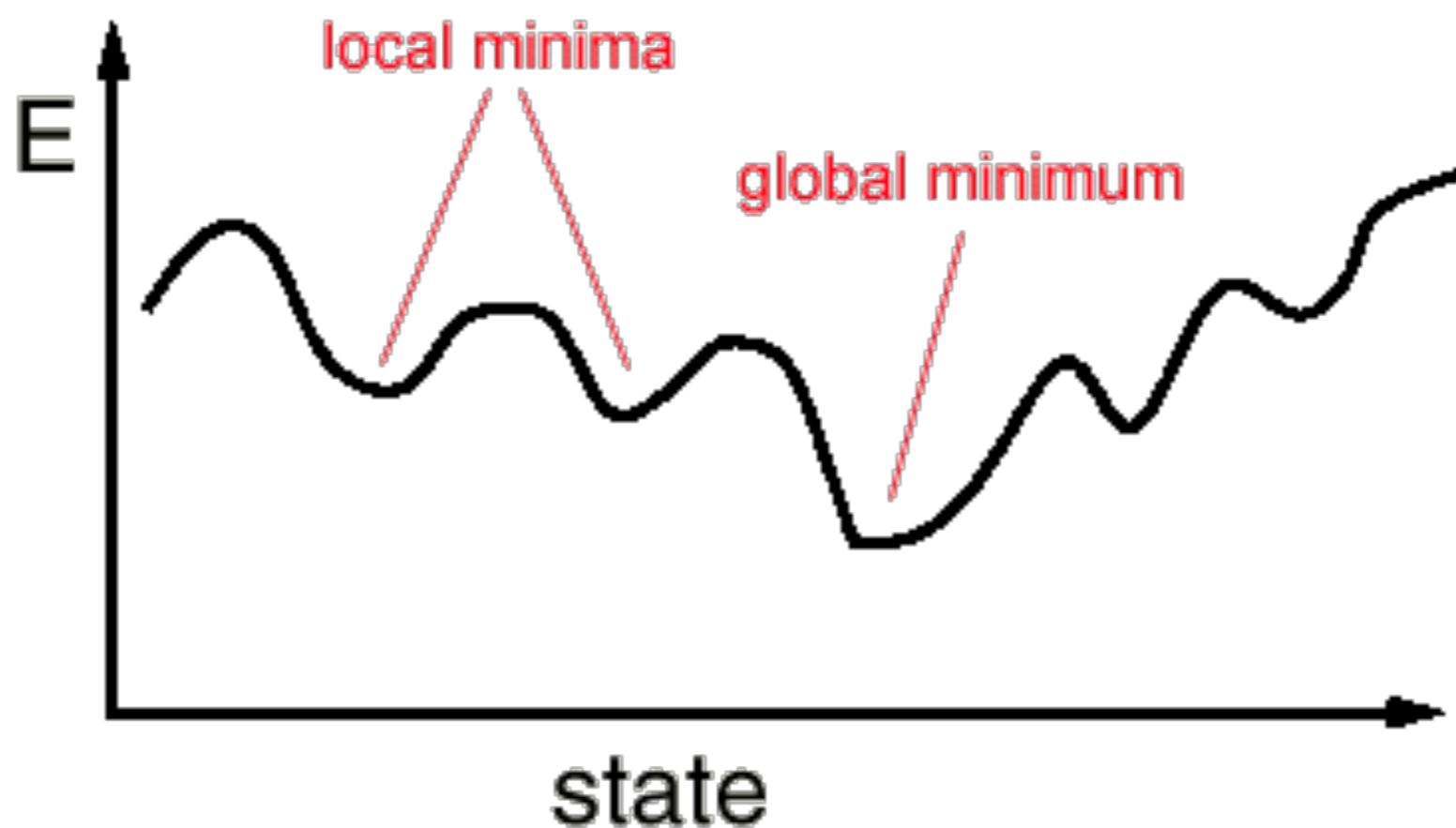


Source: <https://docs.microsoft.com/en-us/azure>

# Recommendation



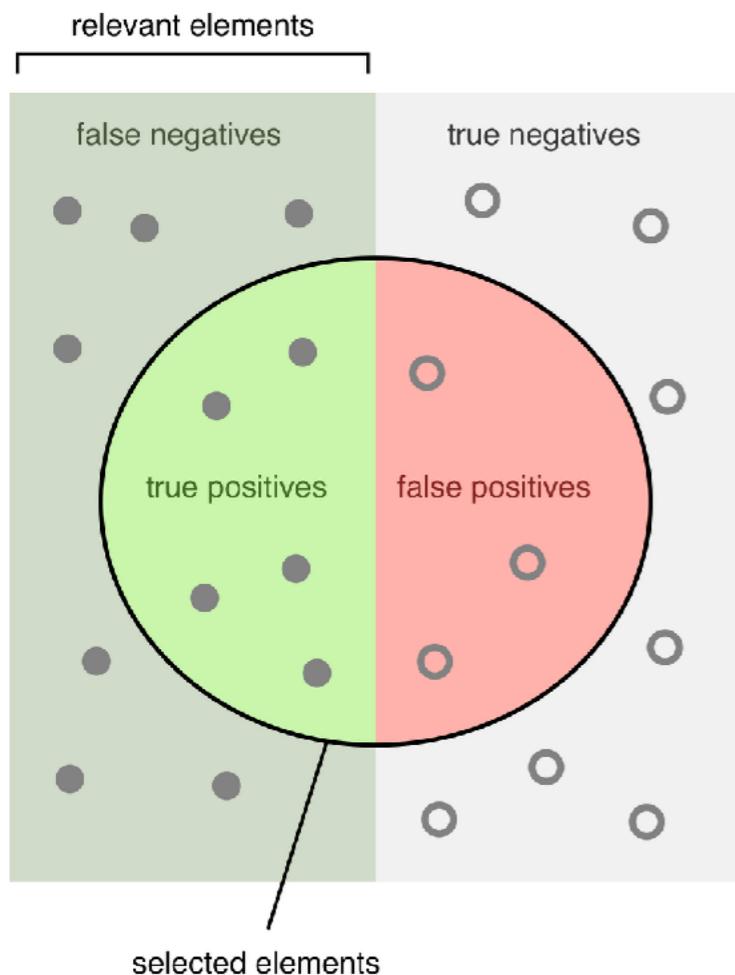
# Optimization



# Data

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

# Model evaluation



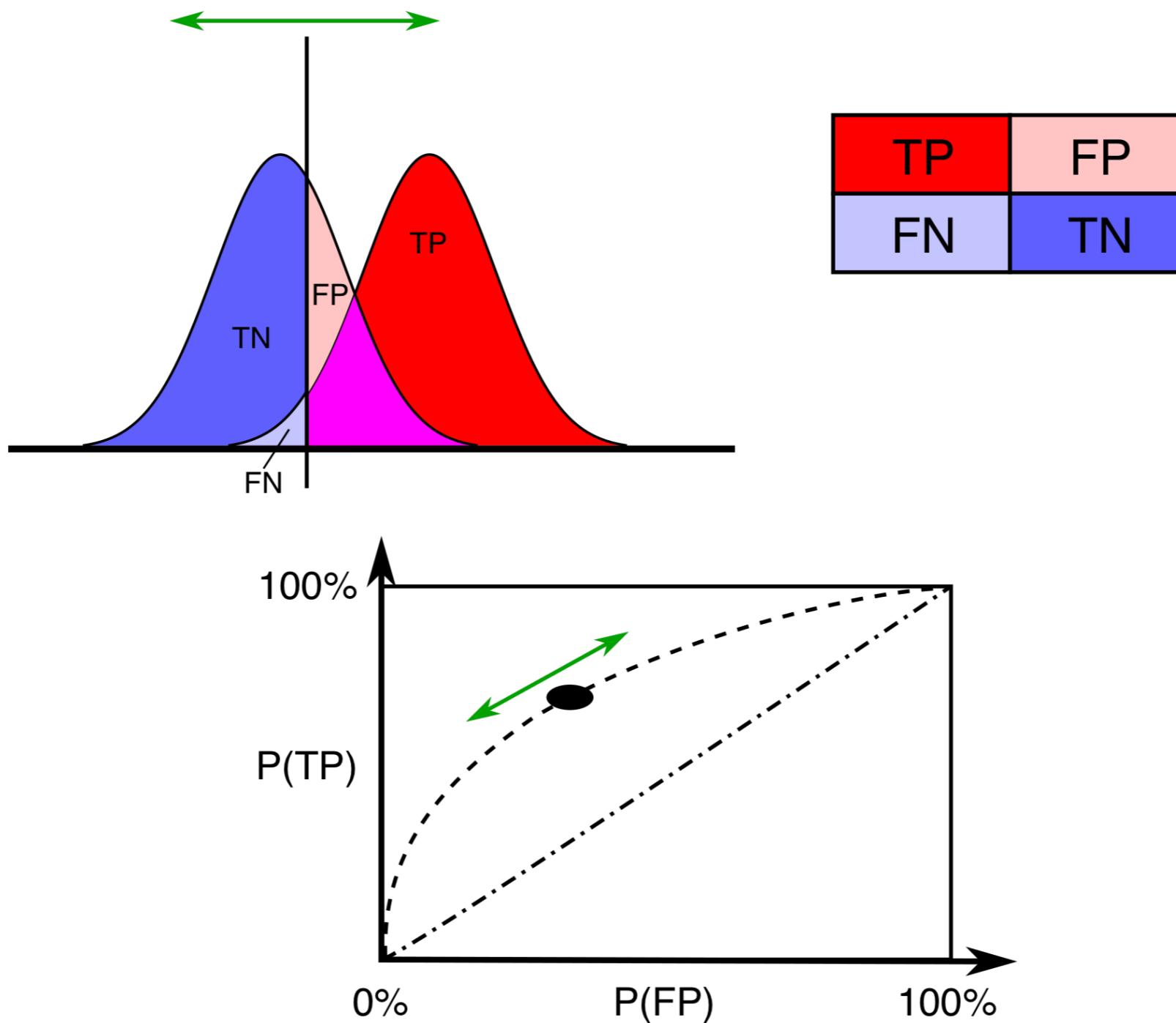
$$\text{Accuracy} = \frac{tp + tn}{tp + tn + fp + fn}$$

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

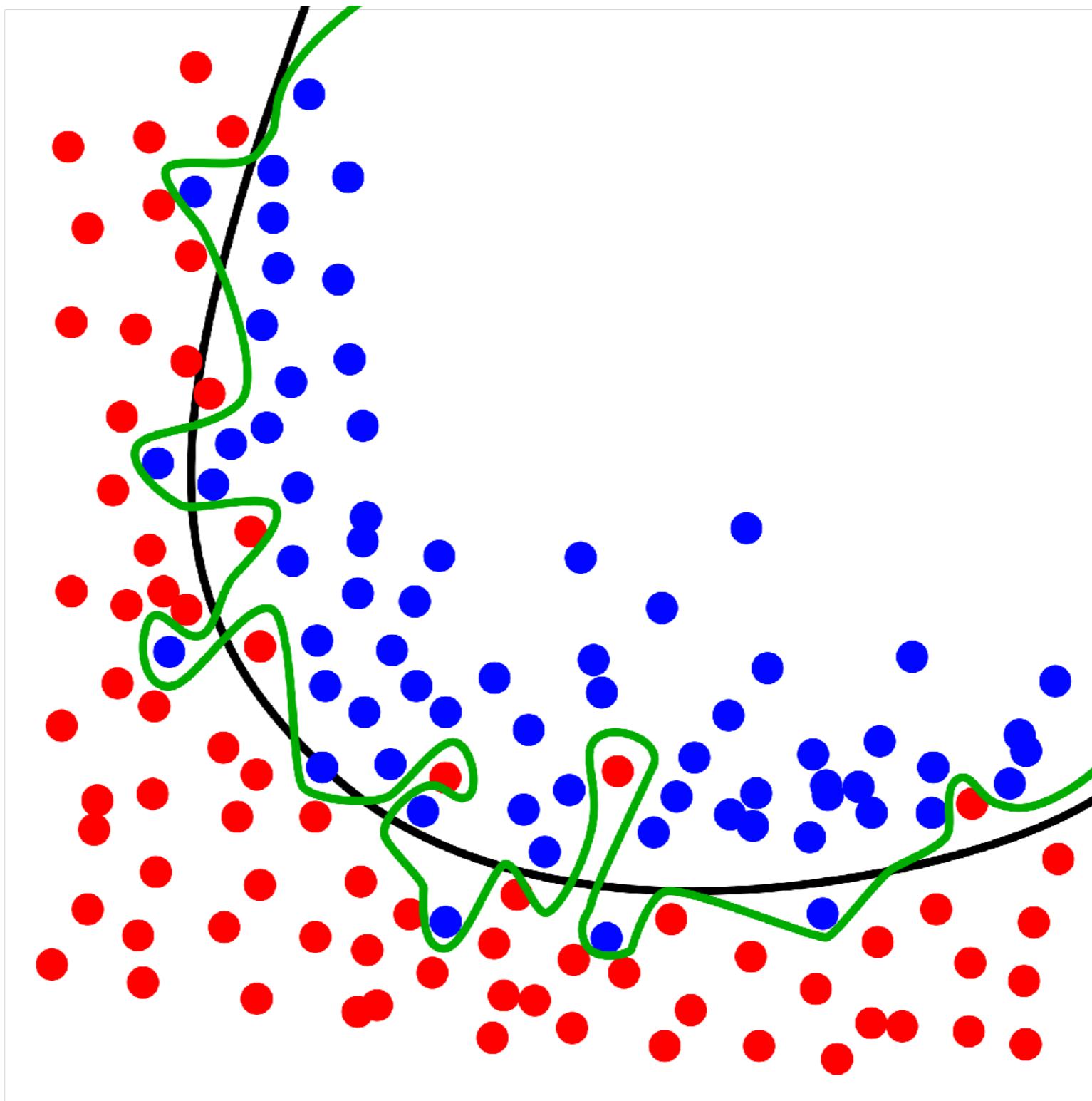
$$\text{Recall} = \frac{tp}{tp + fn}$$

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

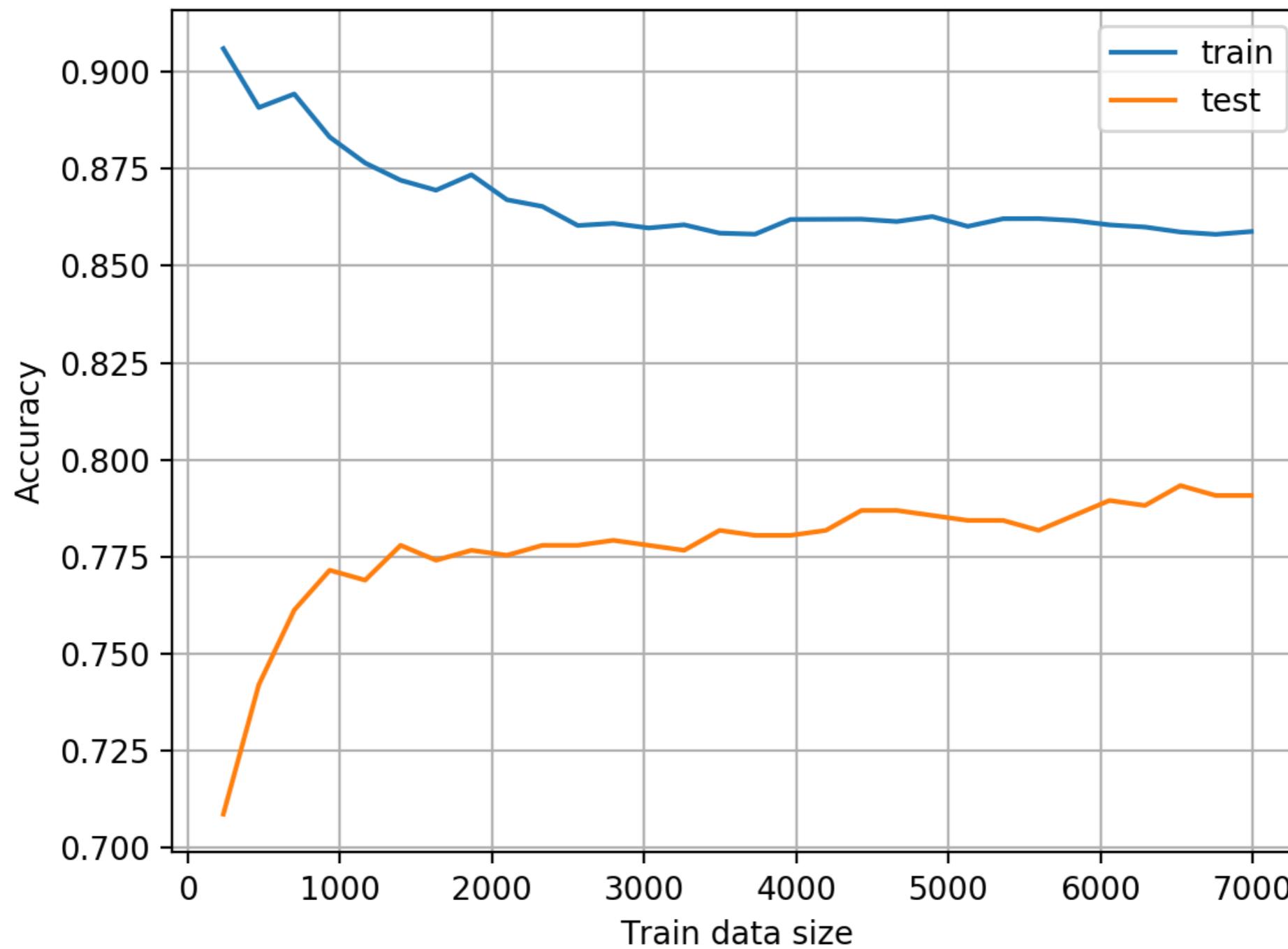
# Receiver operating characteristic (ROC Curve), AUC



# Overfitting



# Overfitting detection



# Conditional probability

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

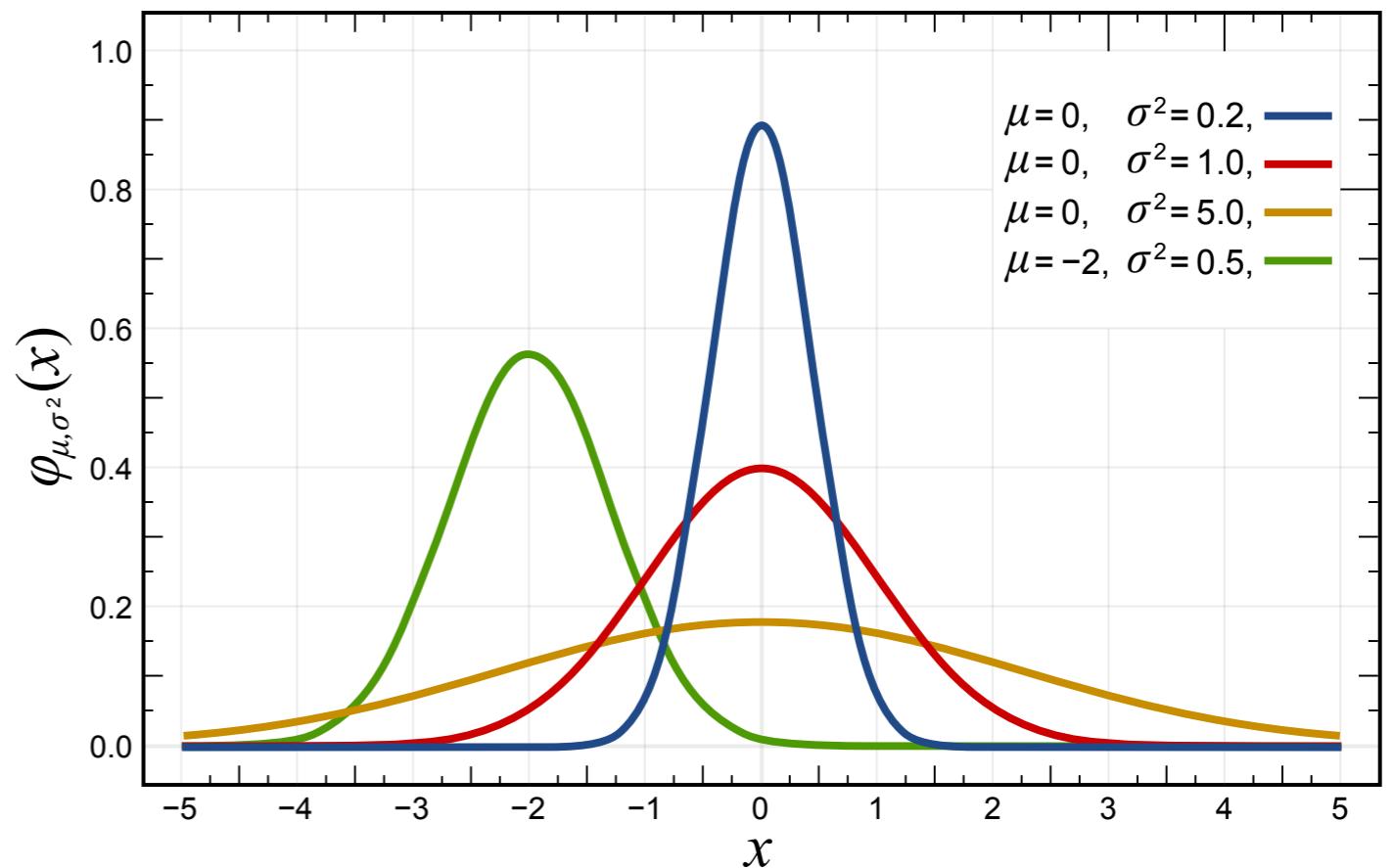
$$A \perp B \iff P(A \cap B) = P(A)P(B)$$

# 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

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



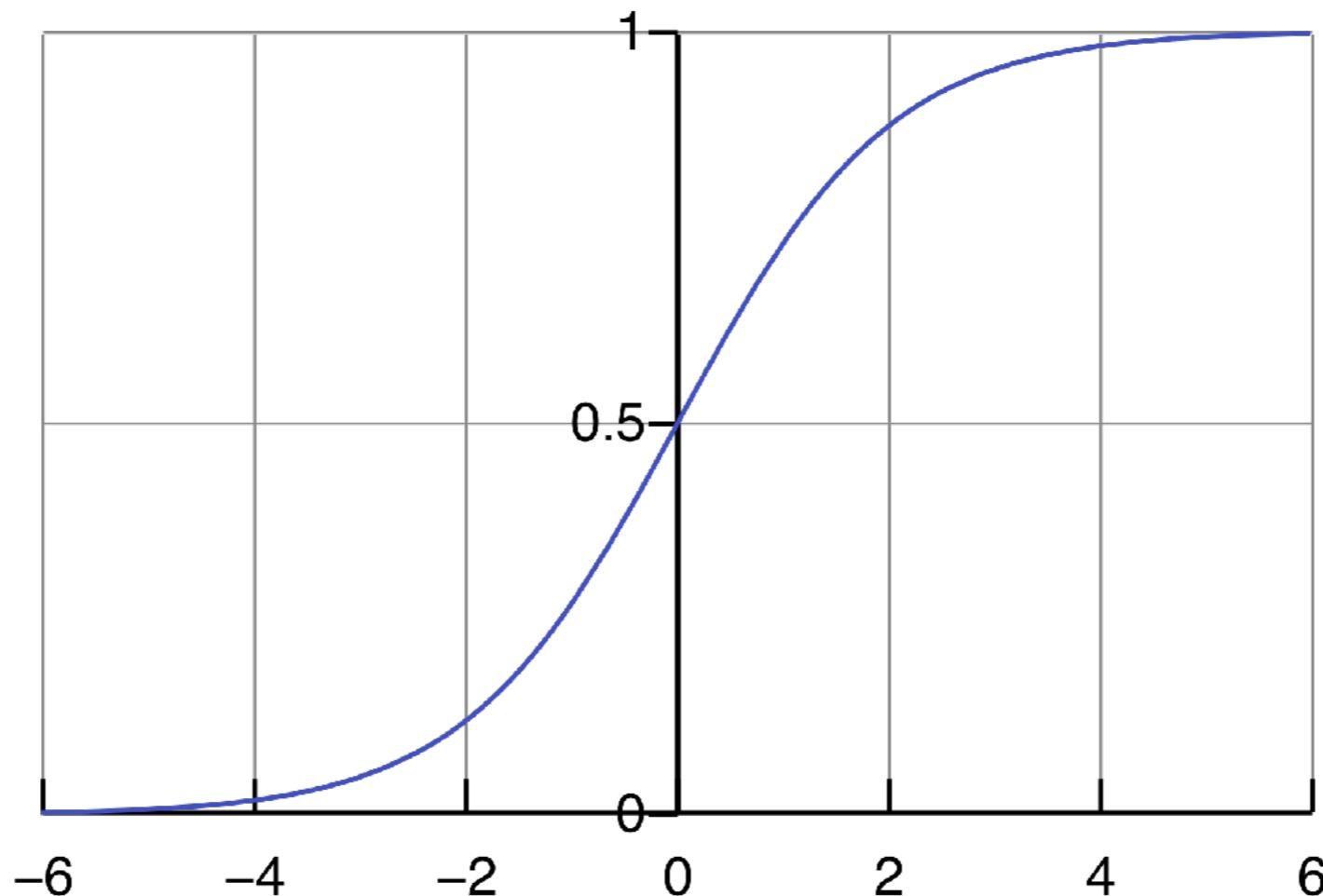
# **Scikit-learn tutorial**

**<http://scikit-learn.org/stable/>**

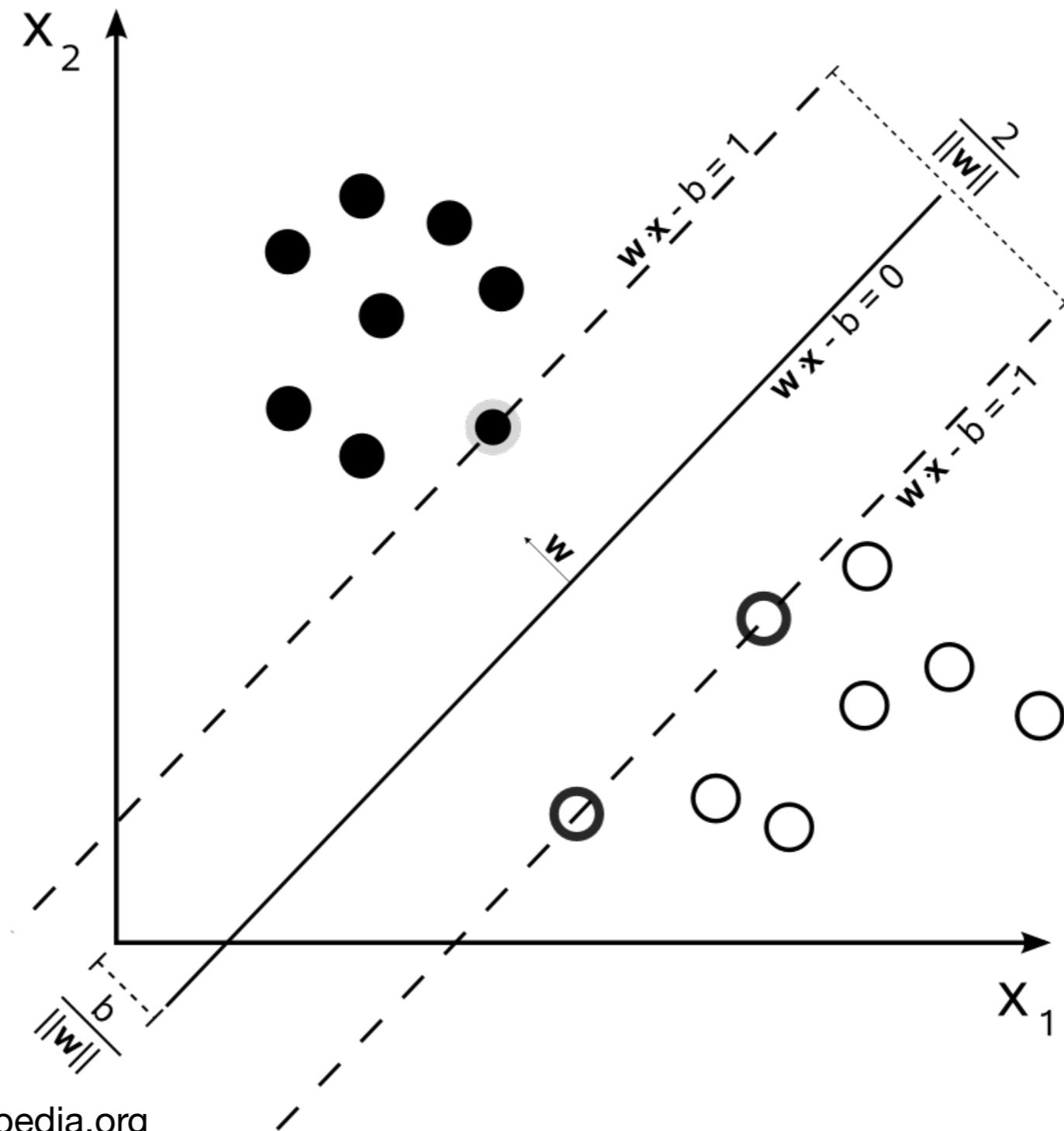
**<http://localhost:9999/notebooks/01-Scikit-introduction.ipynb>**

# Logistic regression

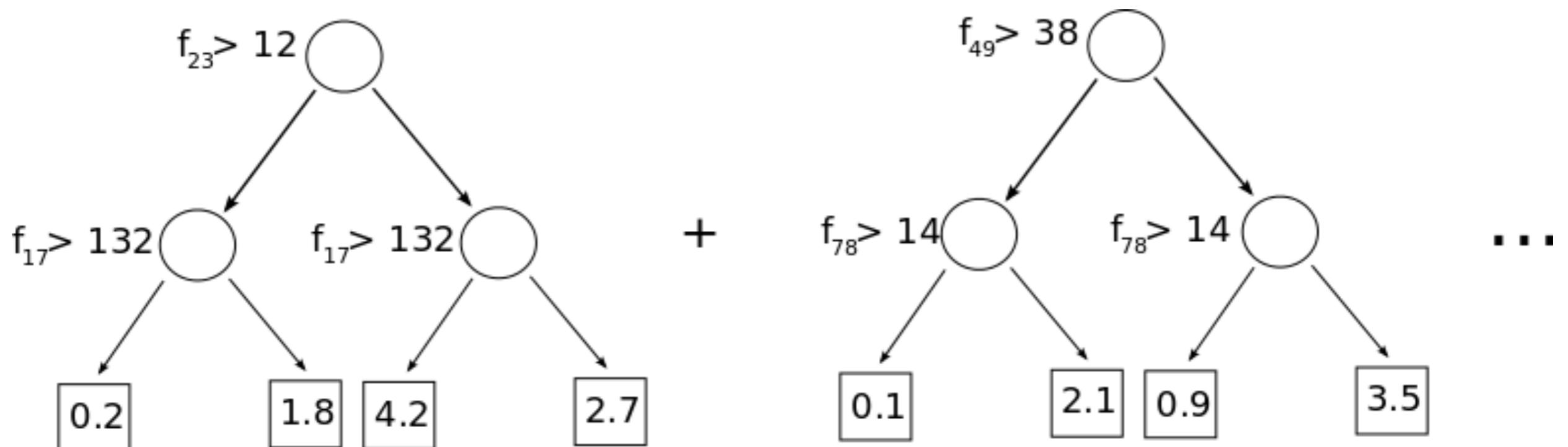
$$P(y|\vec{x}) = \frac{1}{1 + e^{-(\vec{x}\vec{w} + w_0)}}$$



# Support Vector Machines



# (Boosted) Decision/ Regression Trees

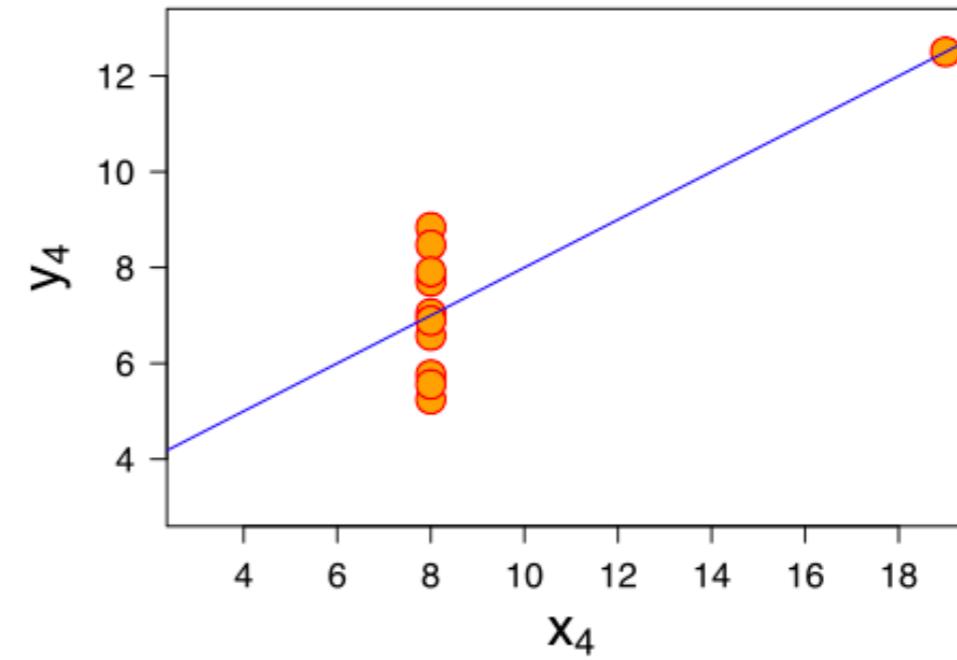
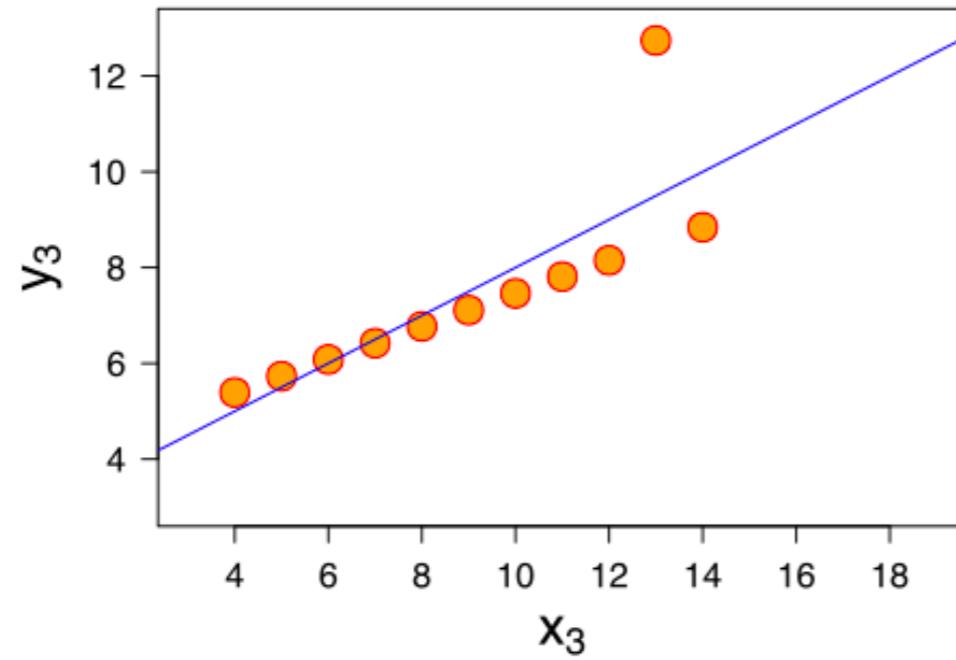
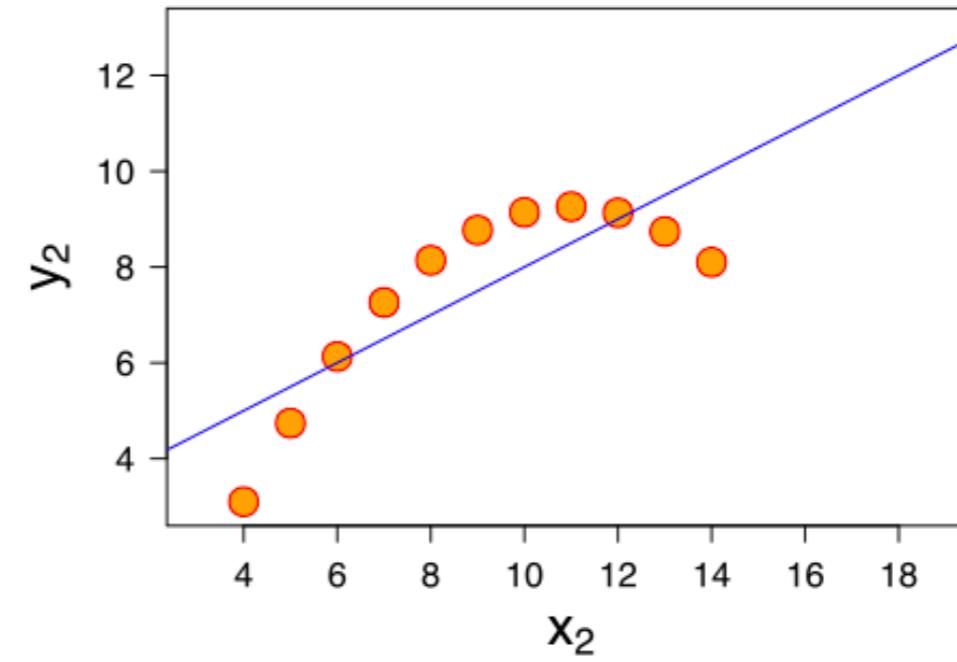
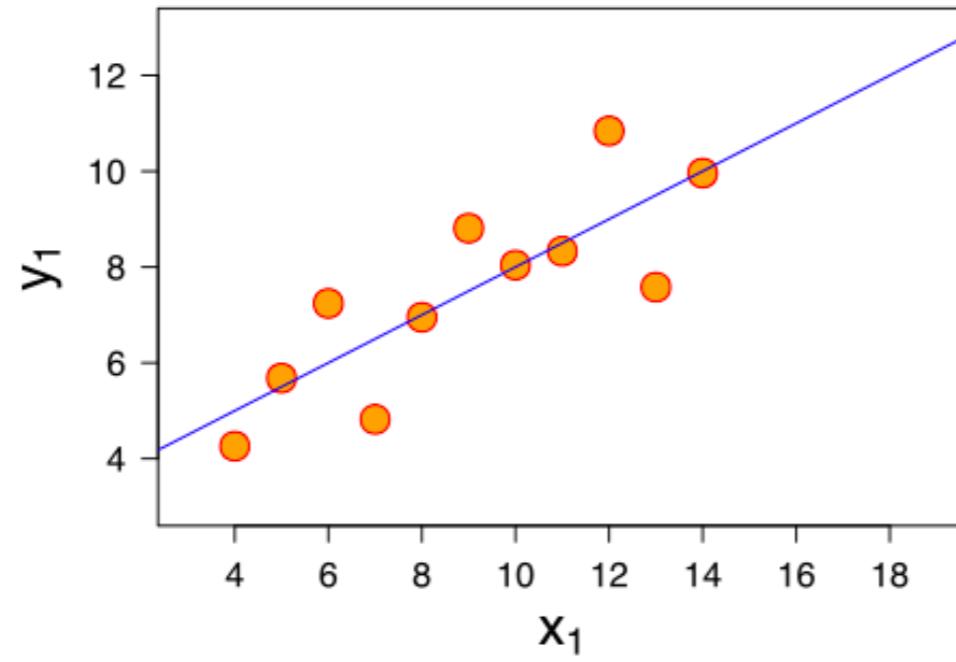


# Classification task

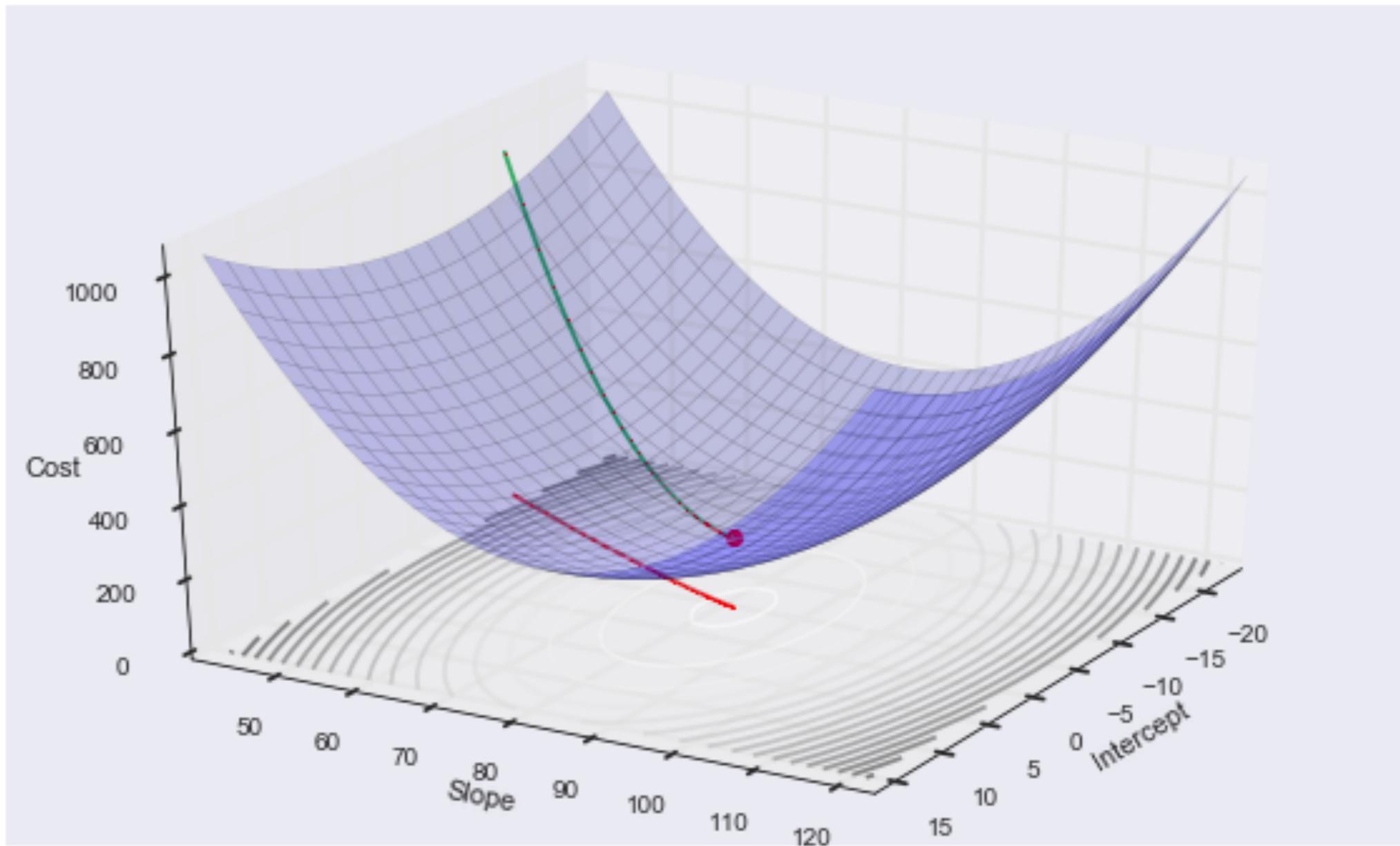
**<http://localhost:9999/notebooks/02-Classification1-assignment.ipynb>**

**<http://localhost:9999/notebooks/03-Classification2-assignment.ipynb>**

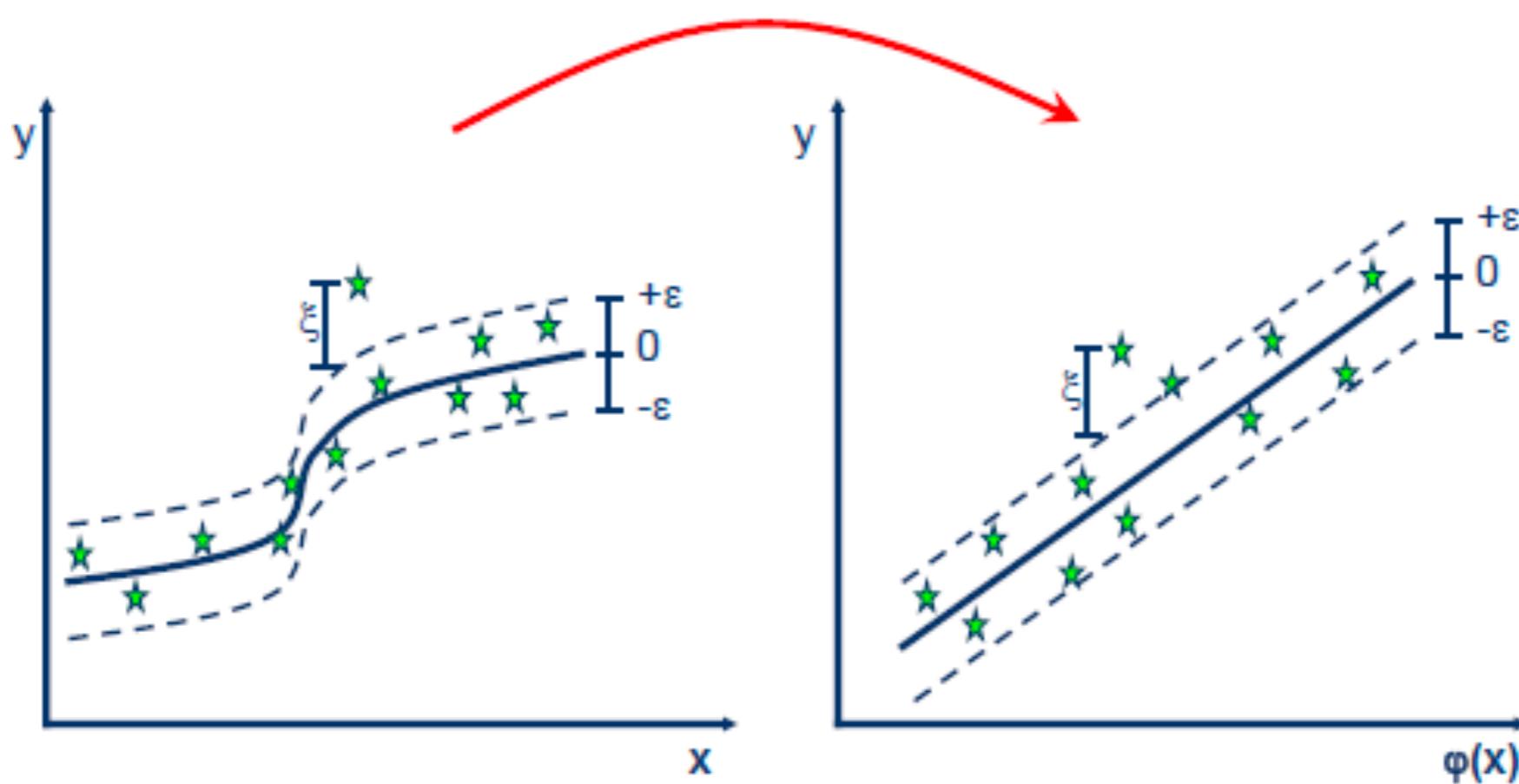
# Regression



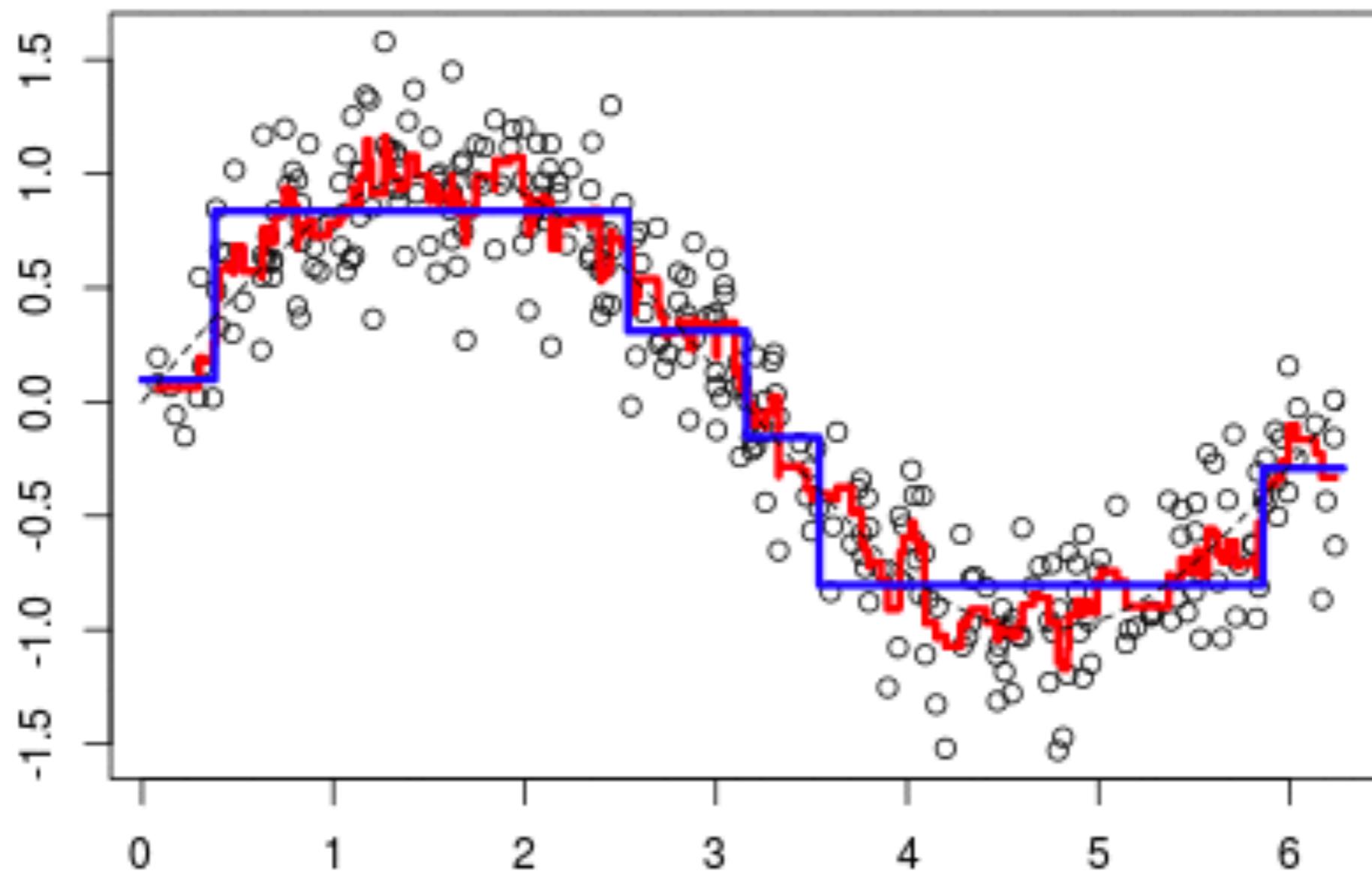
# Linear regression with SGD



# Support vector machines for Regression



# Boosted regression trees



# Evaluation of regression models

**Root mean squared error**

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

**Mean absolute error**

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

**R Squared**

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

# Regression task

**<http://localhost:9999/notebooks/04-Regression1-assignment.ipynb>**

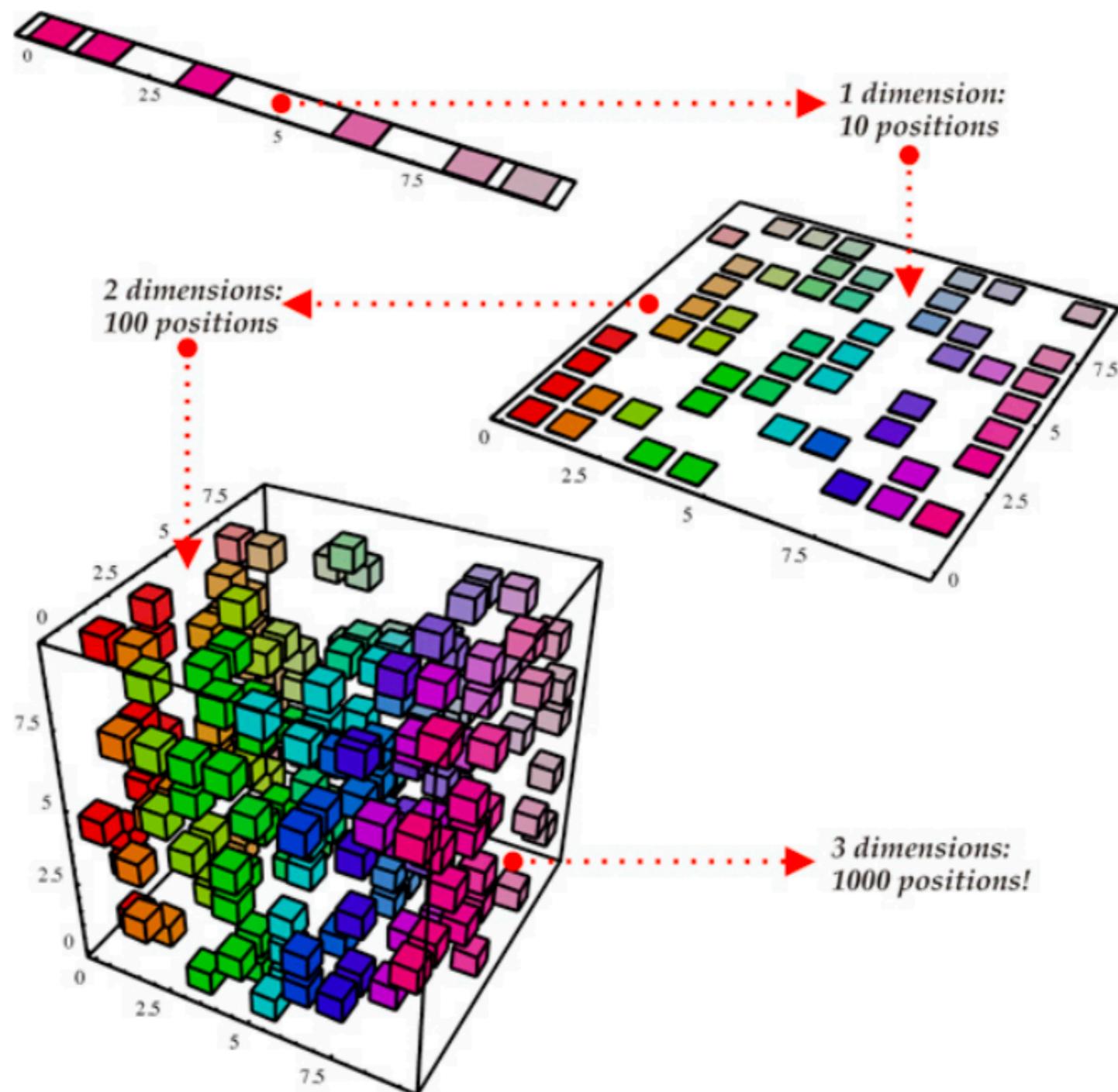
**<http://localhost:9999/notebooks/05-Regression2-assignment.ipynb>**

# Unsupervised techniques

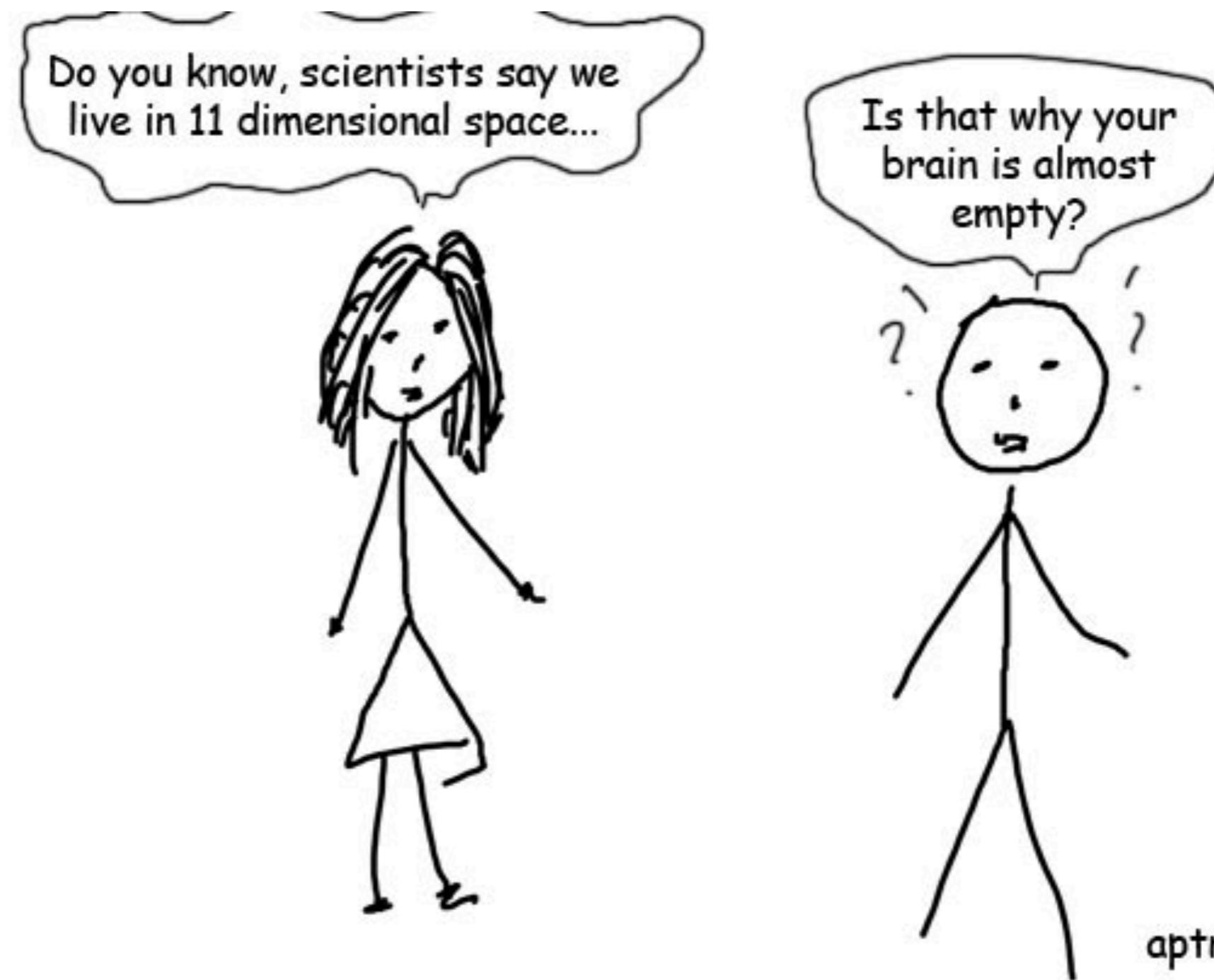


Source: tmdb.org

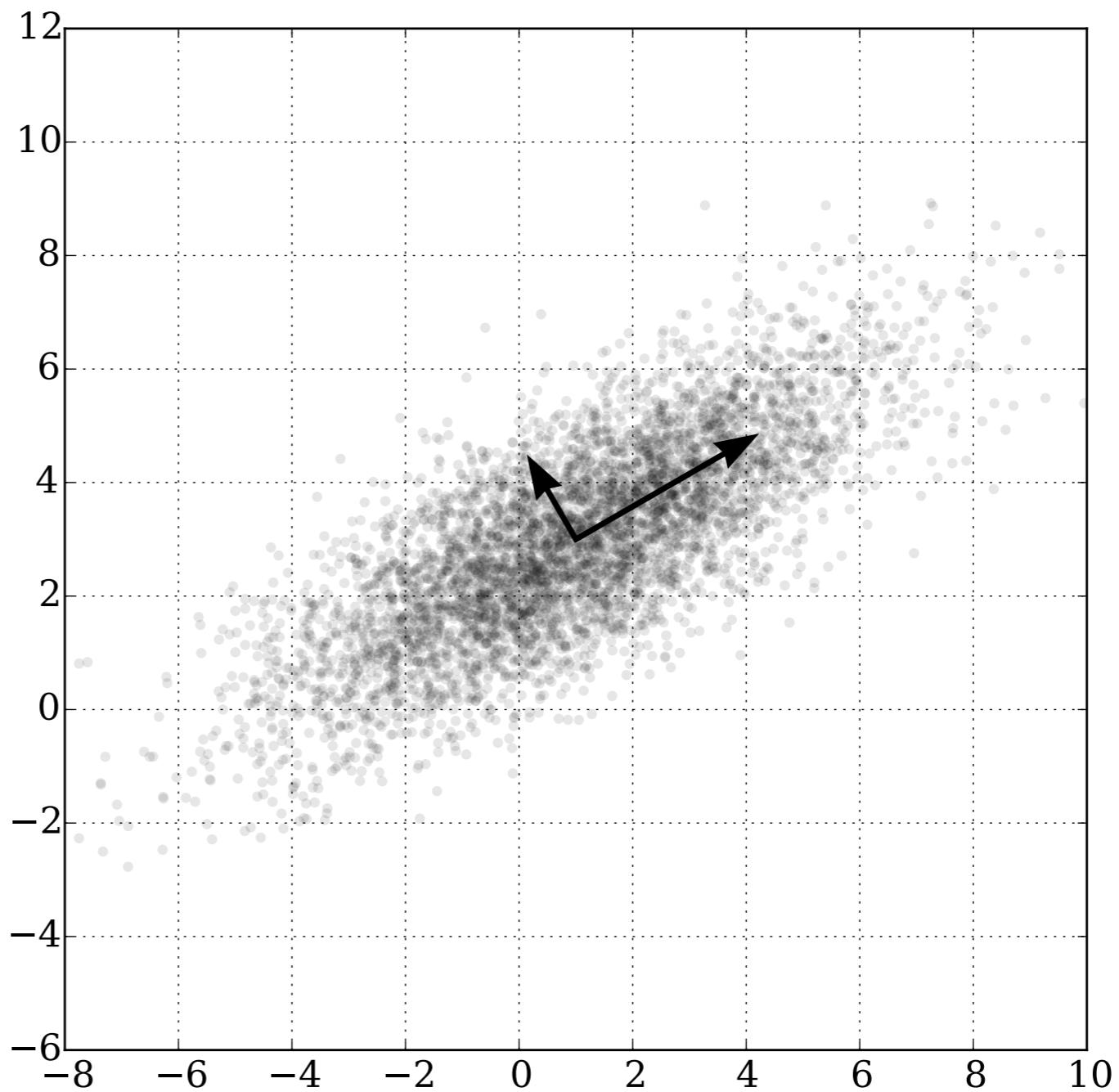
# Dimensionality reduction



# Curse of dimensionality



# Principal Component Analysis



# t-SNE dimensionality reduction

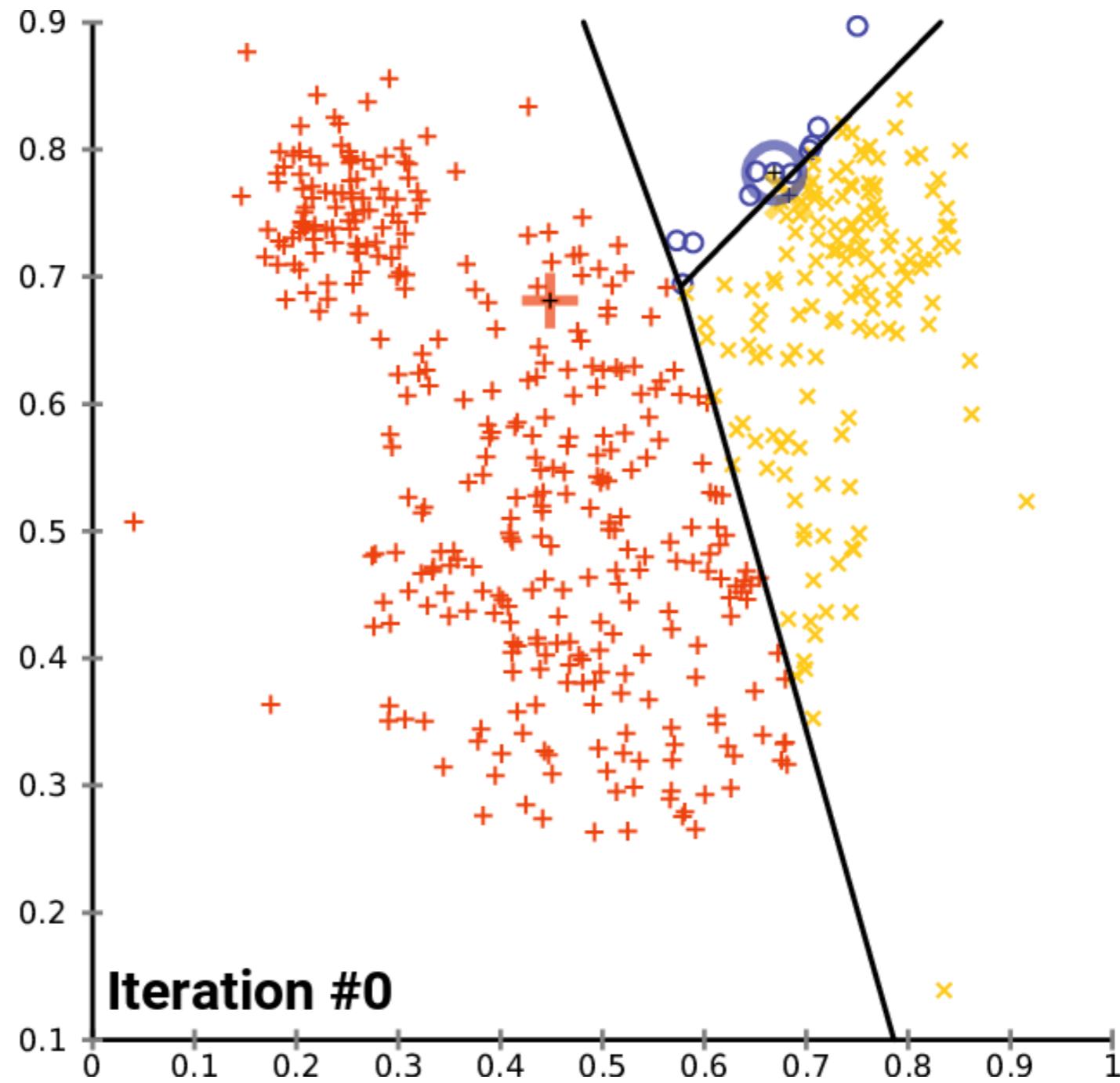


Illustration: <https://bl.ocks.org/mbostock/4062045>

# Dimensionality reduction task

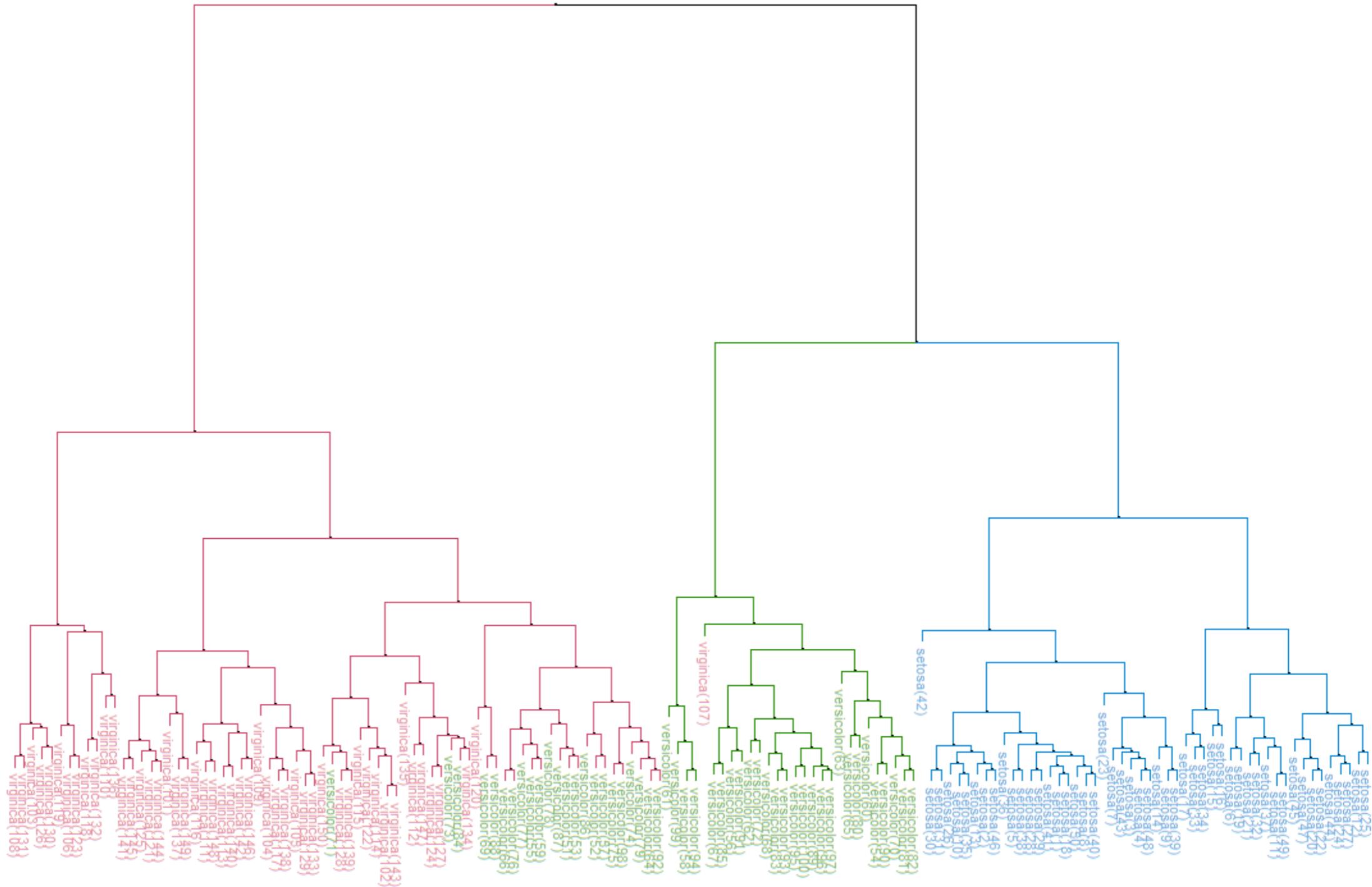
**<http://localhost:9999/notebooks/06-Dim-reduction-assignment.ipynb>**

# k-means clustering



Source: <https://wikipedia.org>

# Agglomerative clustering

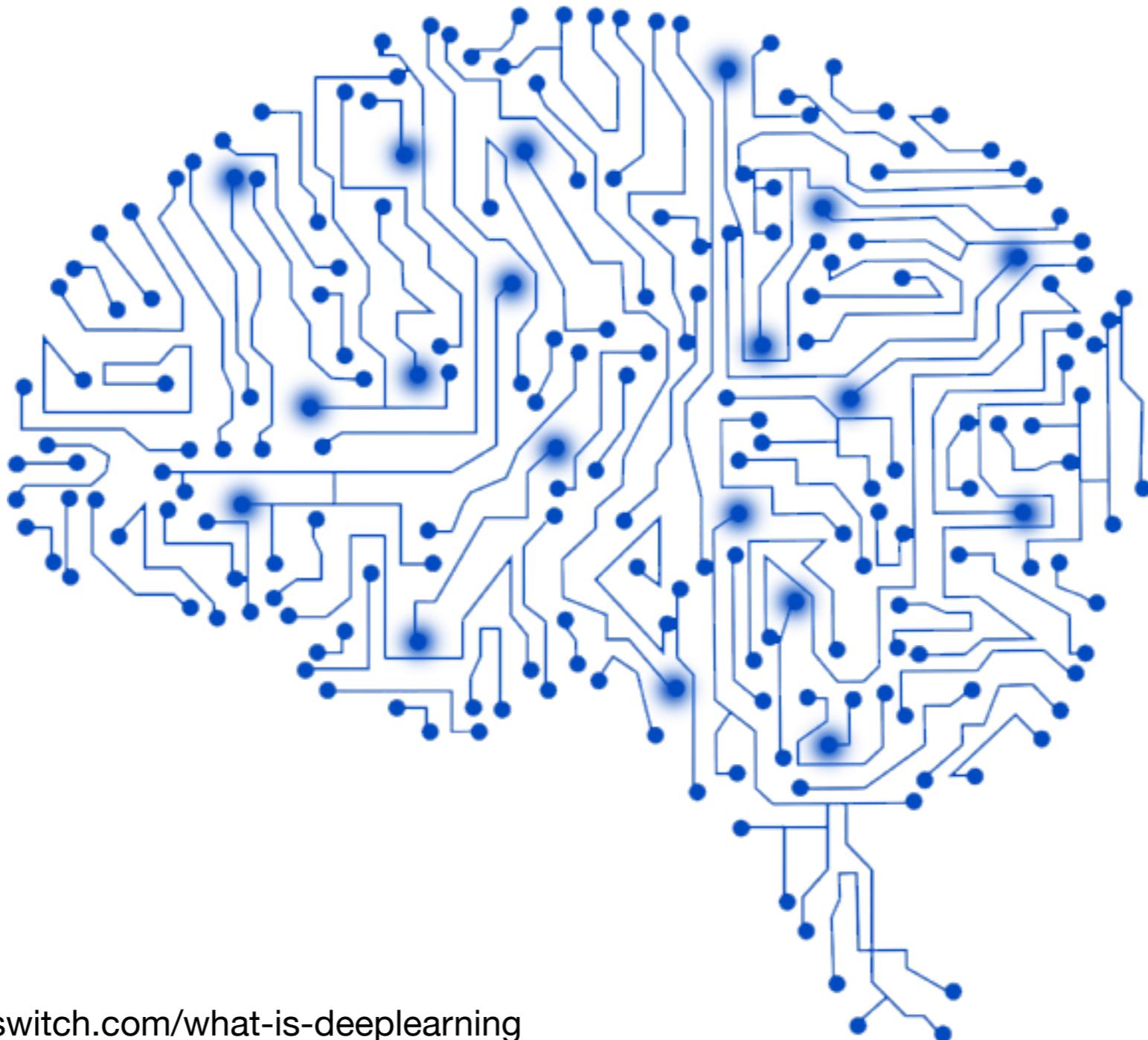


Source: <https://wikipedia.org>

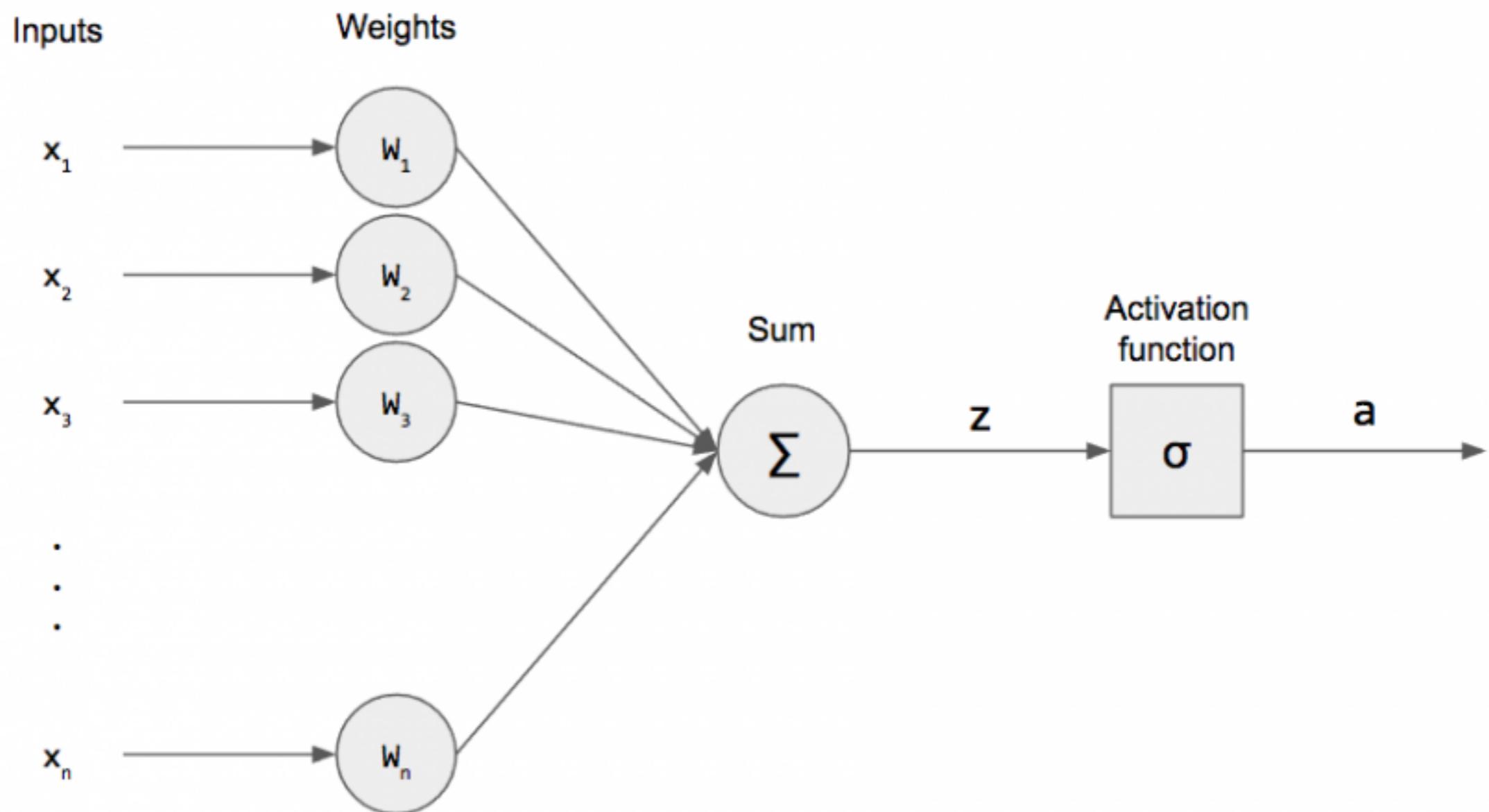
# Clustering task

**<http://localhost:9999/notebooks/07-Clustering-assignment.ipynb>**

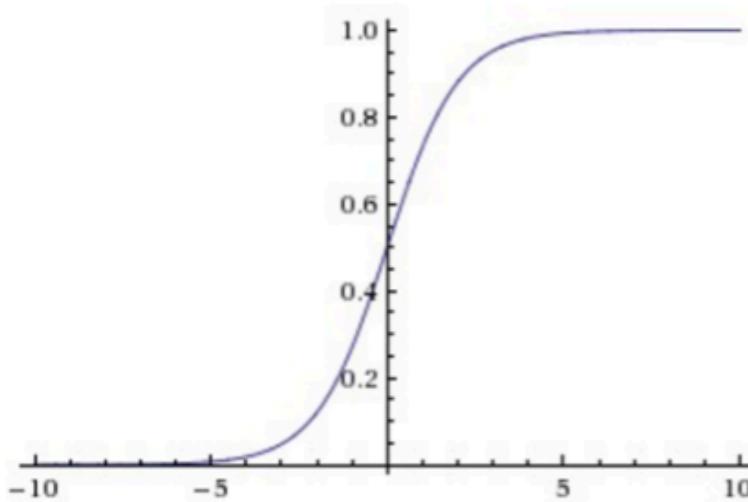
# Neural networks and deep learning



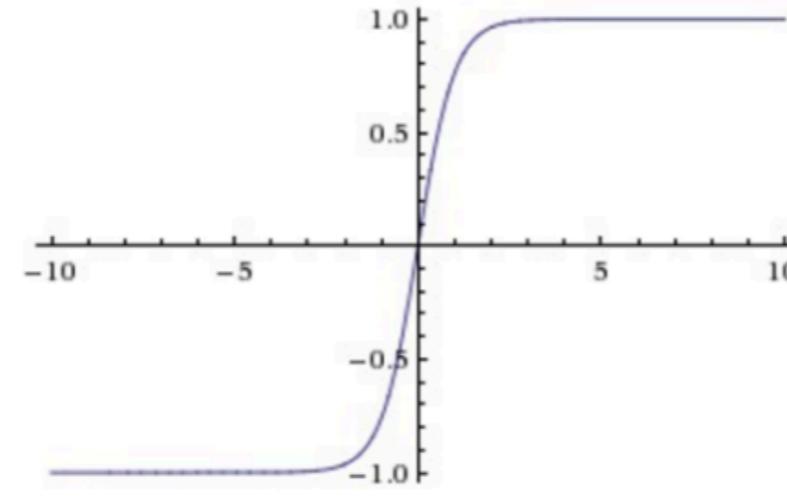
# Perceptron



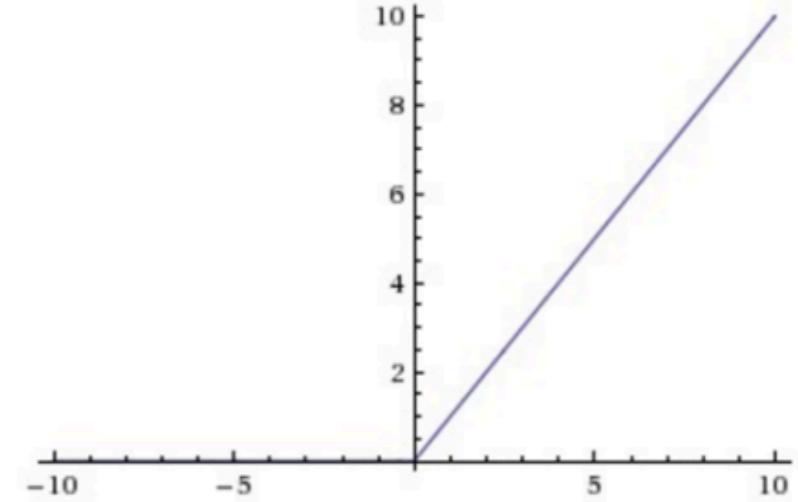
# Activation functions



Sigmoid



tanh

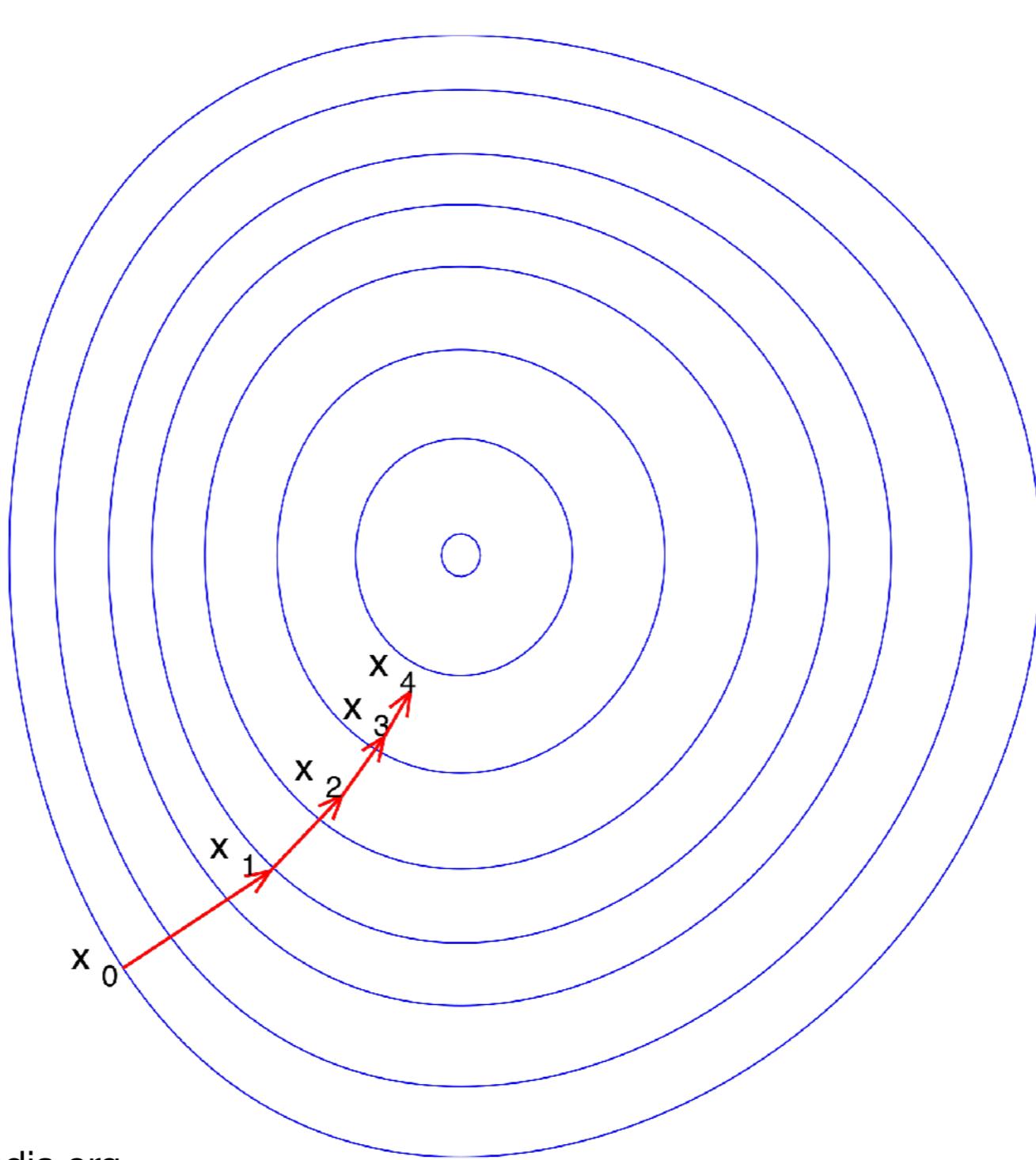


ReLU

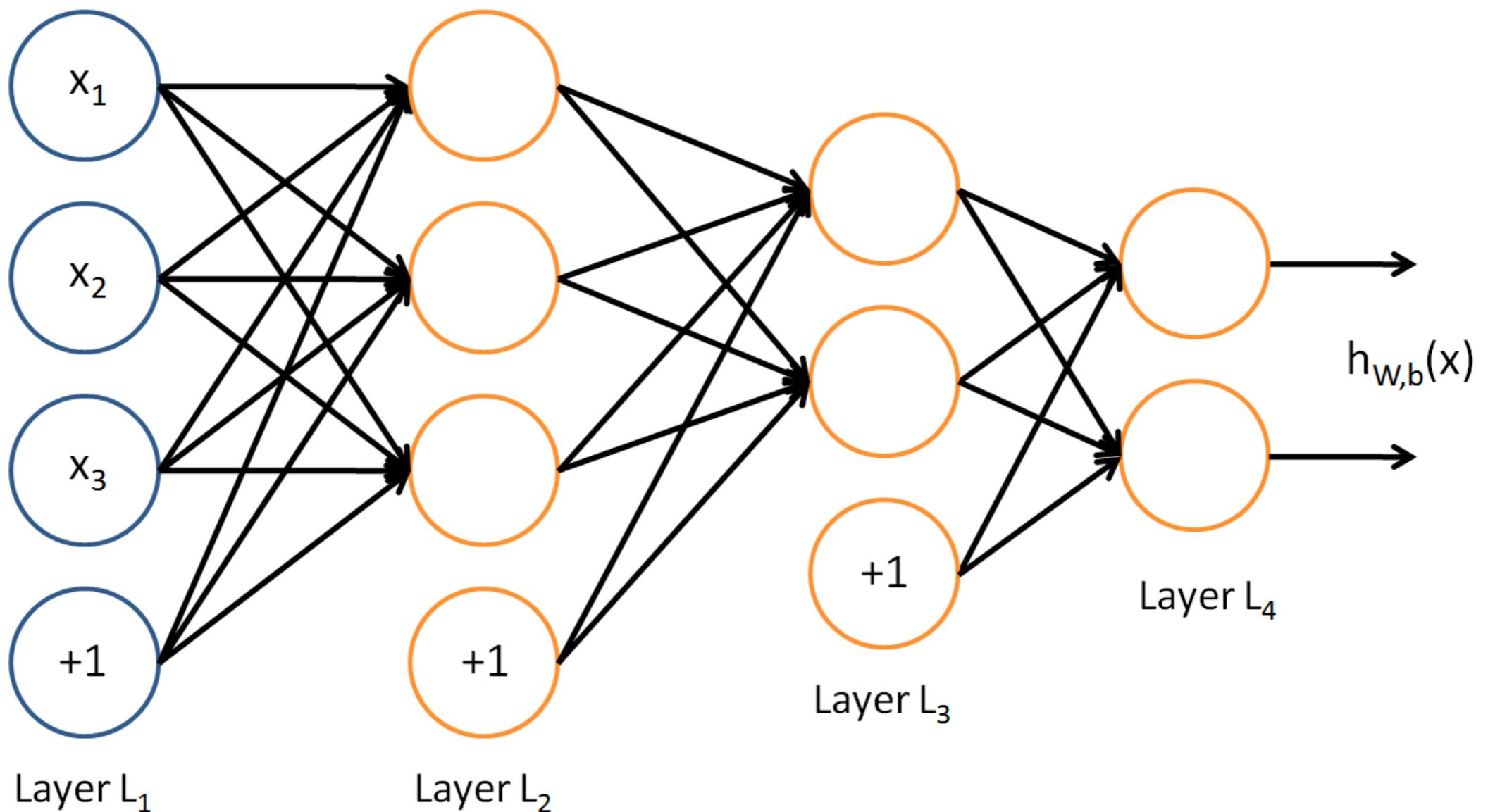
Softmax:

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

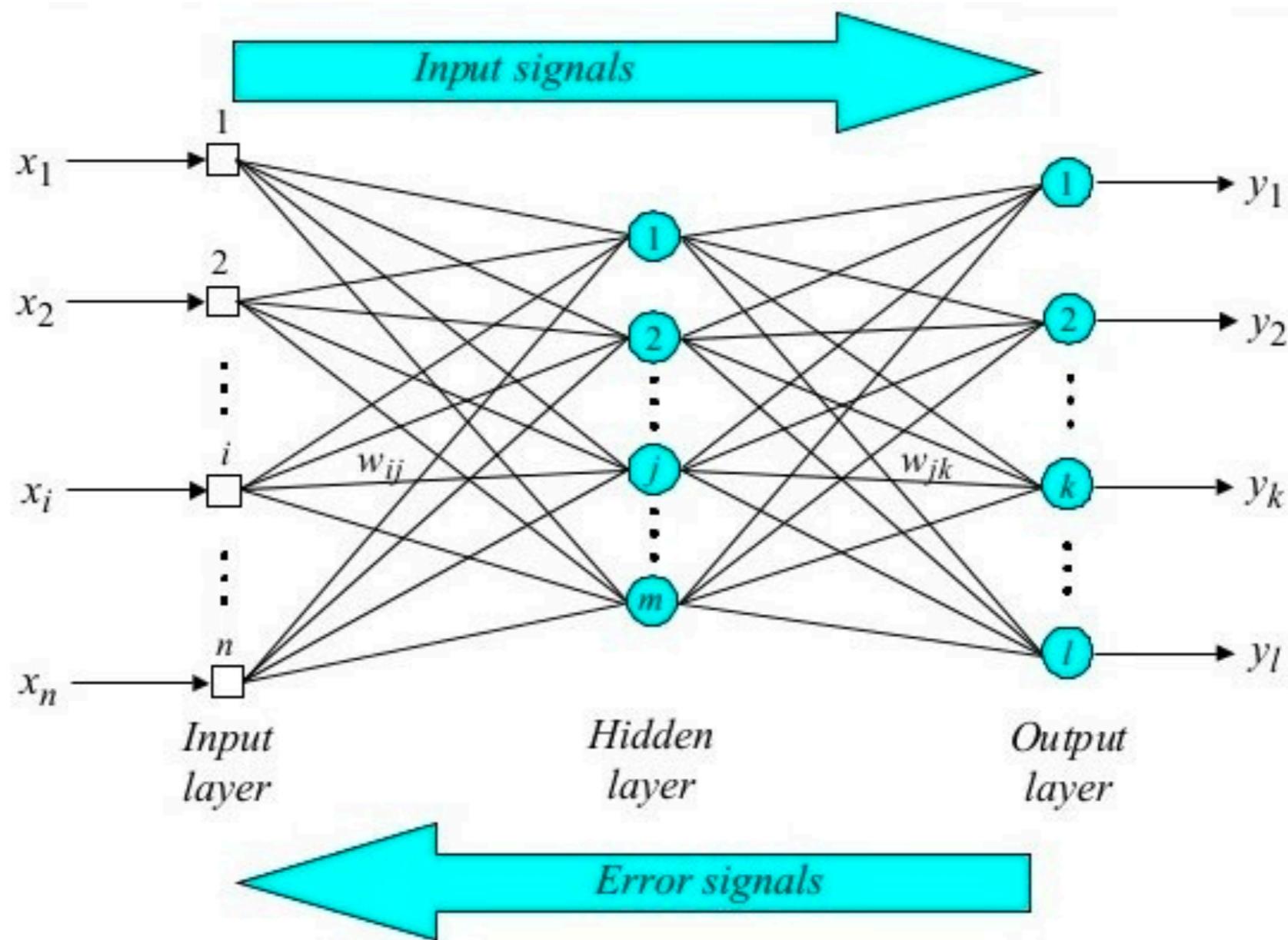
# Steepest gradient descent



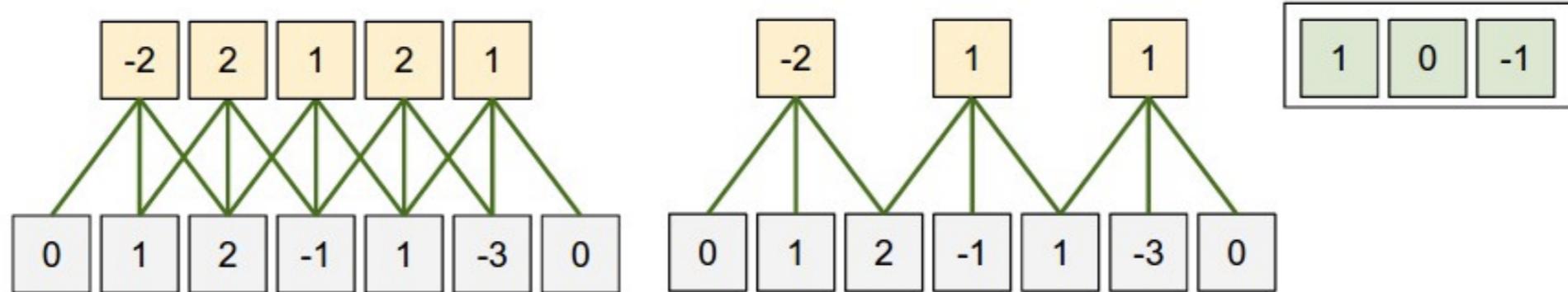
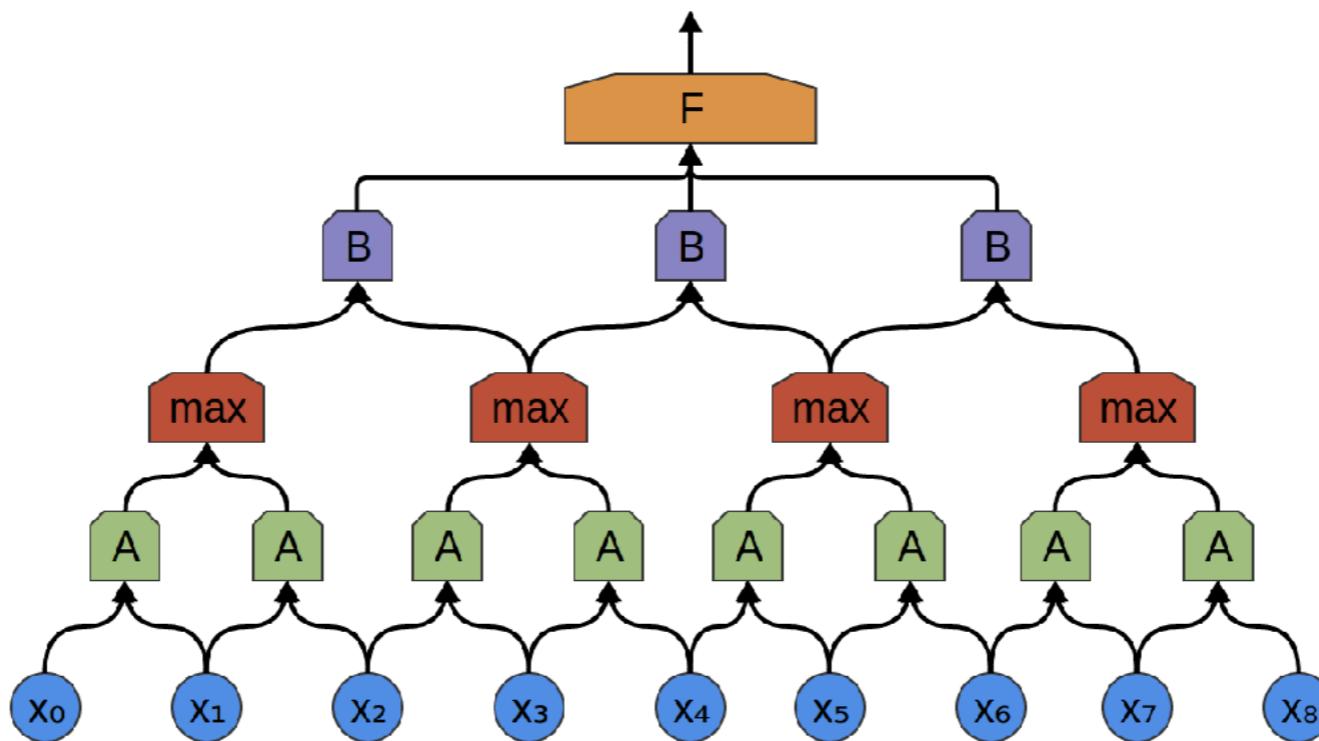
# Multilayer Neural Networks



# Back propagation



# Convolution



Source: <https://www.tensorflow.org>

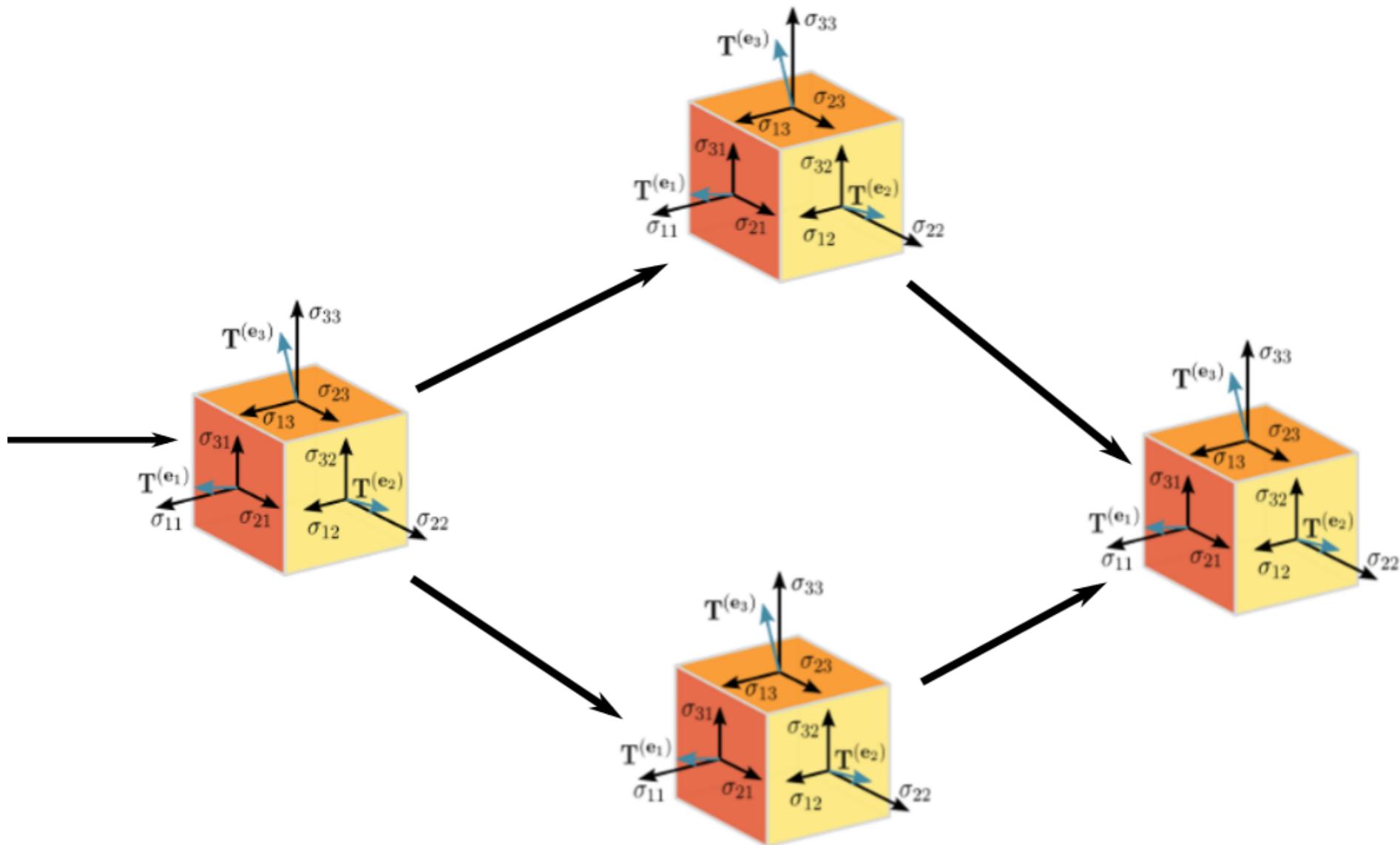
# Important terms

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

# What is not TensorFlow



# What is TensorFlow?



# Keras tutorial

**<http://localhost:9999/notebooks/08-Keras-introduction.ipynb>**

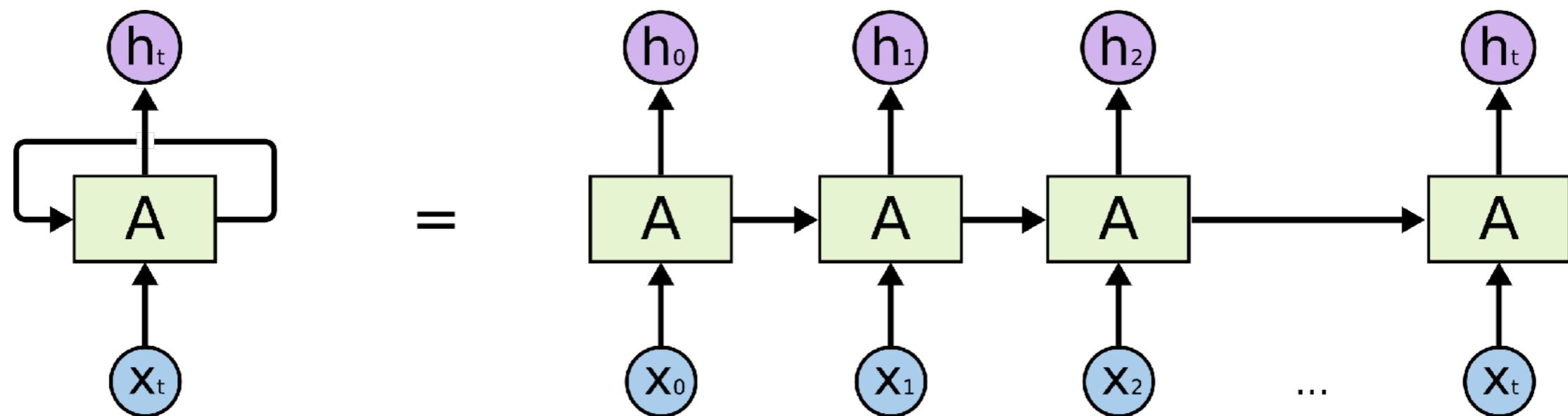
# **Reimplementation of the classification and regression task using NN**

**<http://localhost:9999/notebooks/09-Classification-nn-assignment.ipynb>**

**<http://localhost:9999/notebooks/10-Regression-nn-assignment.ipynb>**

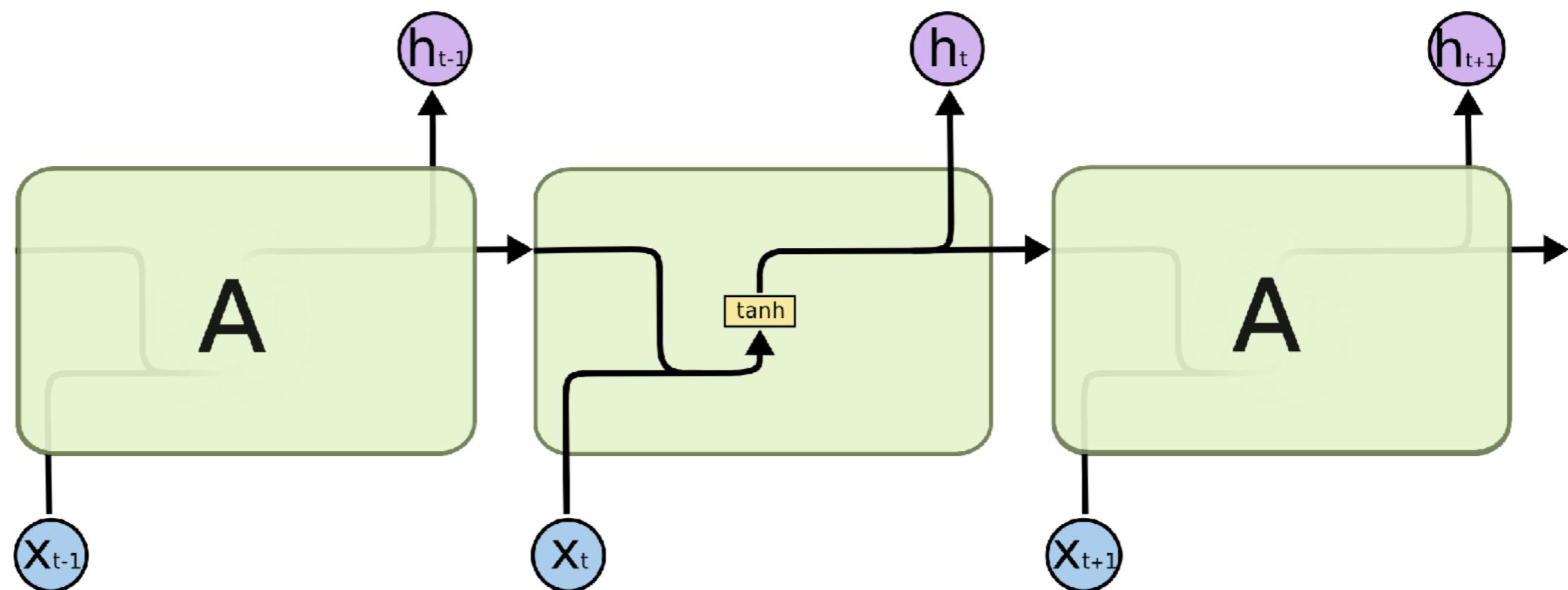
# Recurrent Neural Networks

## 1/2

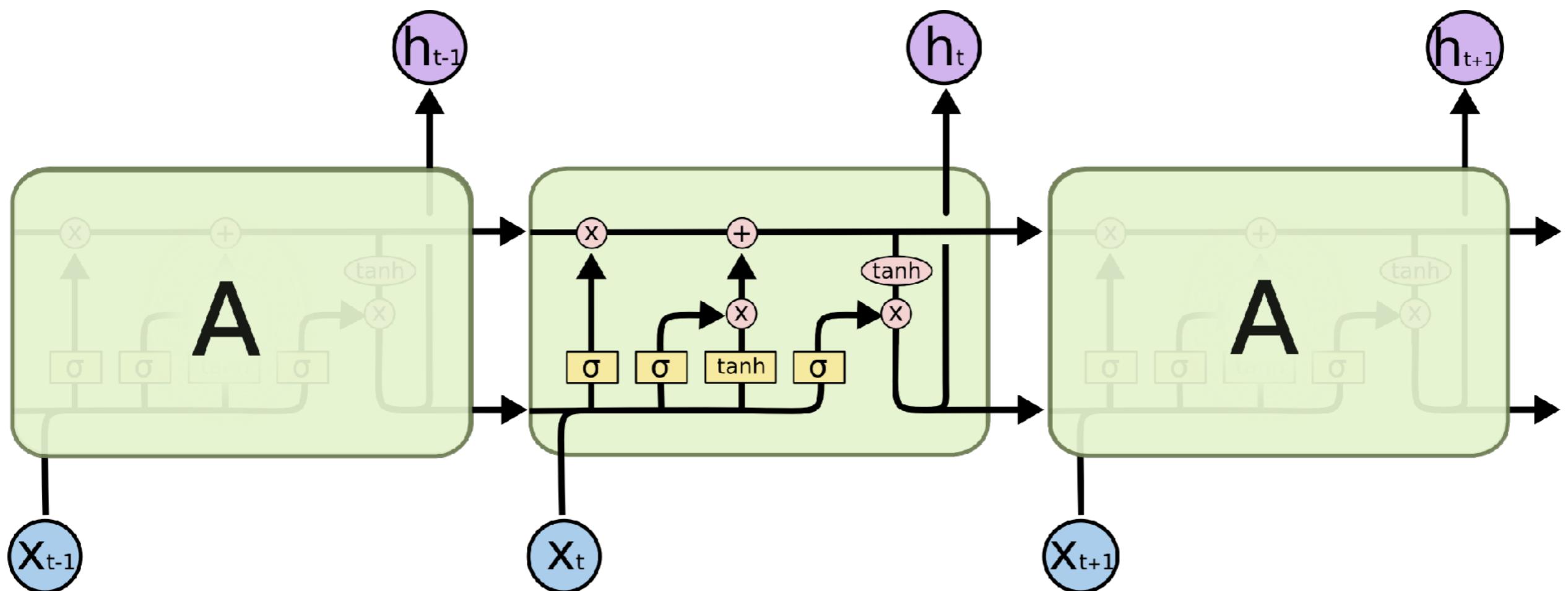


# Recurrent Neural Networks

2/2

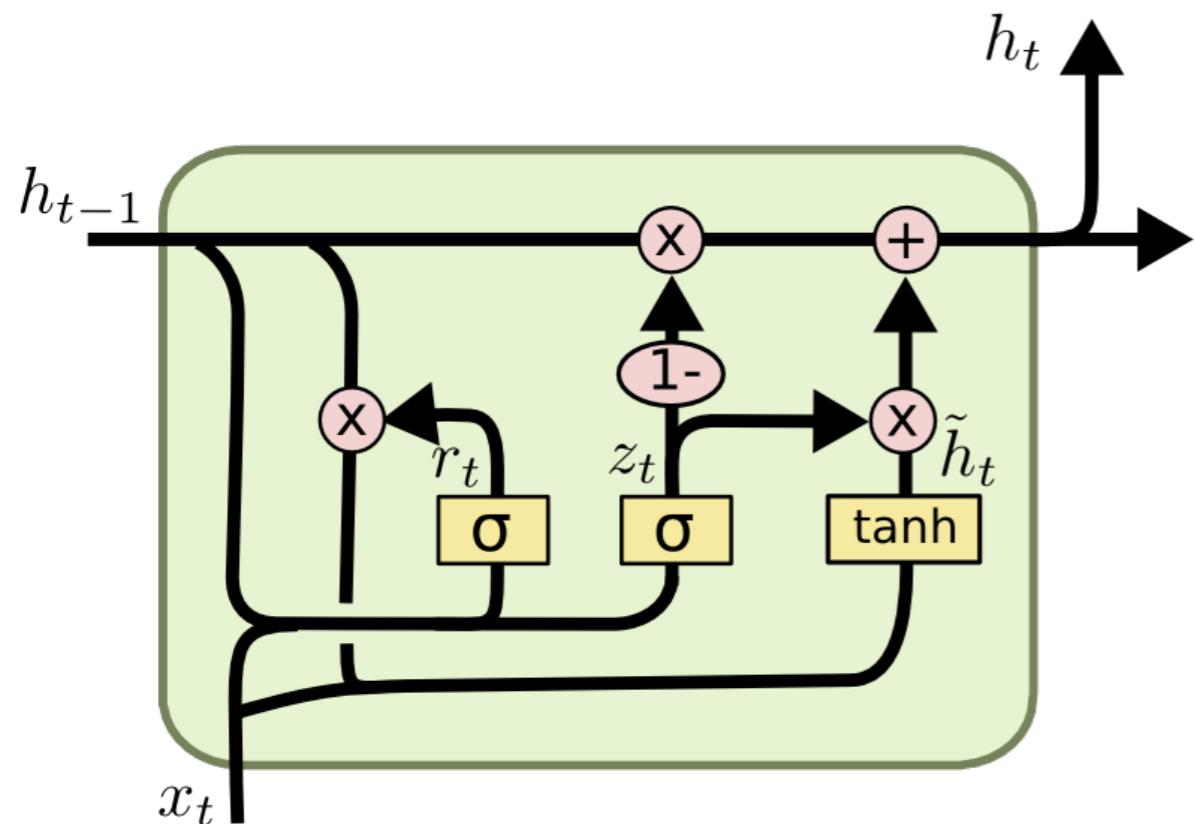


# Long Short-Term Memory



Source: <https://www.tensorflow.org>

# Gated Recurrent Unit



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

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

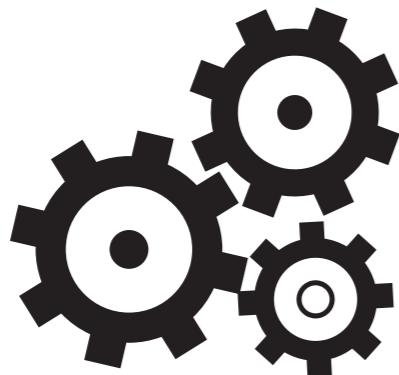
$$\tilde{h}_t = \tanh (W \cdot [r_t * h_{t-1}, x_t])$$

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

# **Reimplementation of the regression task using Recurrent neural network**

**<http://localhost:9999/notebooks/11-Regression-rnn.ipynb>**

# What next?



Machine Learning Prague

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**MU** meetups

**<http://www.mlguru.com>**

# Thank you for your attention

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