

Utilization of Machine Learning and Artificial Intelligence in Scientific Practice

Jiří Materna

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presentation:

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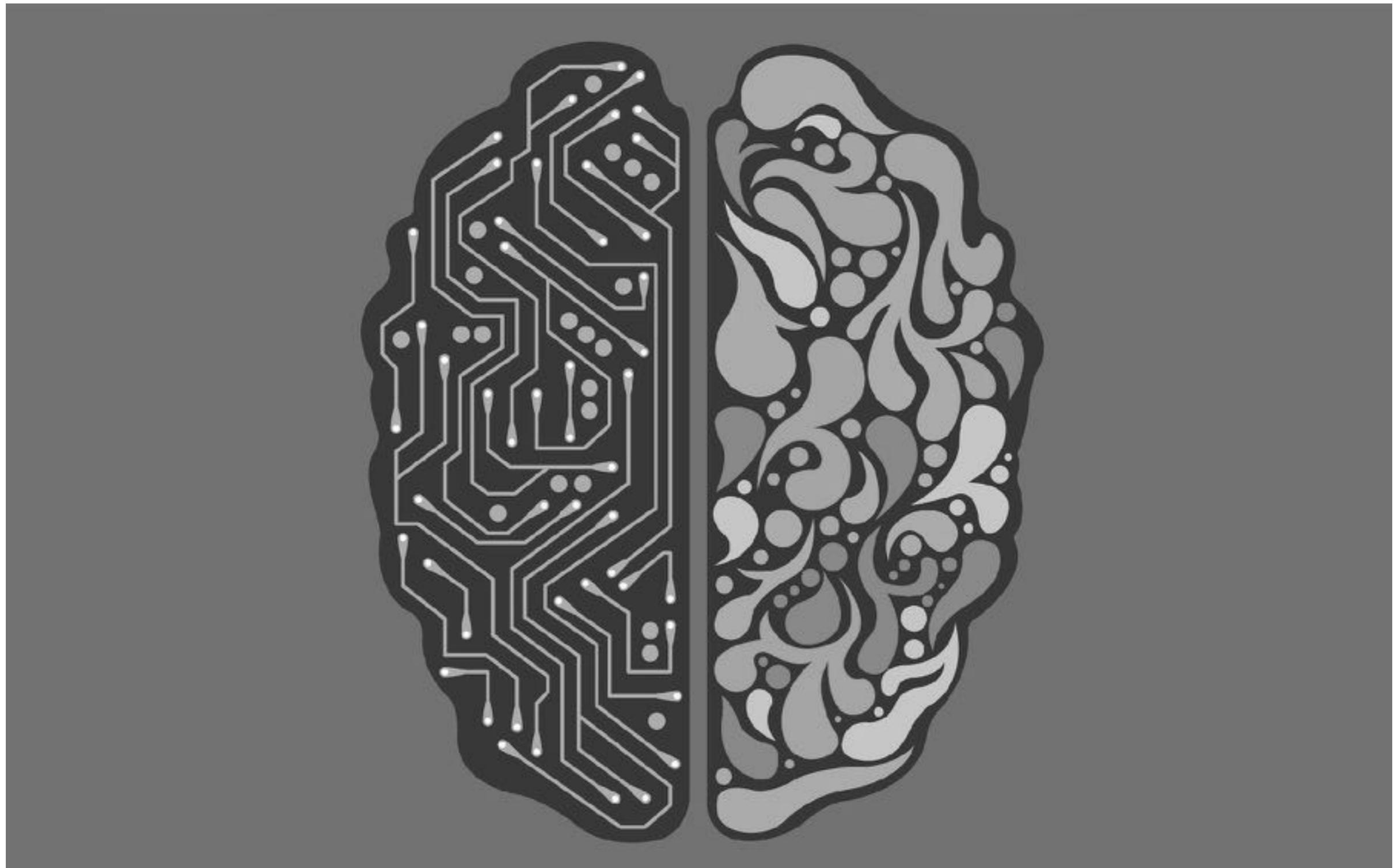
About me

- 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

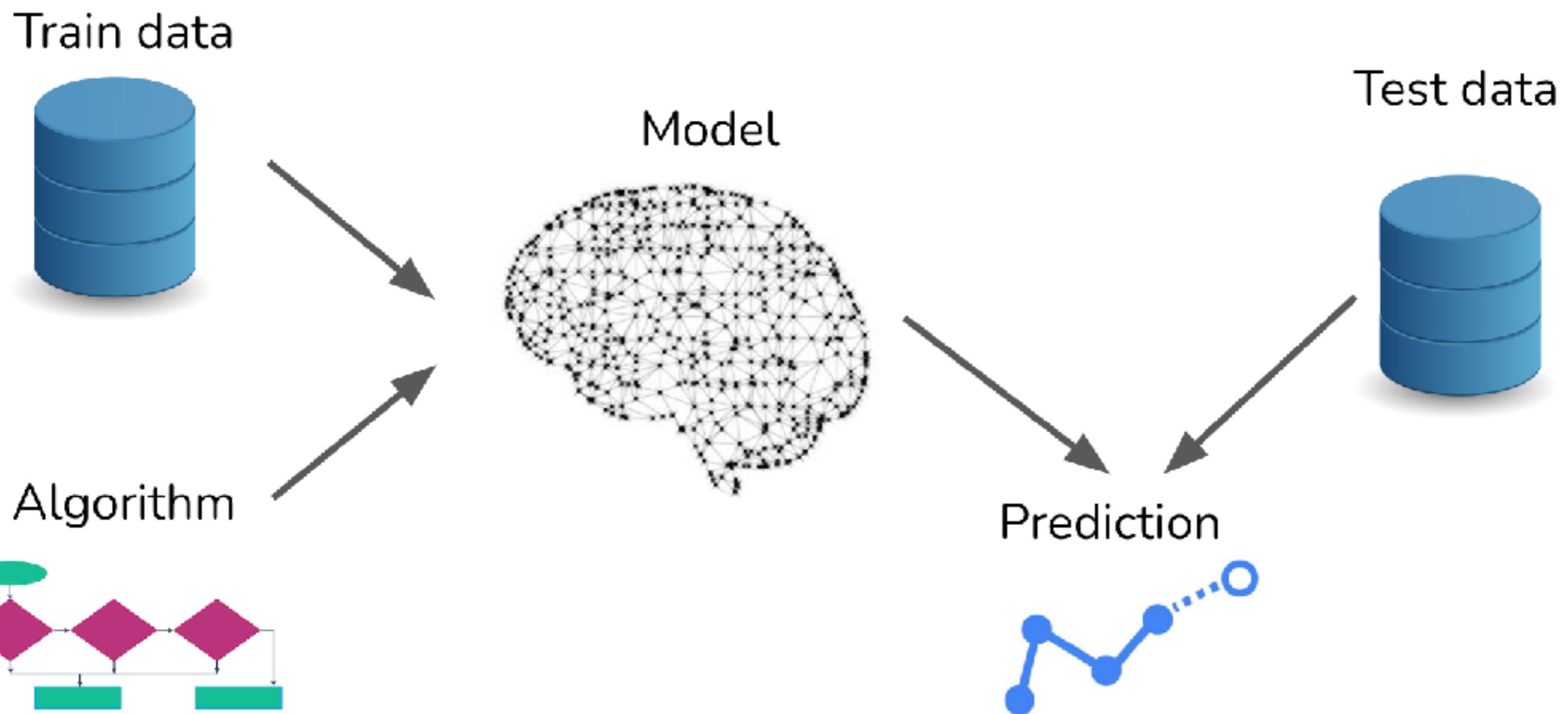
Outline

- Introduction to machine learning
- Types of ML tasks
- Classification and regression tutorial
- Artificial neural networks
- Neural network tutorial in Keras
- Advanced neural networks for image processing
- Introduction to Time series analysis
- Introduction to Large Language Models

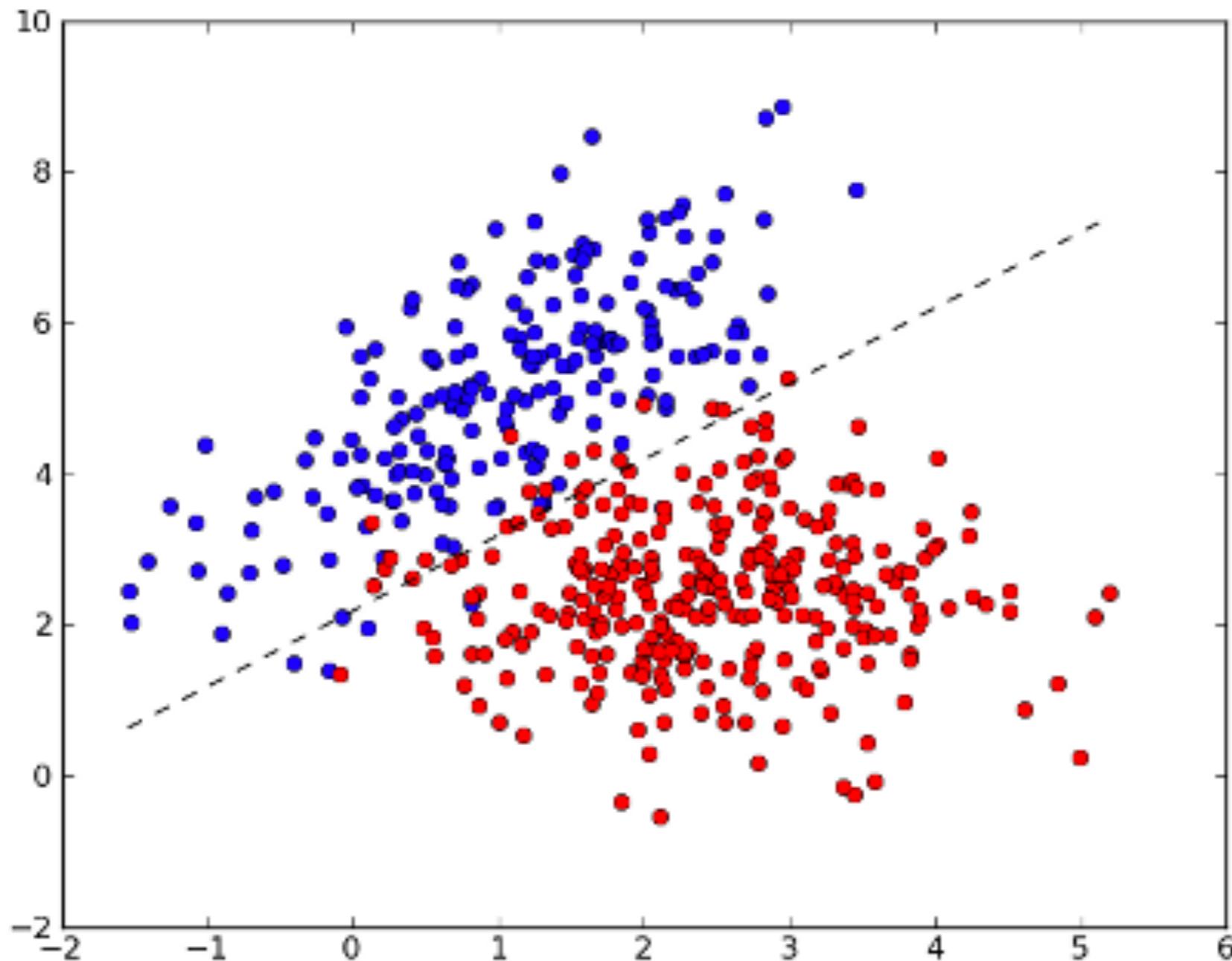
What is (not) machine learning?



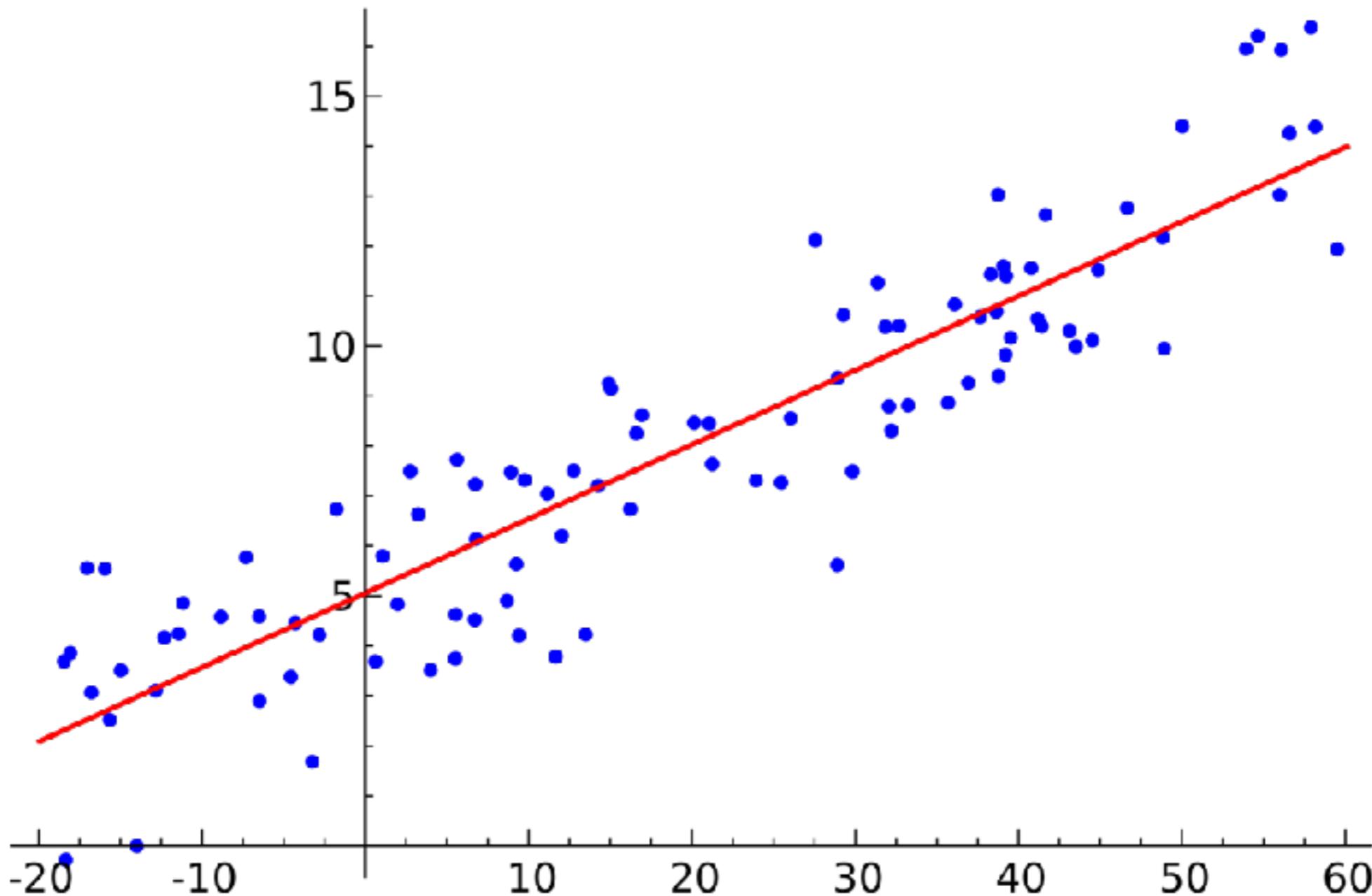
Machine learning pipeline



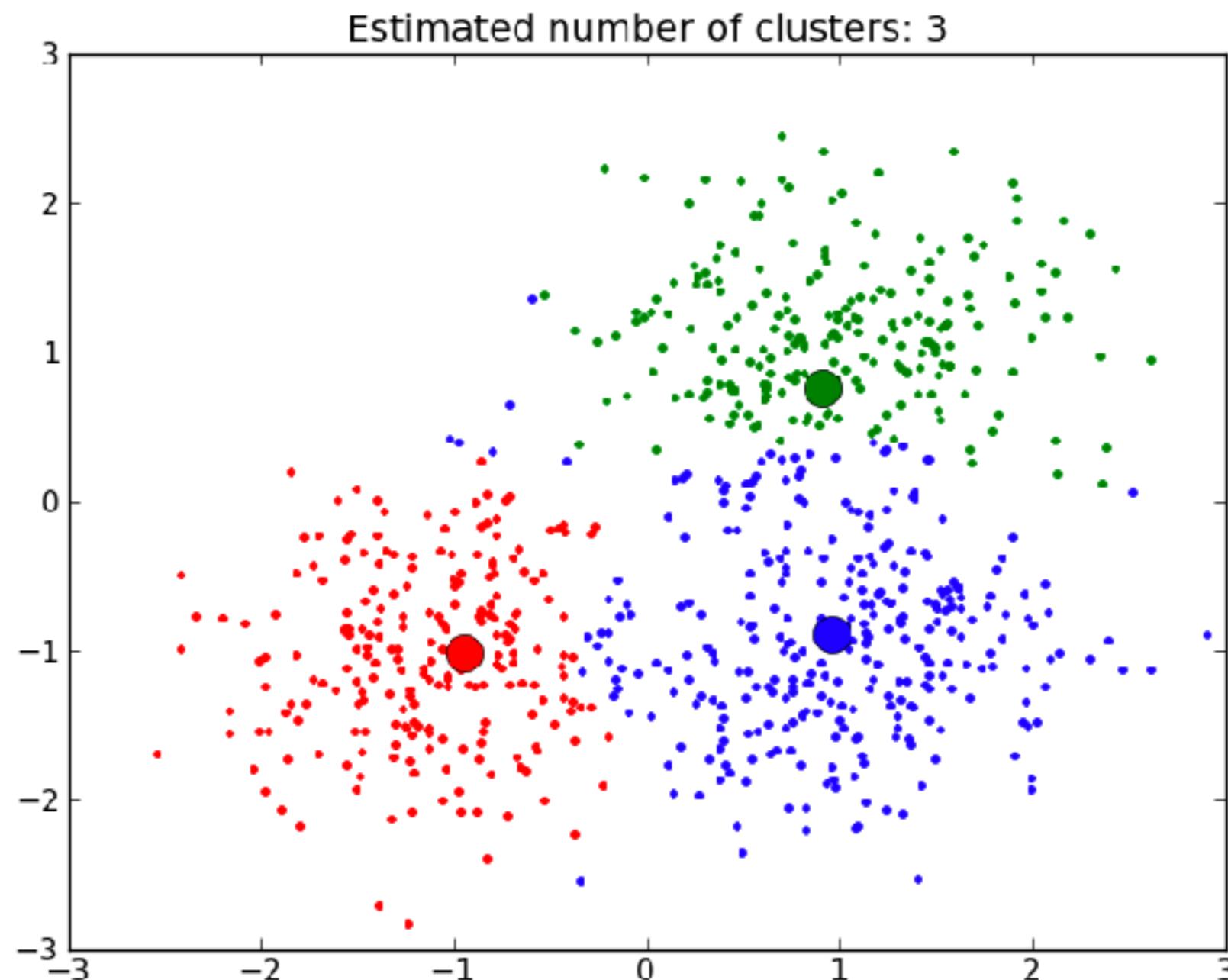
Classification



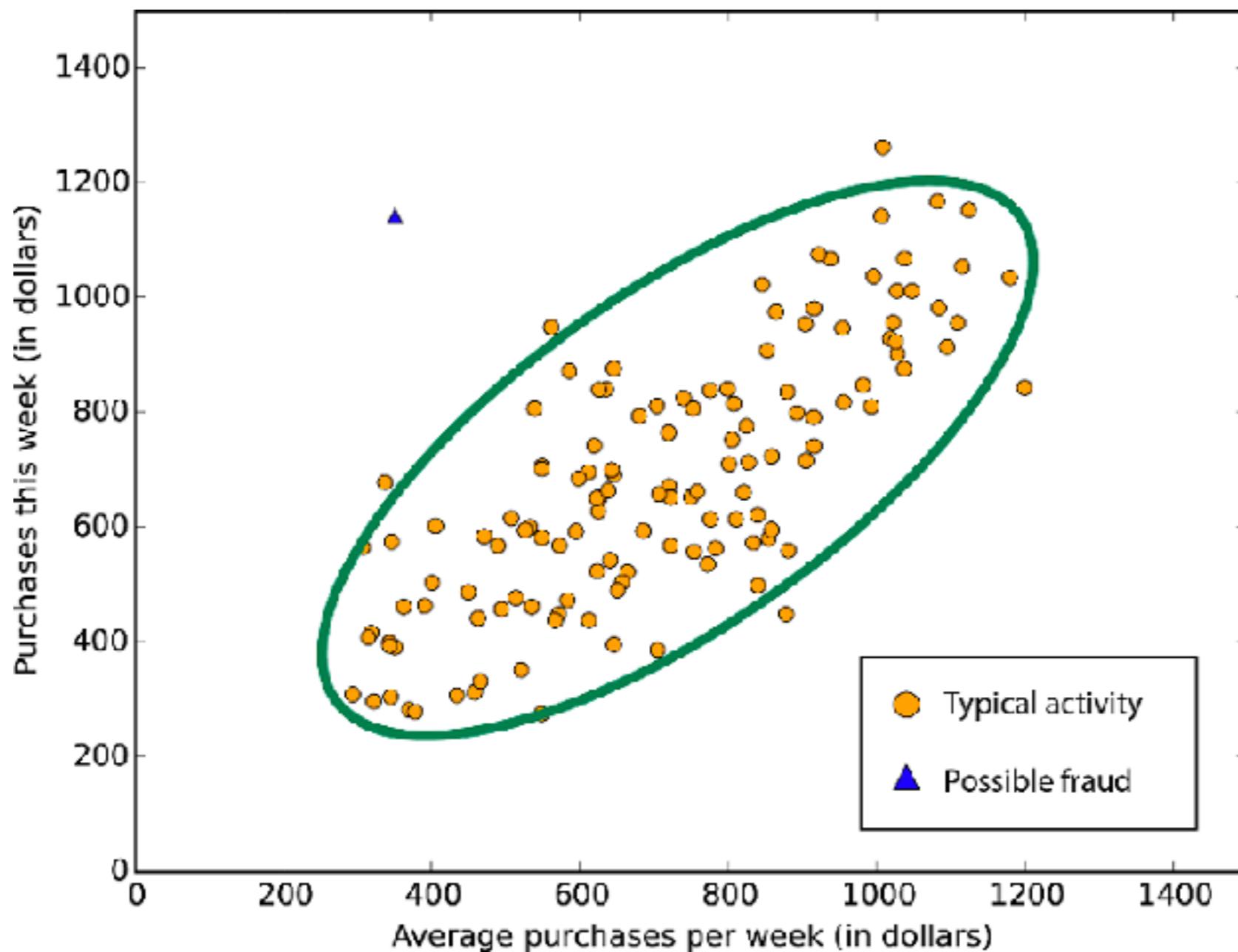
Regression



Clustering

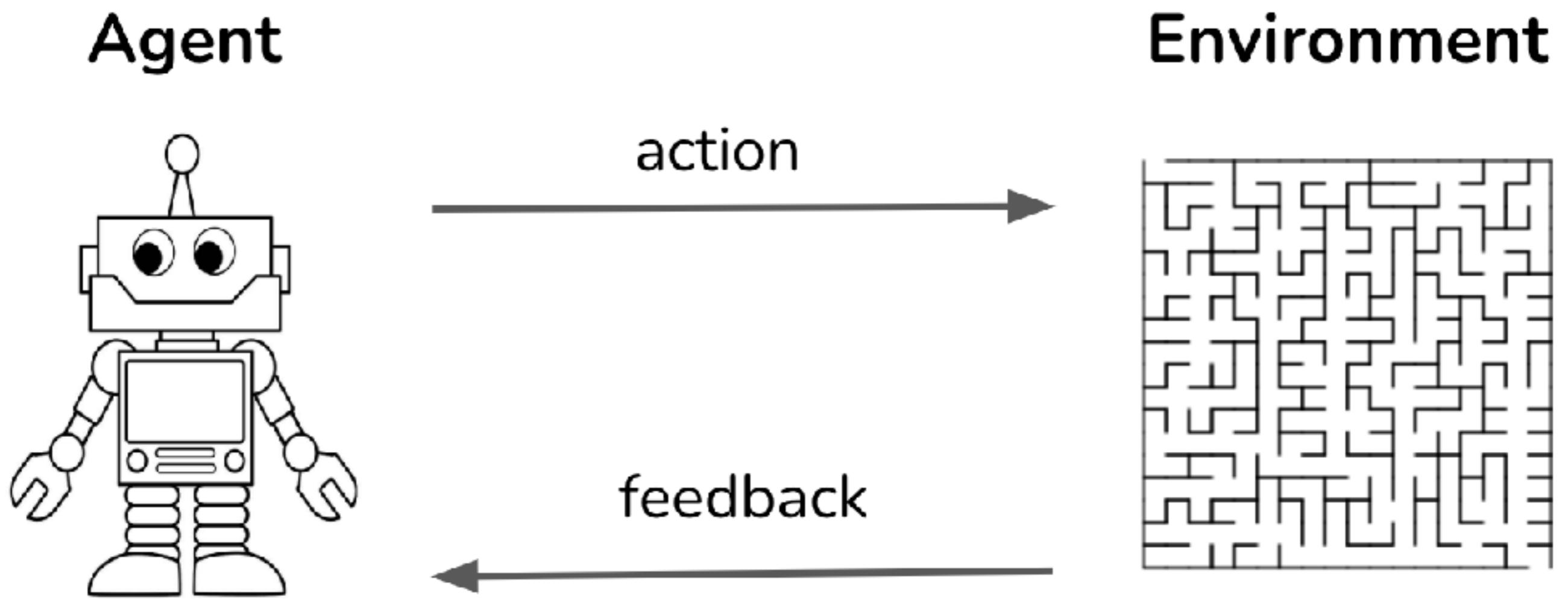


Anomaly detection



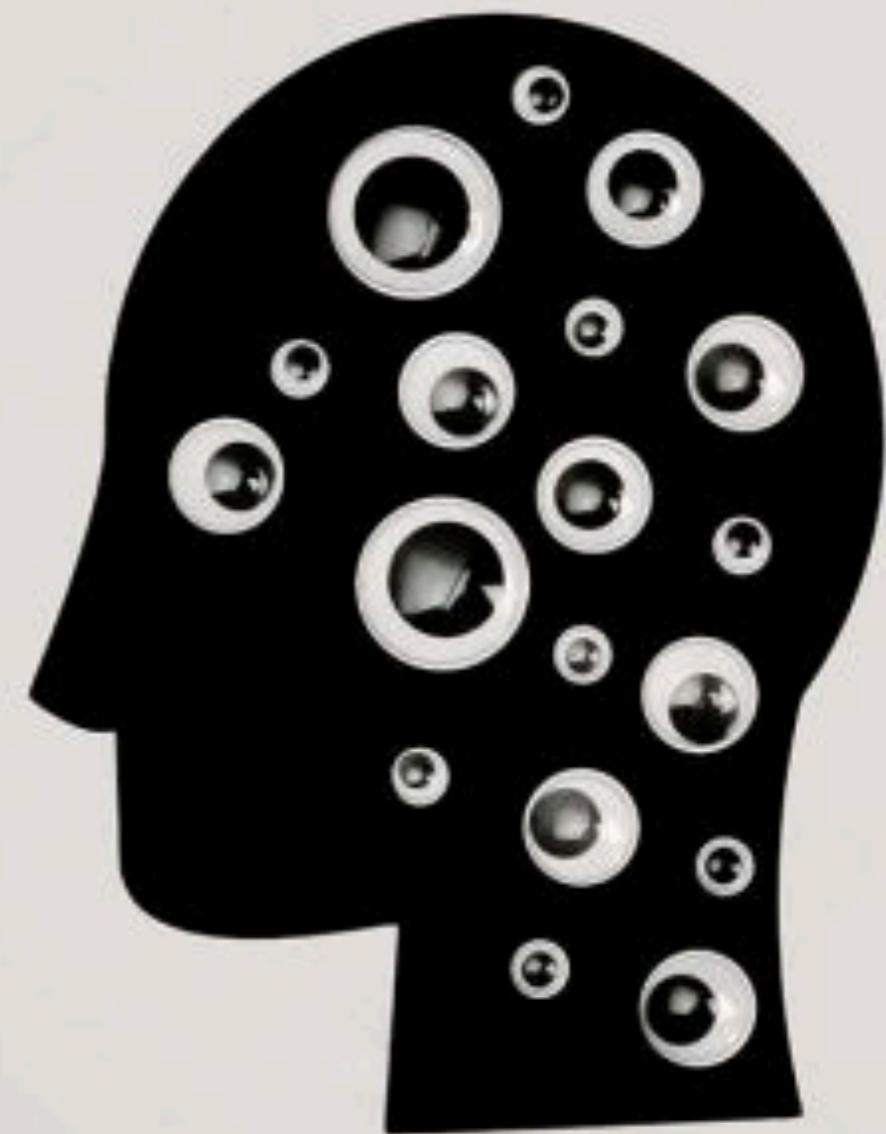
Source: <https://docs.microsoft.com/en-us/azure>

Reinforcement learning



Generative

AI

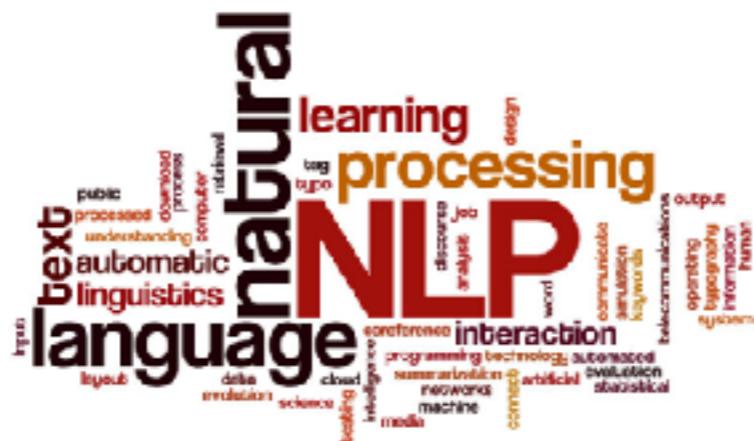


Applications of machine learning

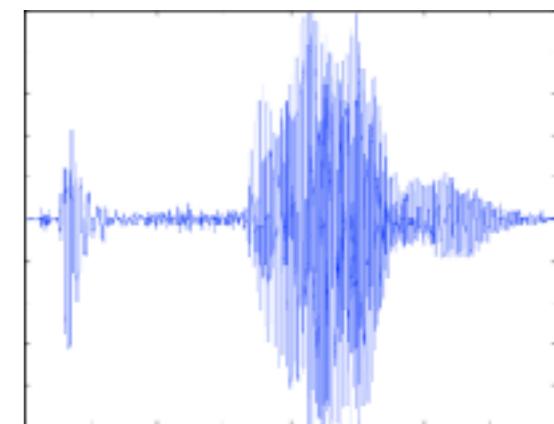
Image processing



Natural language processing



Time series and sequence analysis



Recommendation systems



Robotics



Tabular data analysis

	Total defects	A	B	C	D	E
A4000	101	37	21	28	45	
A2524	85	20	24	21	1	70
A2715	75	17	10	18		27
A4492	73	6	30	17		18
A4066	72	14	16	12	2	28
A2105	63	14	13	14	1	26
A2156	63	16	13	19	2	18
A0681	63	12	16	0	1	28
A1388	50	11	15	12		12
A2610	39	5	7	12		16
Total	728	151	171	102	7	527

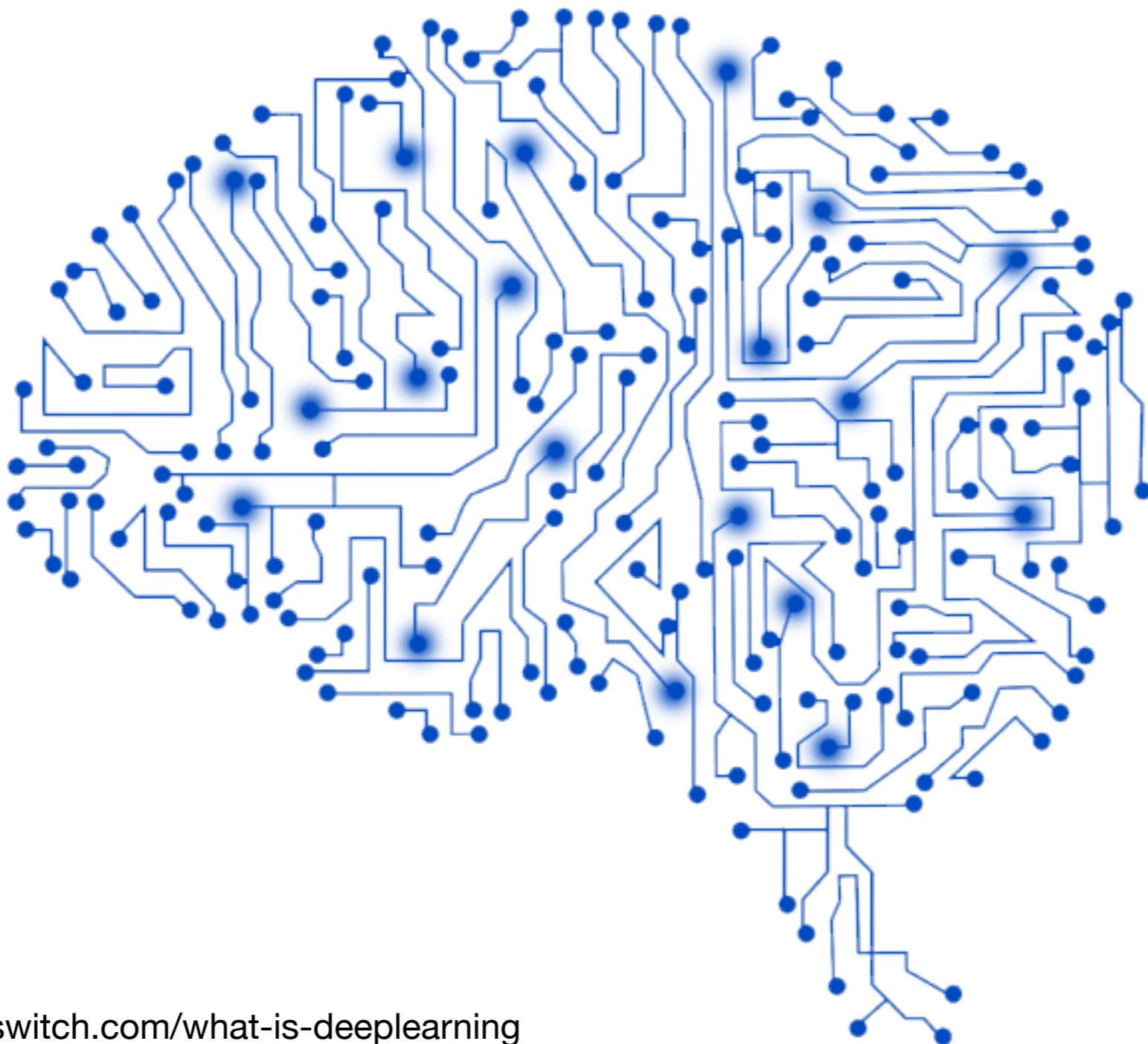
Classification tutorial in Scikit Learn

[Classification tutorial](#)

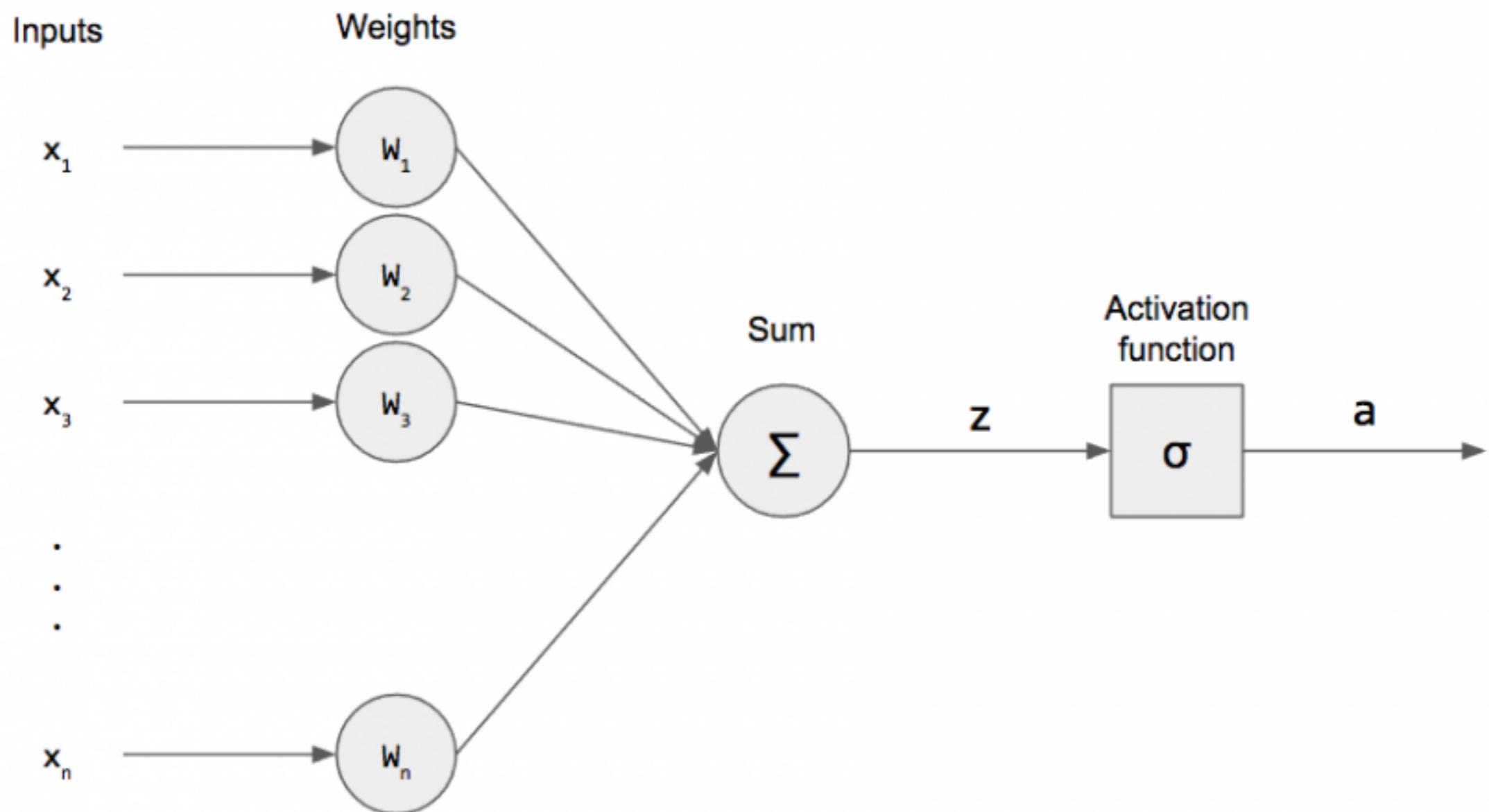
Regression tutorial

Regression tutorial

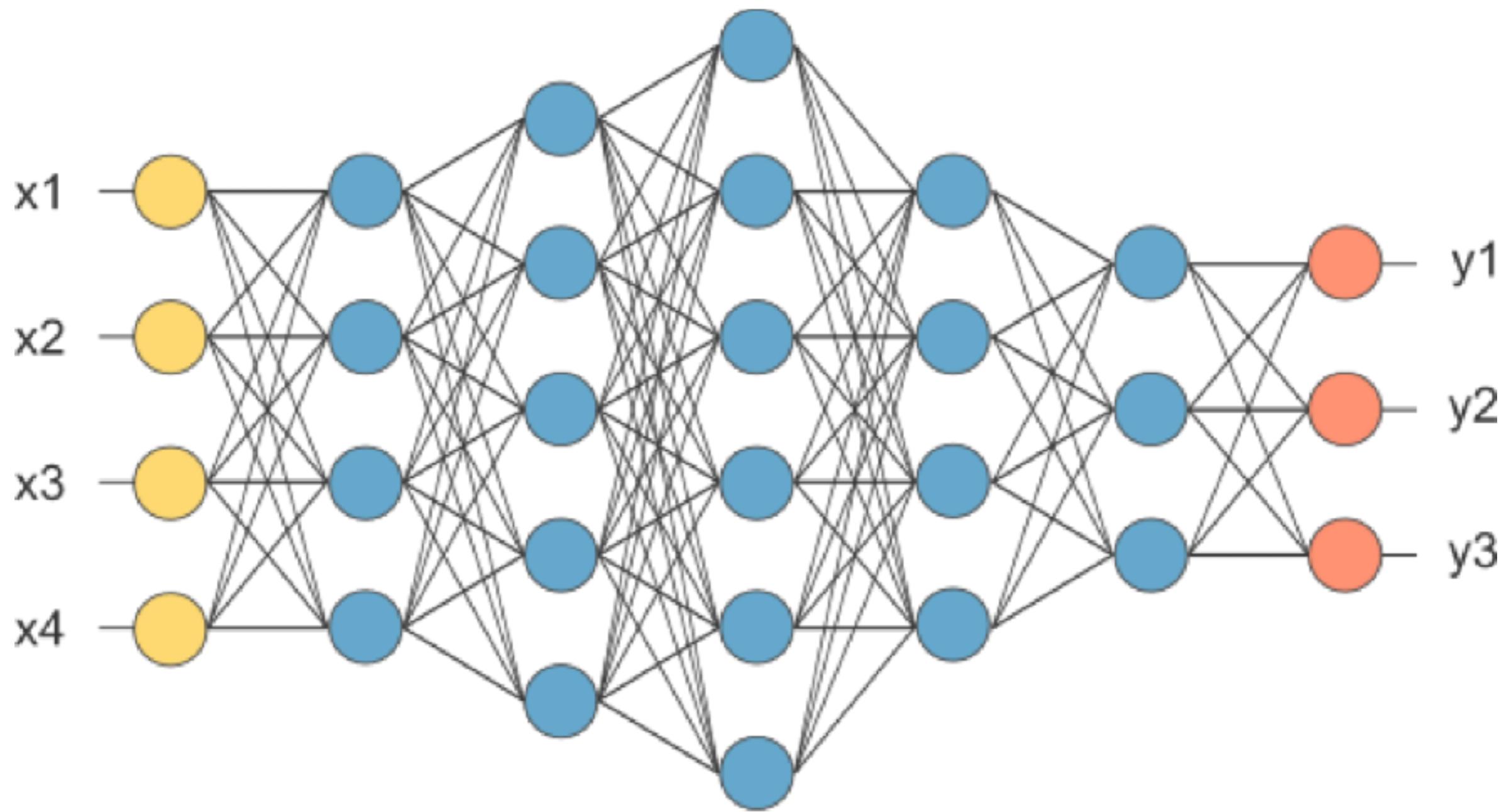
Neural networks and deep learning



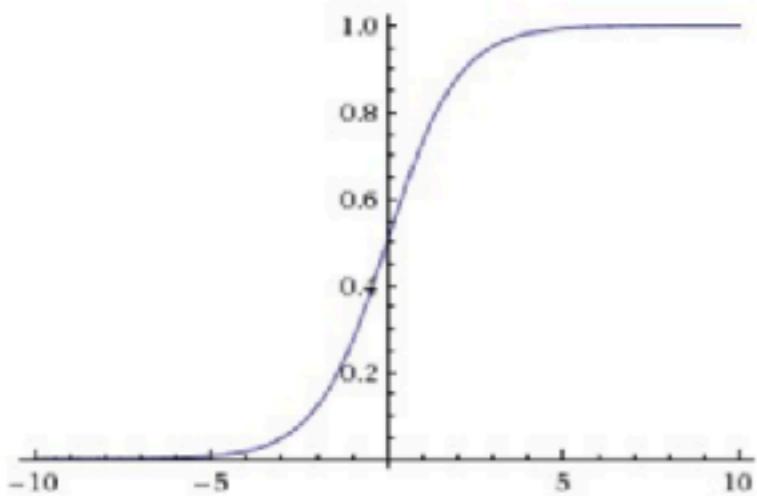
Perceptron



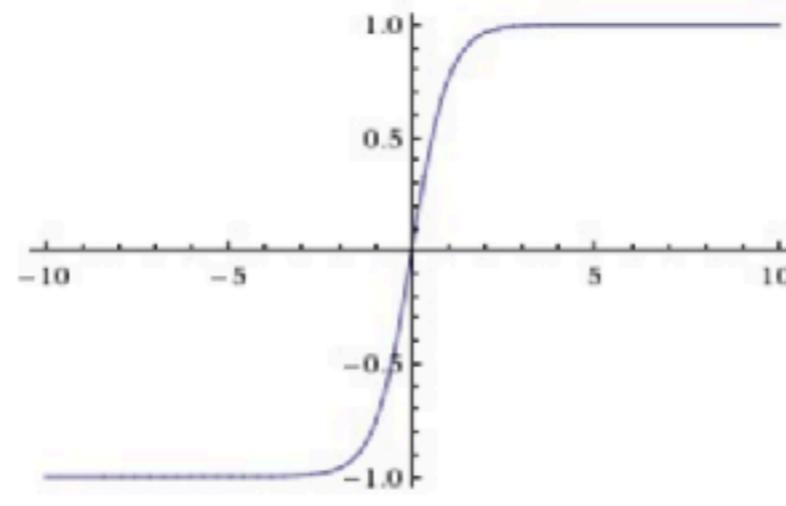
Multilayered Perceptron



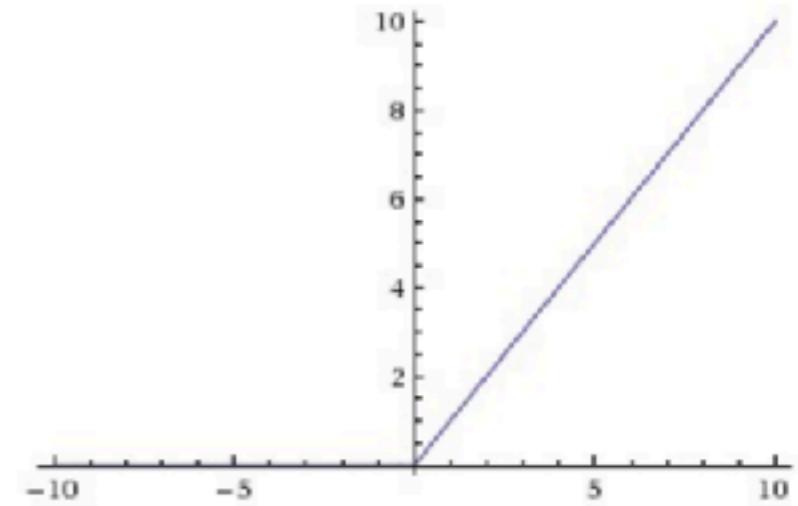
Activation functions



Sigmoid



tanh

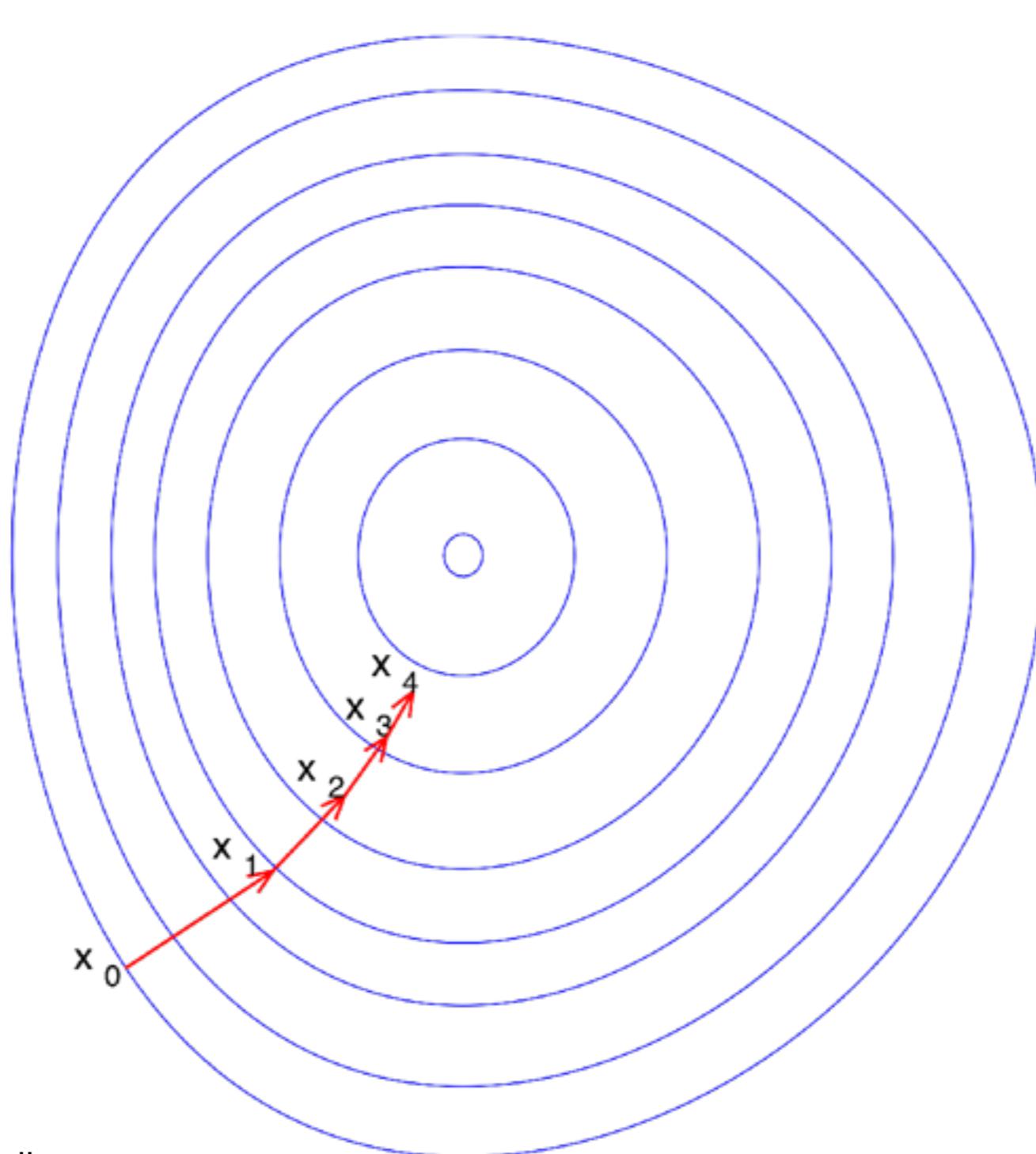


ReLU

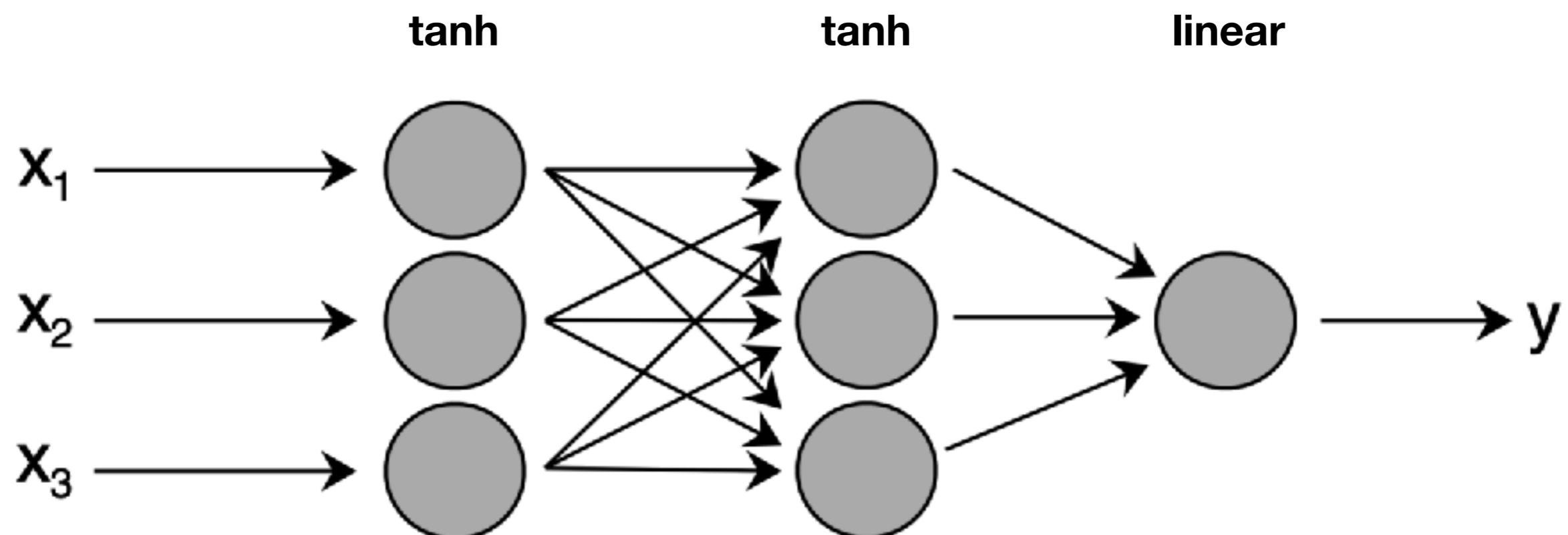
Softmax:

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

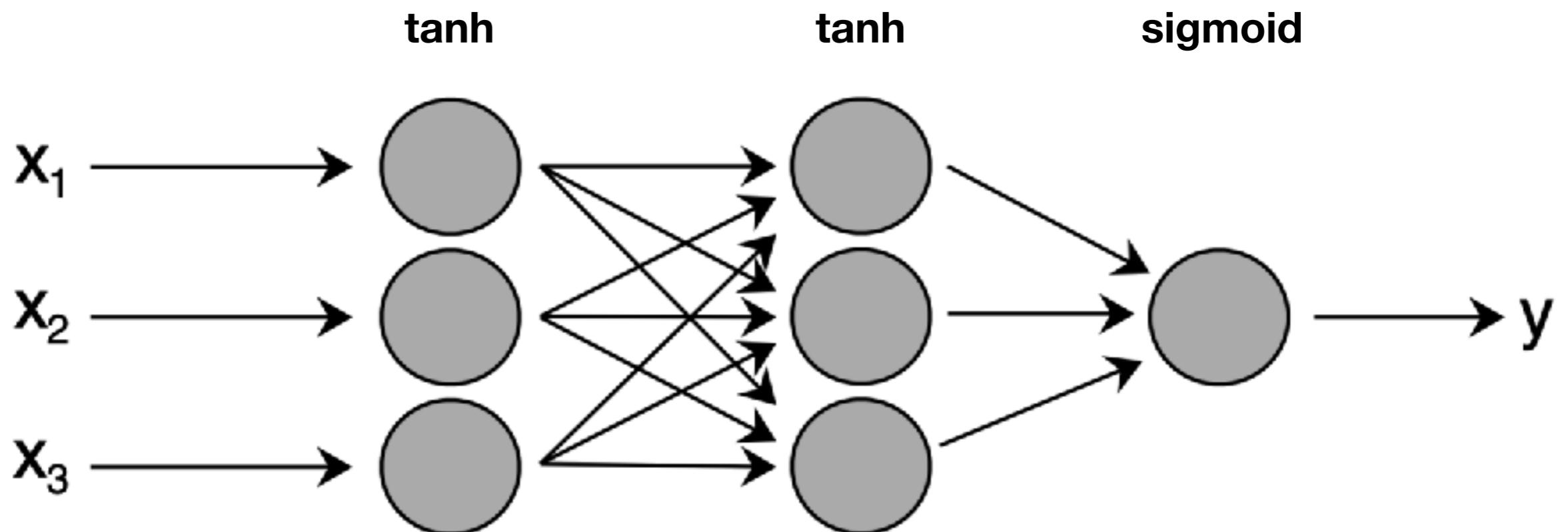
Steepest gradient descent



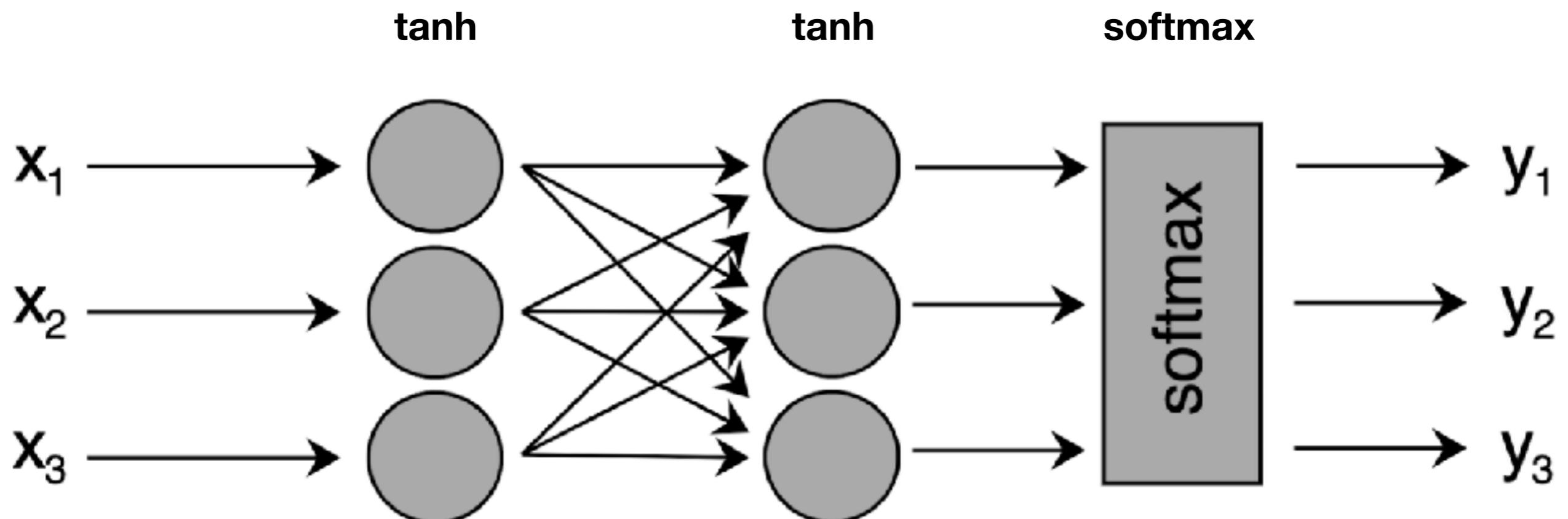
Example - NN for regression



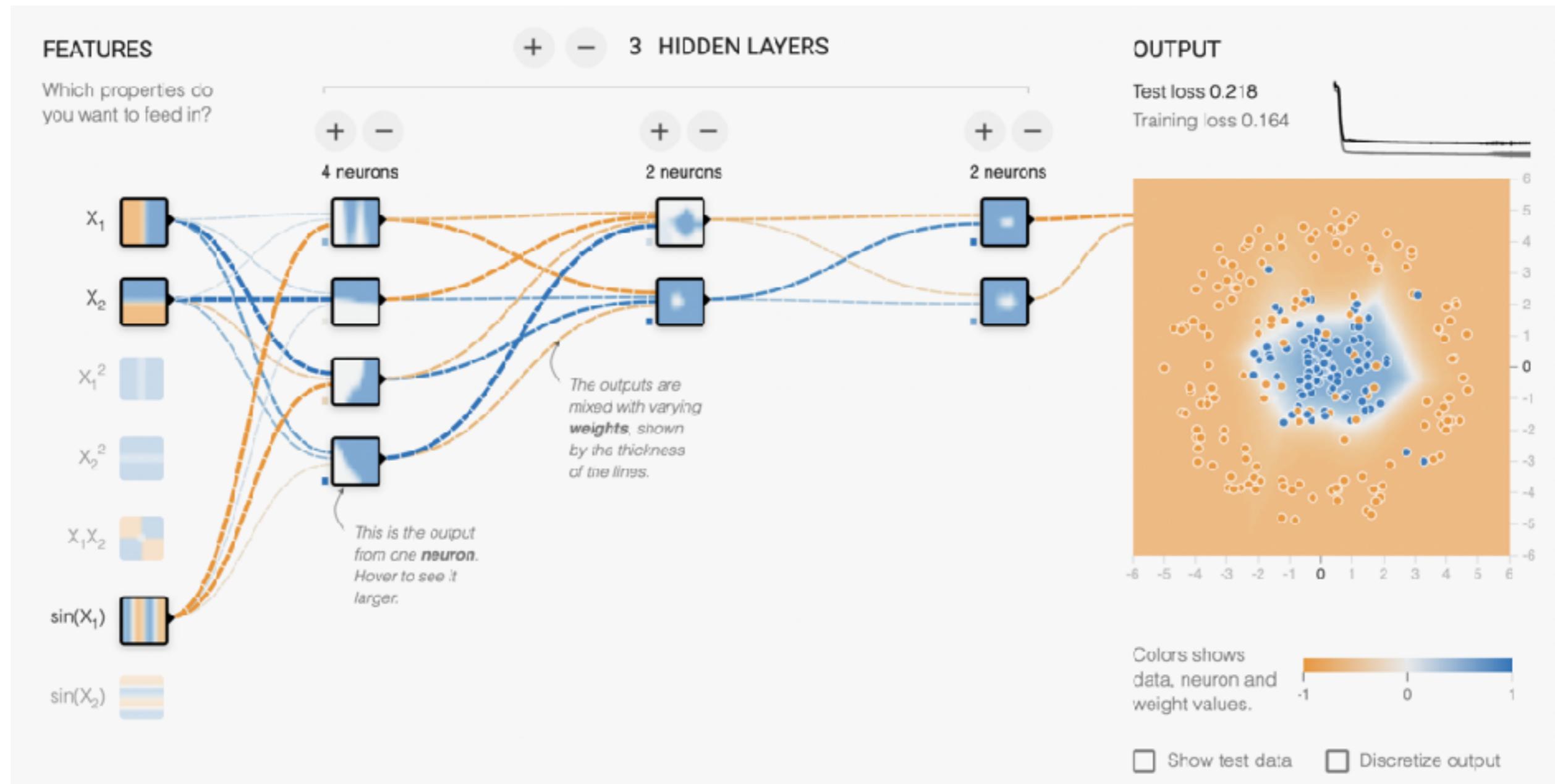
Example - NN for binary classification



Example - NN for multi-class classification



Neural network playground



<https://playground.tensorflow.org/>

Neural network classification tutorial

Neural network tutorial

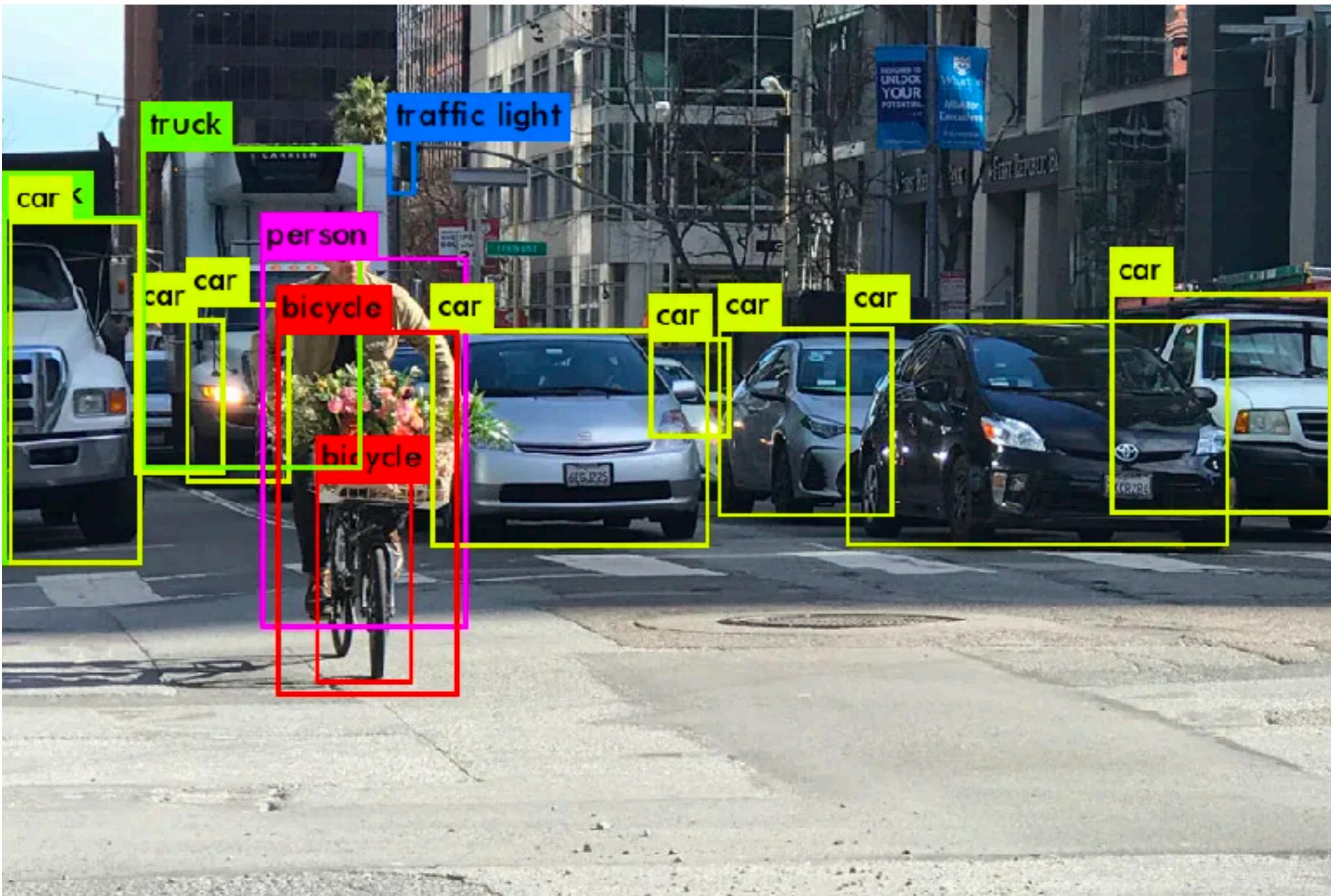
Advanced neural networks for image processing

Finetuning

Transfer Learning



Object detection



YOLO (You Only Look Once)

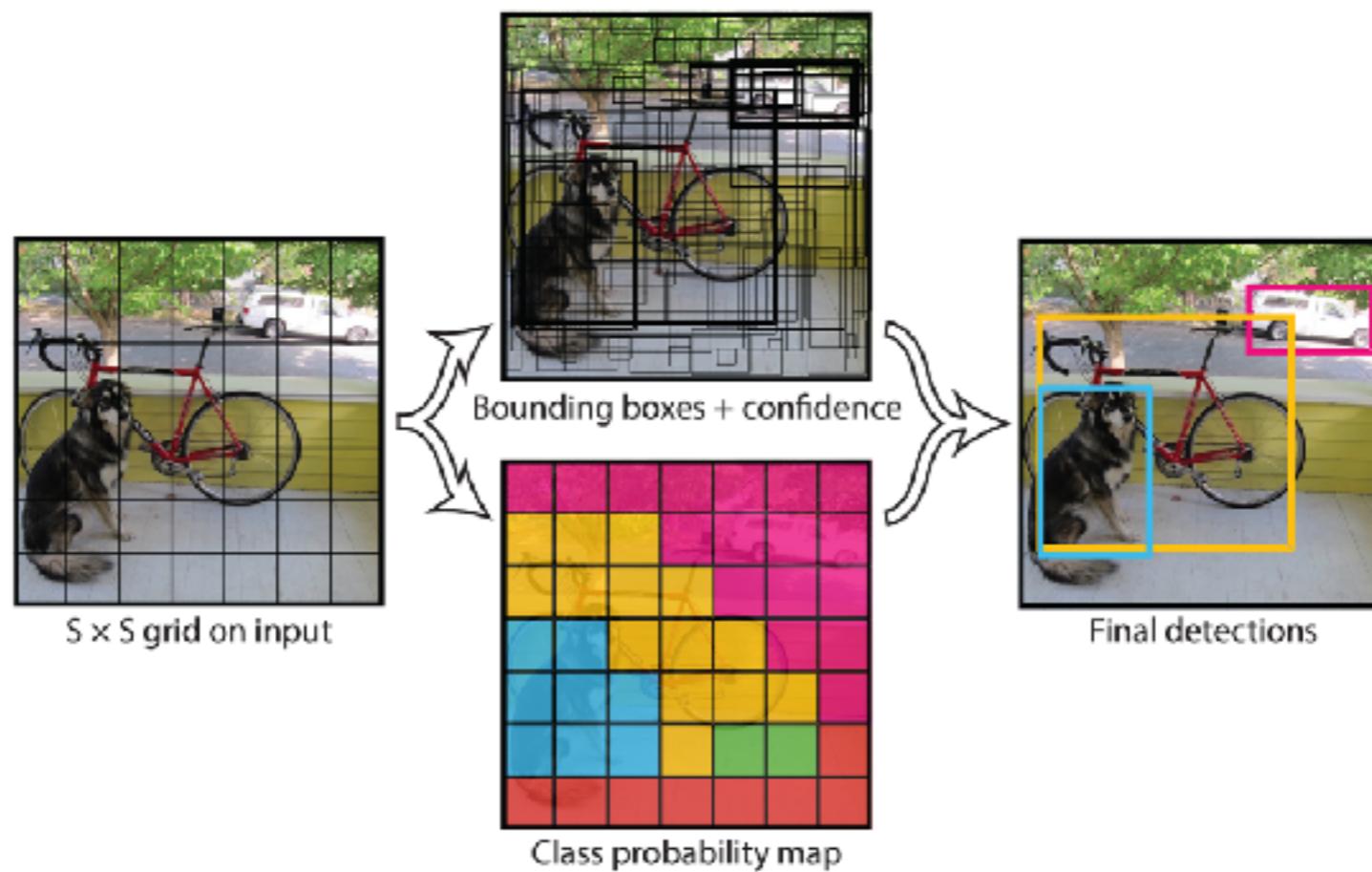


Figure 2: The Model. Our system models detection as a regression problem. It divides the image into an $S \times S$ grid and for each grid cell predicts B bounding boxes, confidence for those boxes, and C class probabilities. These predictions are encoded as an $S \times S \times (B * 5 + C)$ tensor.

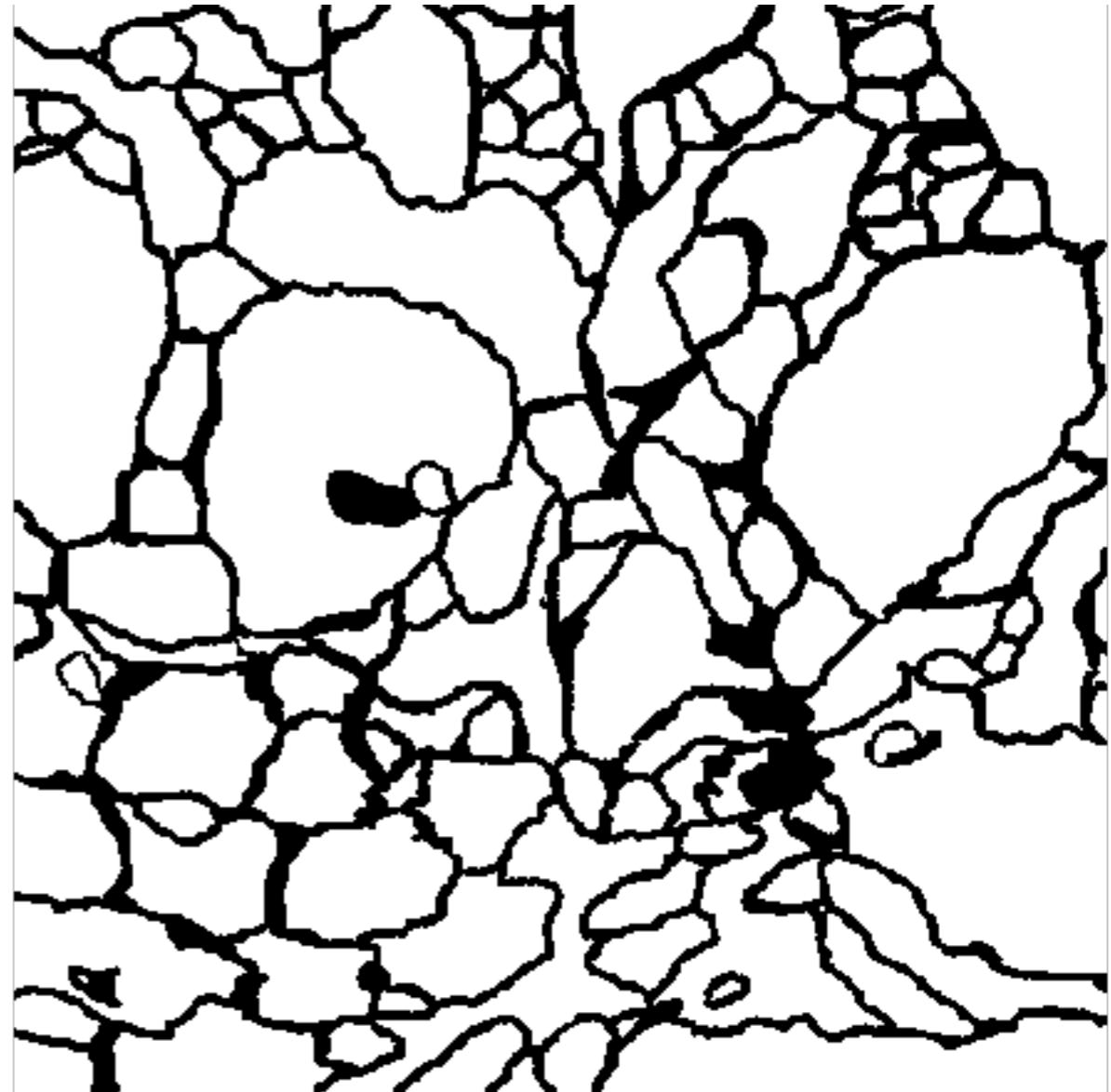
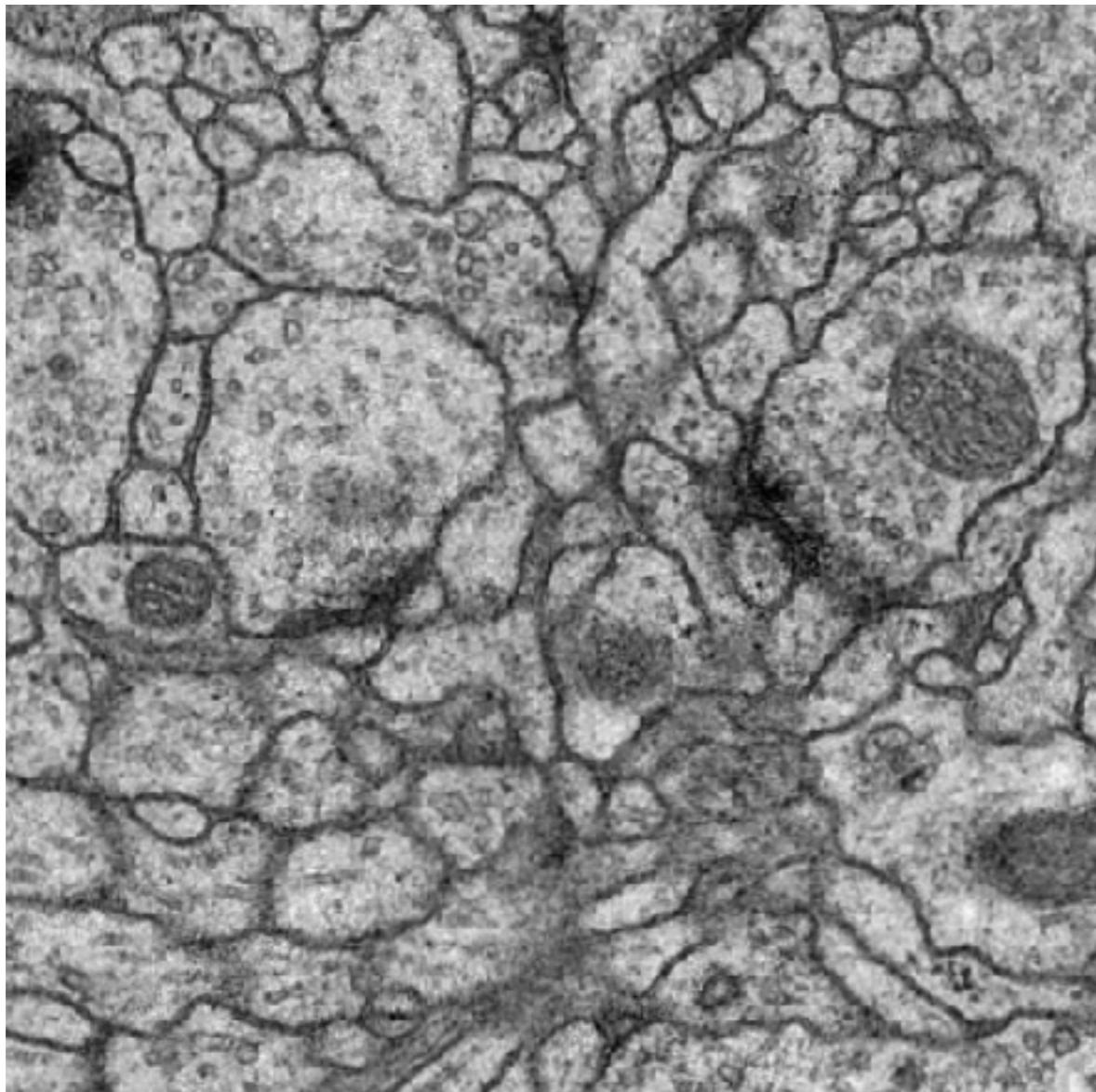
YOLO v8 usage

```
from ultralytics import YOLO

# Load a model
model = YOLO("yolov8n.yaml") # build a new model from scratch
model = YOLO("yolov8n.pt") # load a pretrained model (recommended for training)

# Use the model
model.train(data="coco128.yaml", epochs=3) # train the model
metrics = model.val() # evaluate model performance on the validation set
results = model("https://ultralytics.com/images/bus.jpg") # predict on an image
path = model.export(format="onnx") # export the model to ONNX format
```

Image segmentation



U-Net

Network Architecture

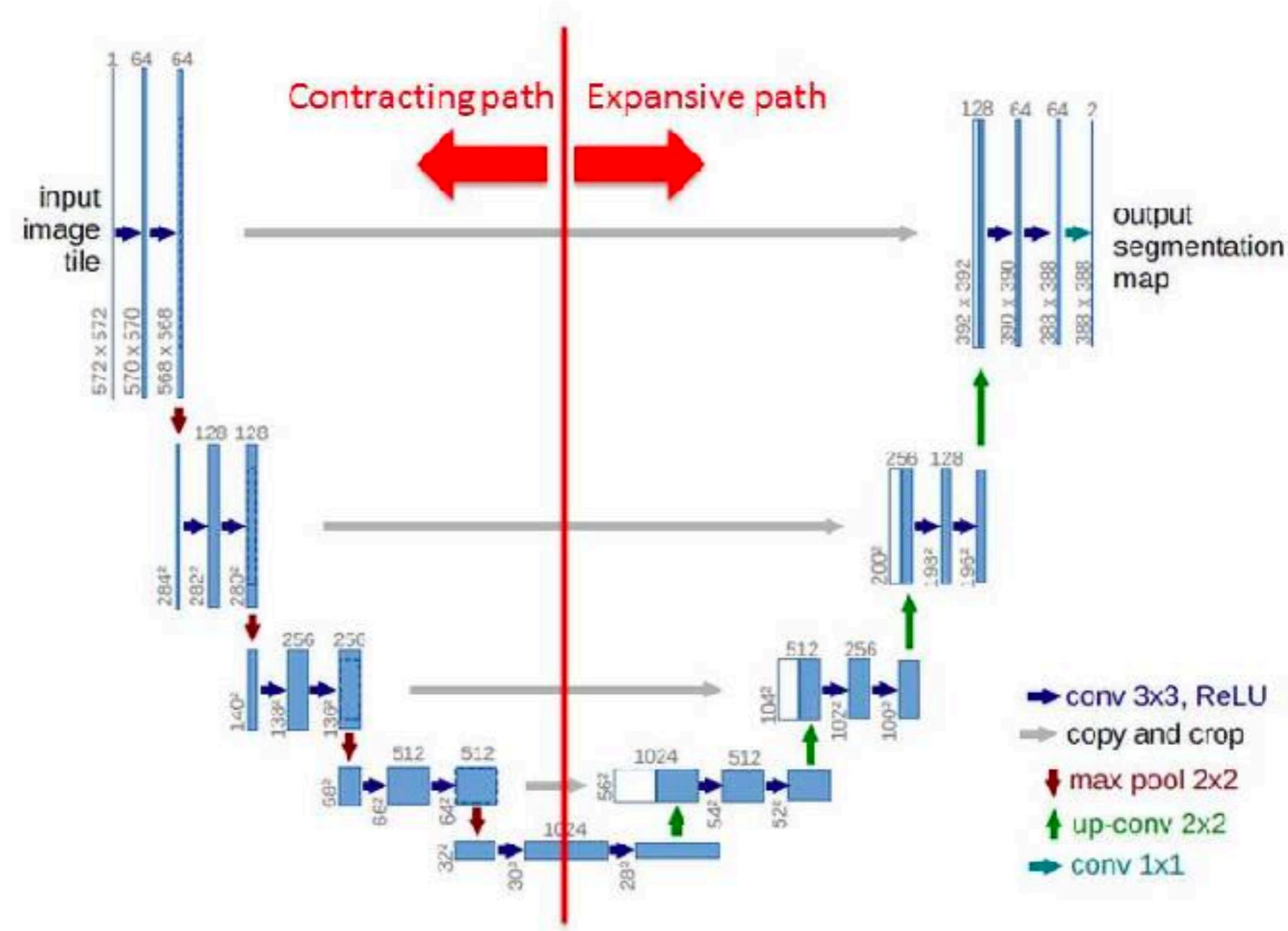
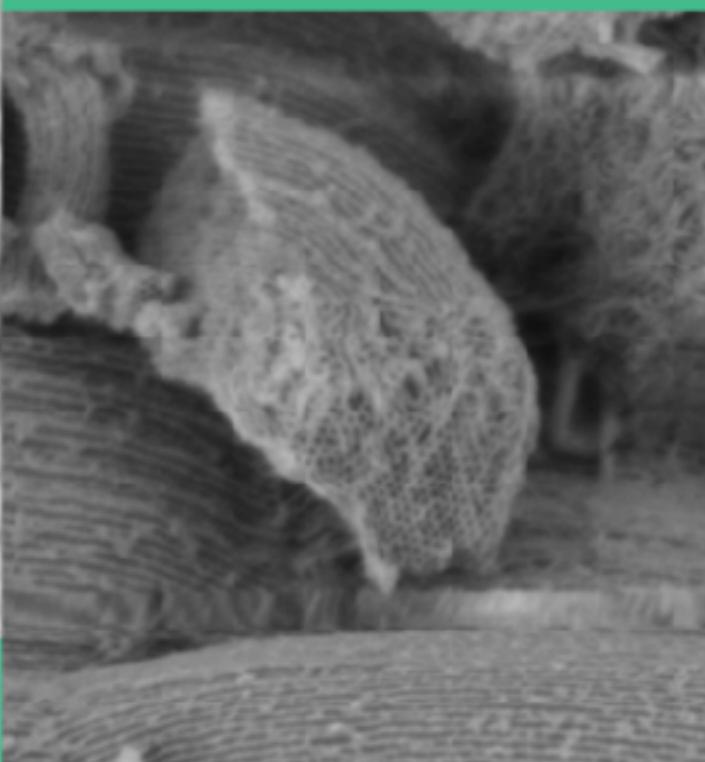


Image denoising

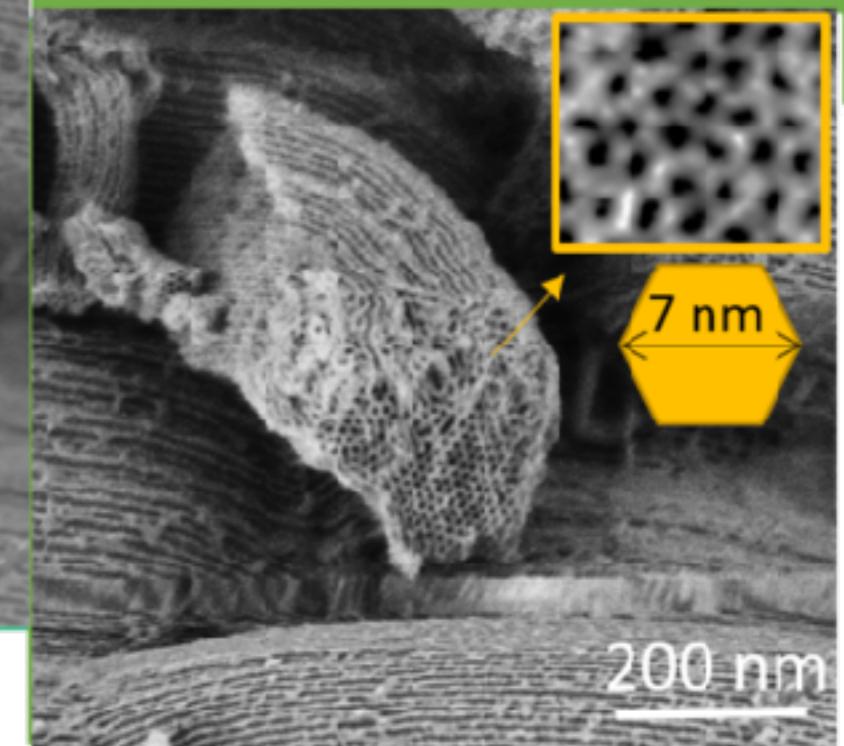
Scanning Electron Microscopy (SEM)



Scanning Low Energy Electron Microscopy (SLEEM)



SLEEM + Deep Learning



Generative Adversarial Networks

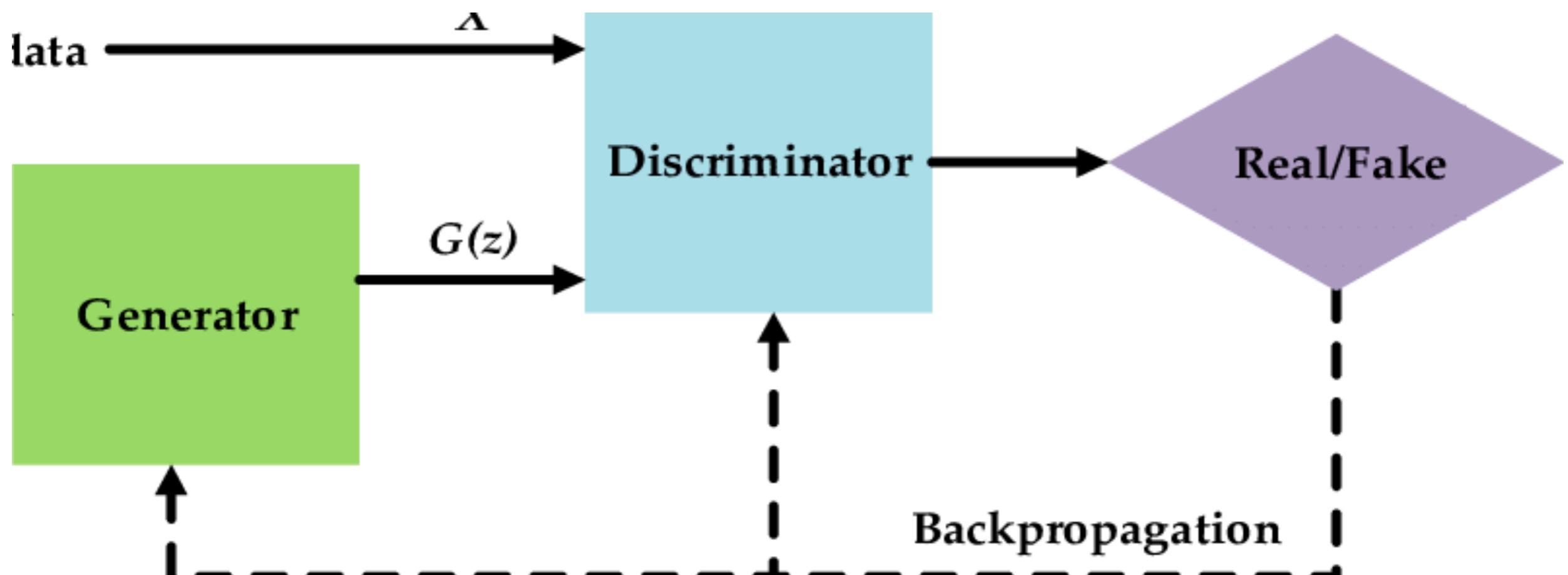
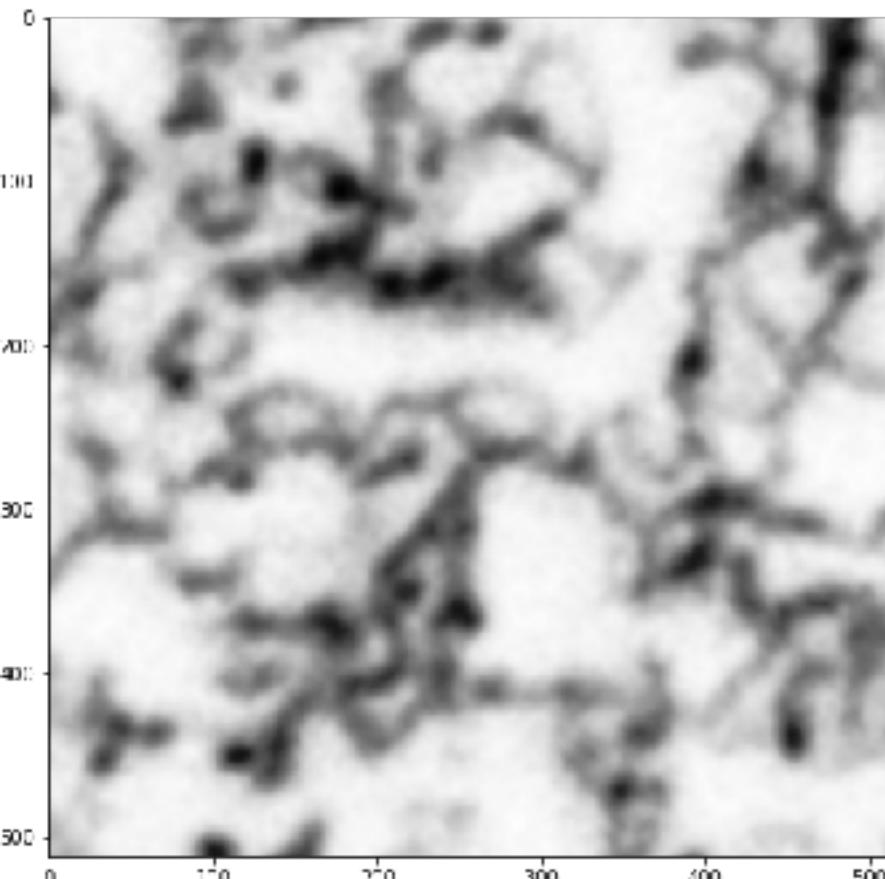
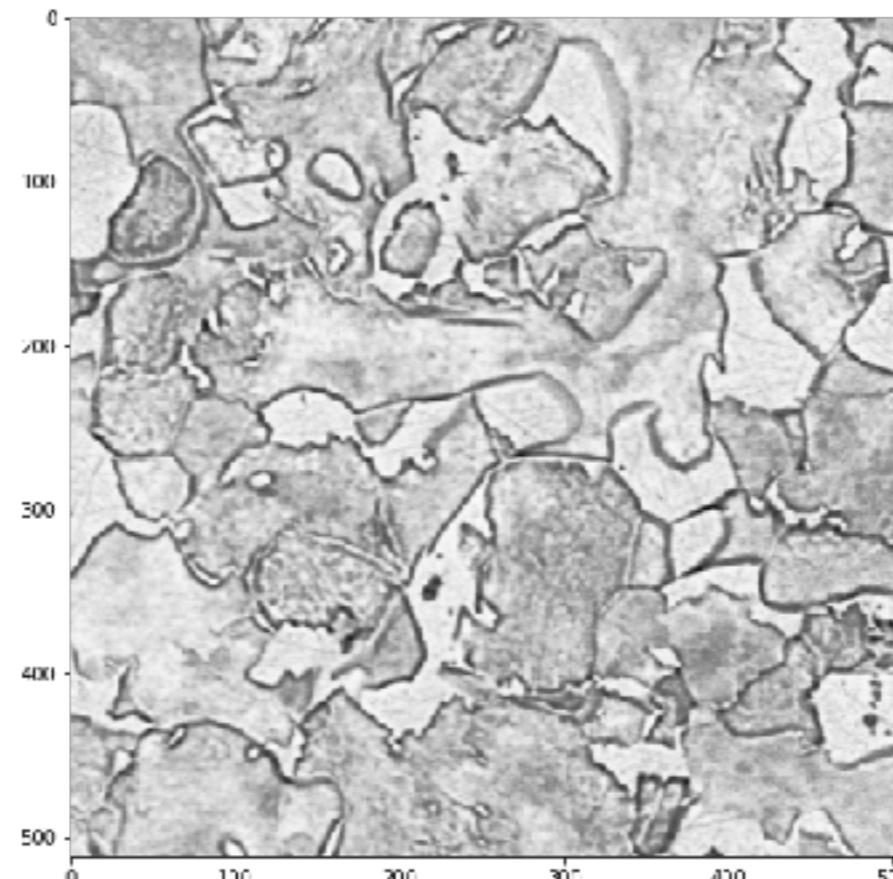


Image transformation with U-Net + GAN

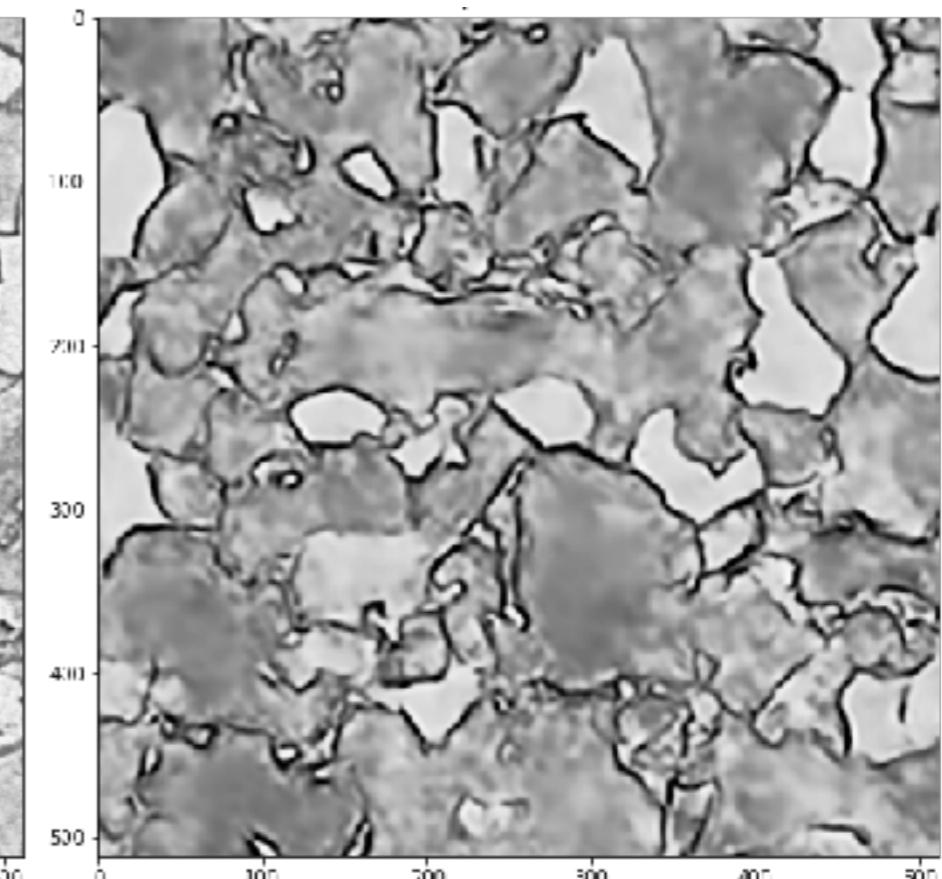
light microscope



electron microscope

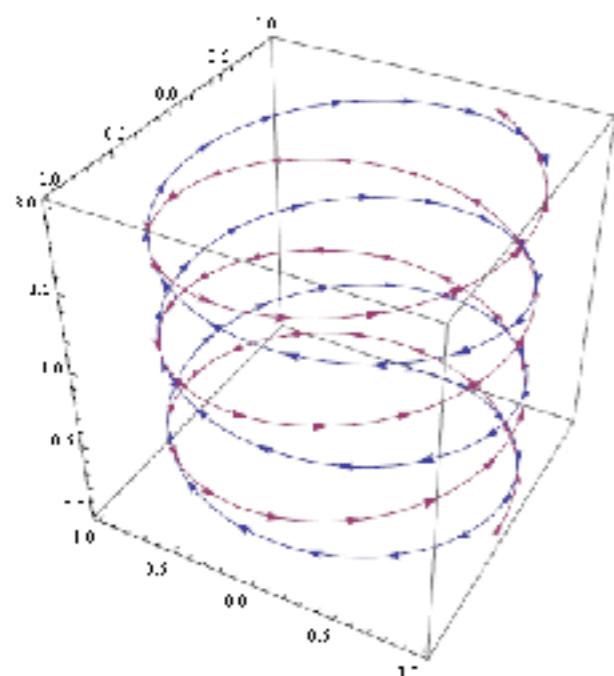
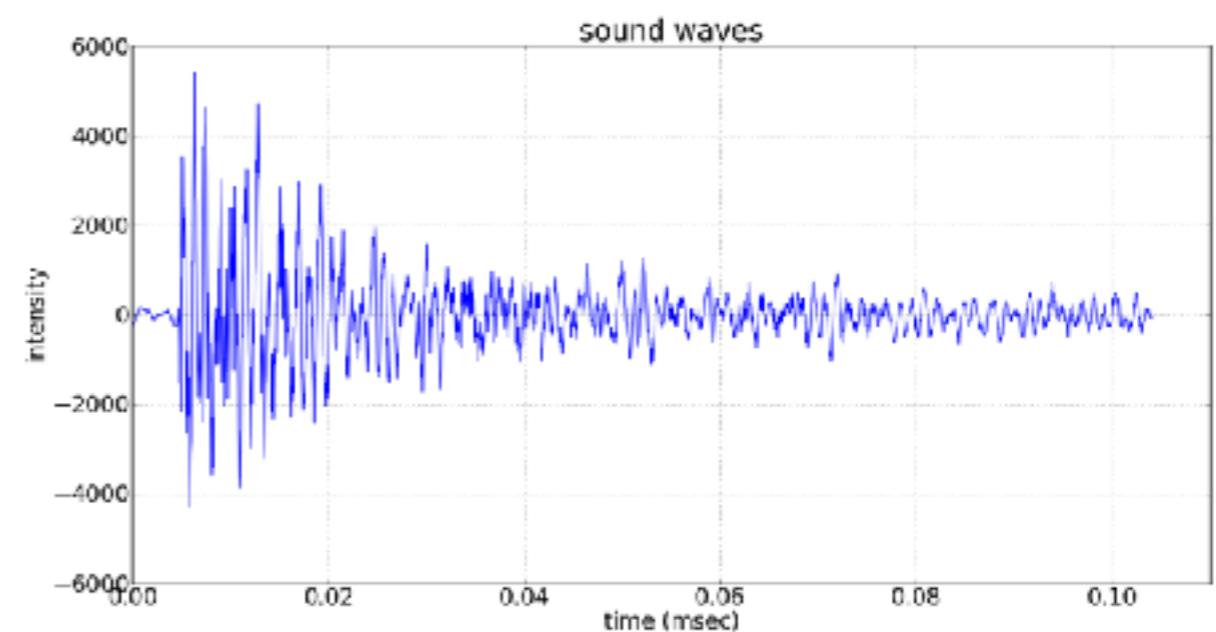
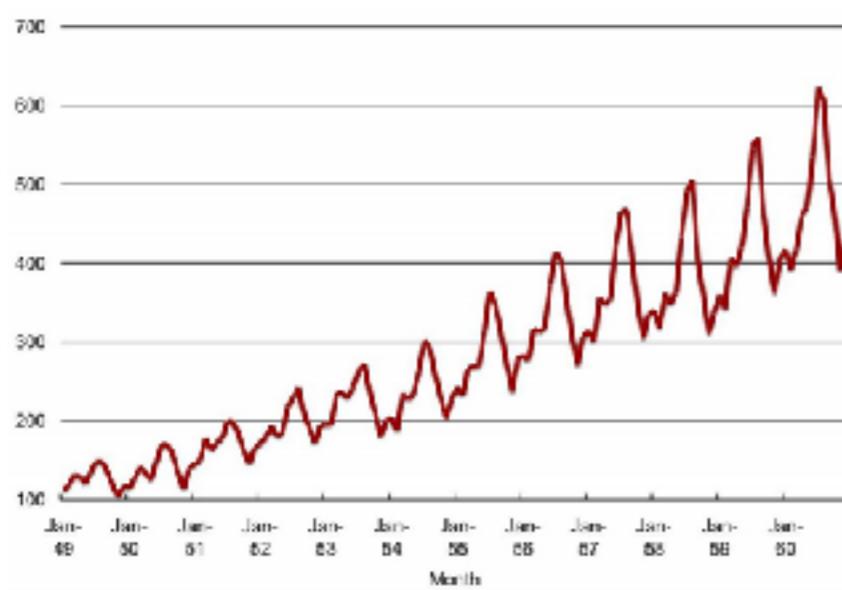


transformation

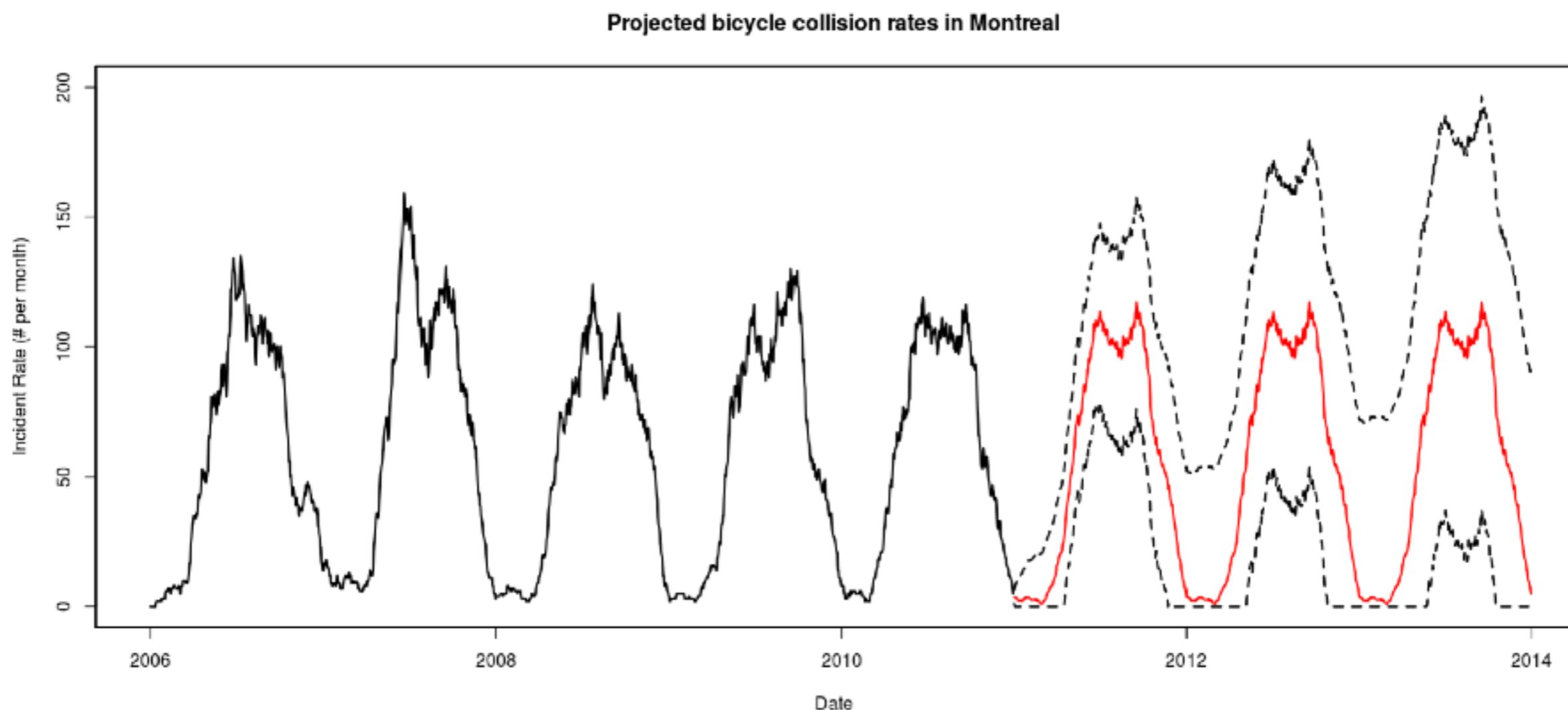


Time series analysis

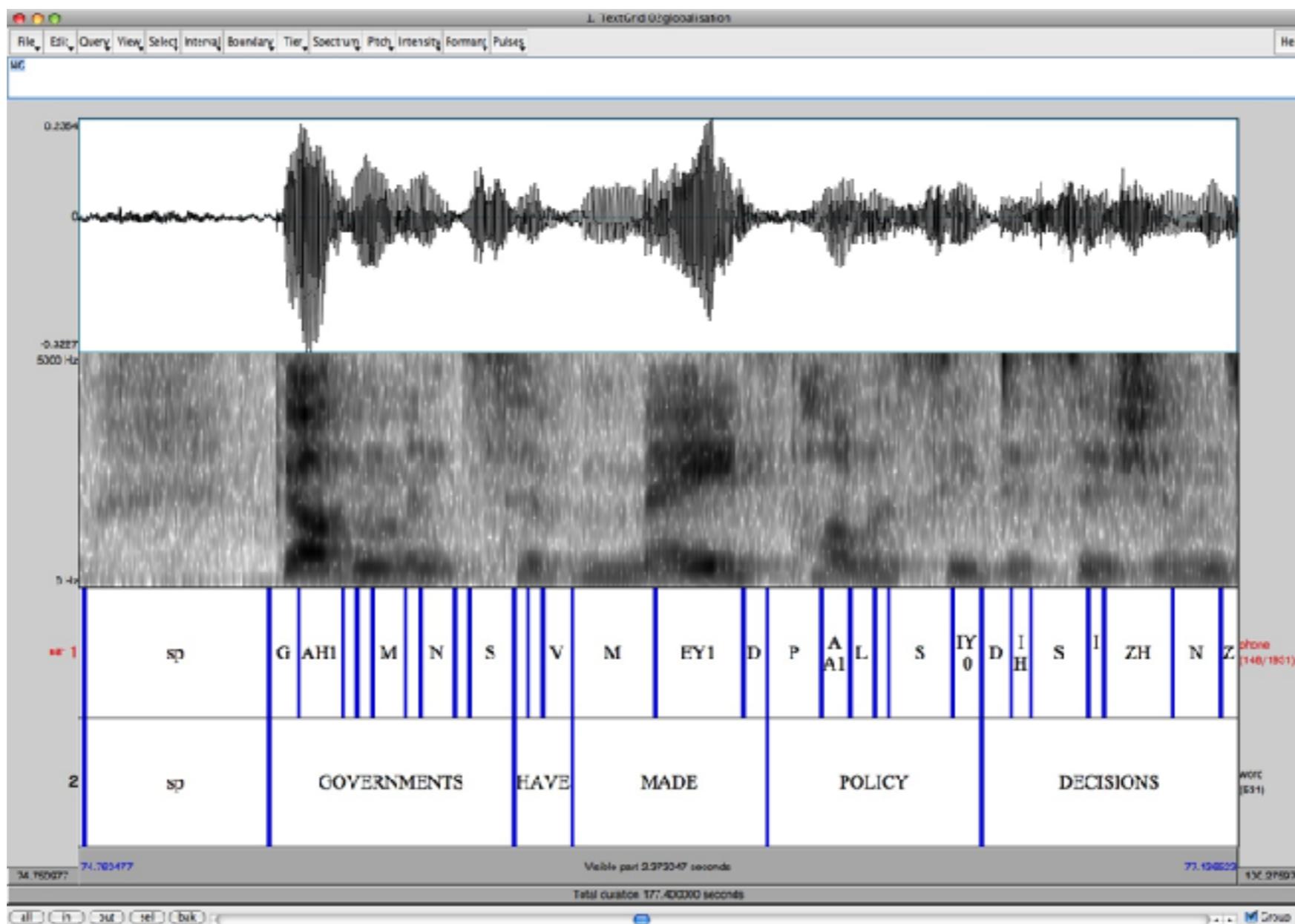
Time series data types



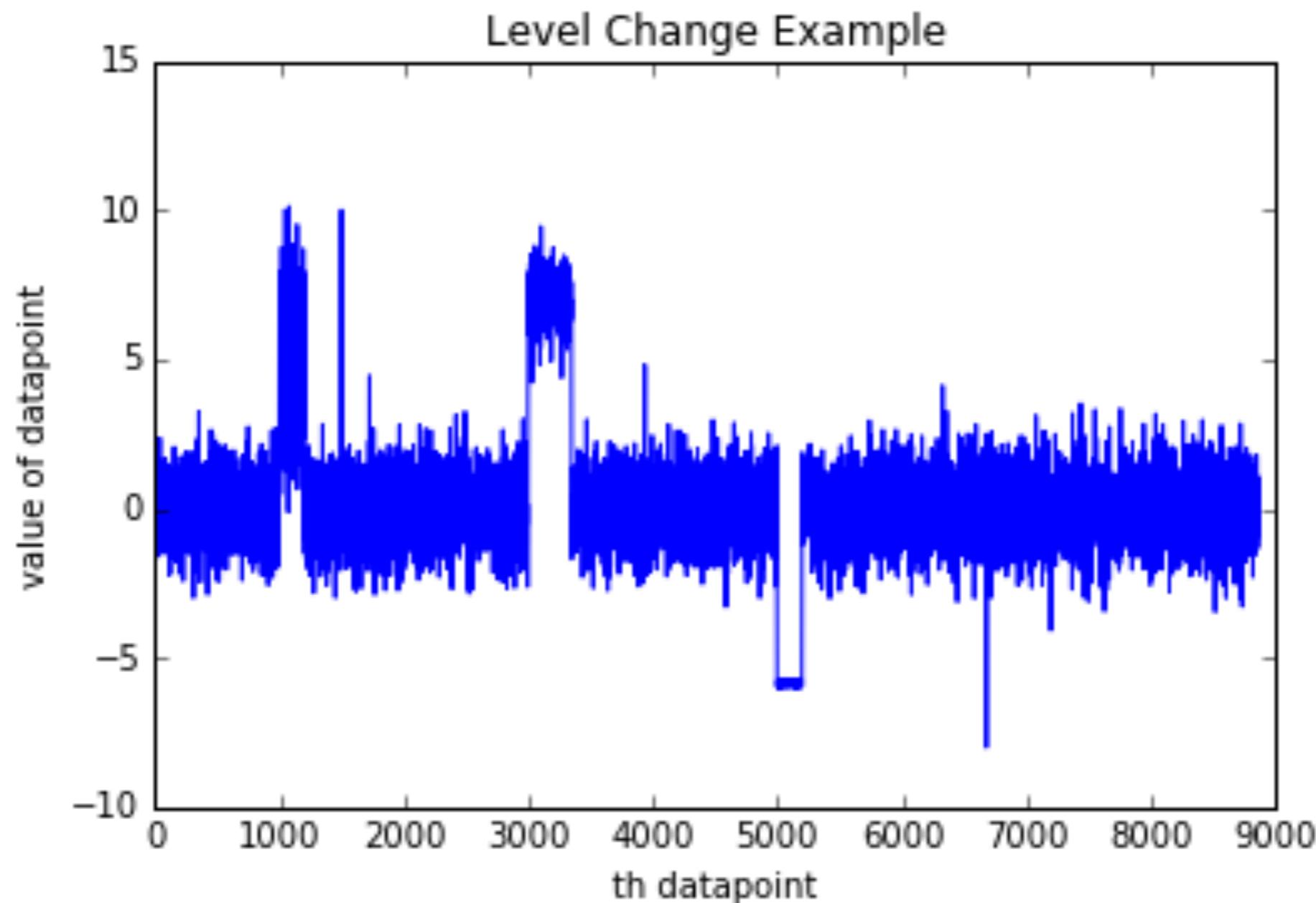
Time series tasks - forecasting



Time series tasks - classification

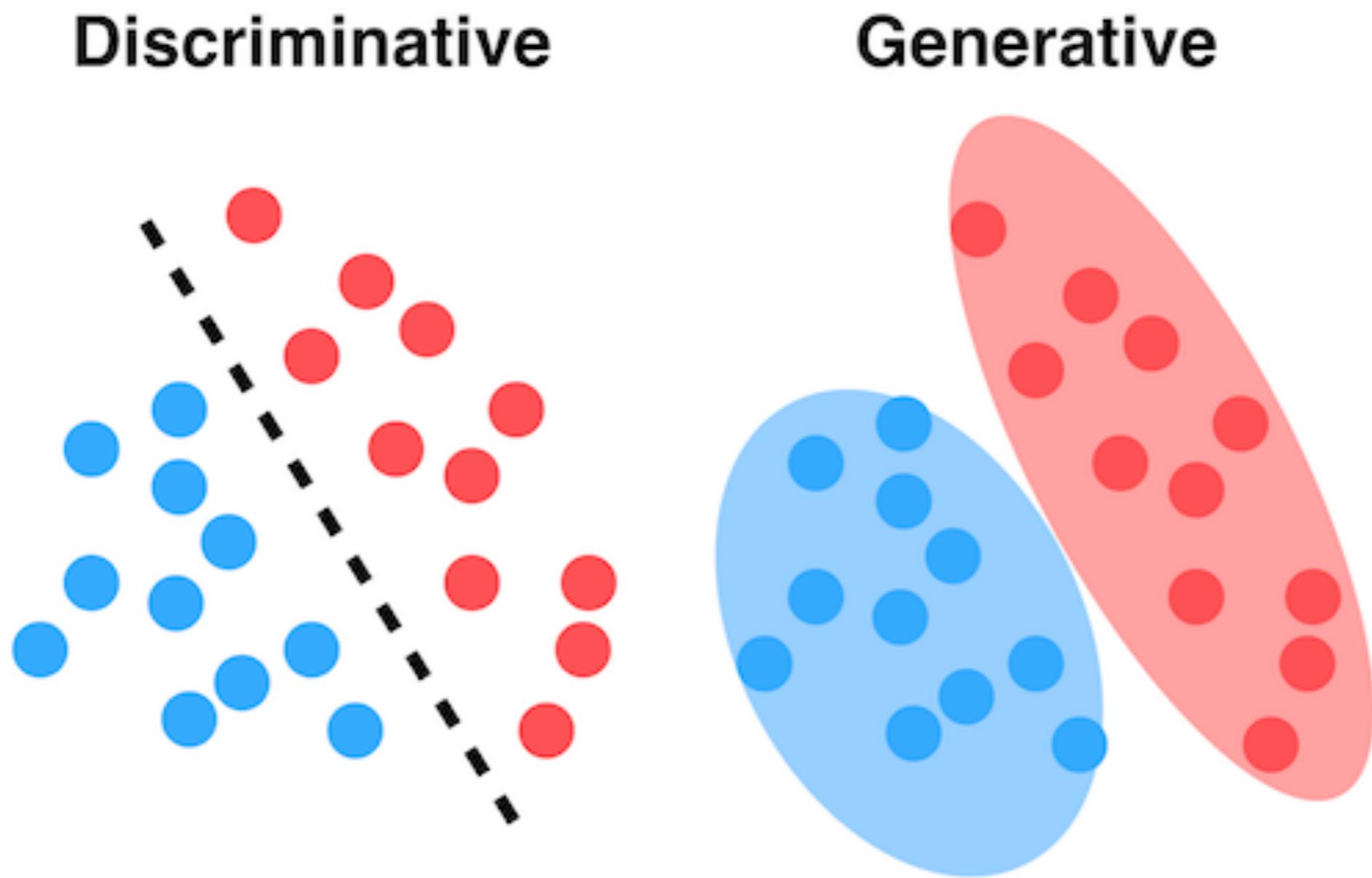


Time series tasks - anomaly detection



Large Language Models

Discriminative vs. generative models

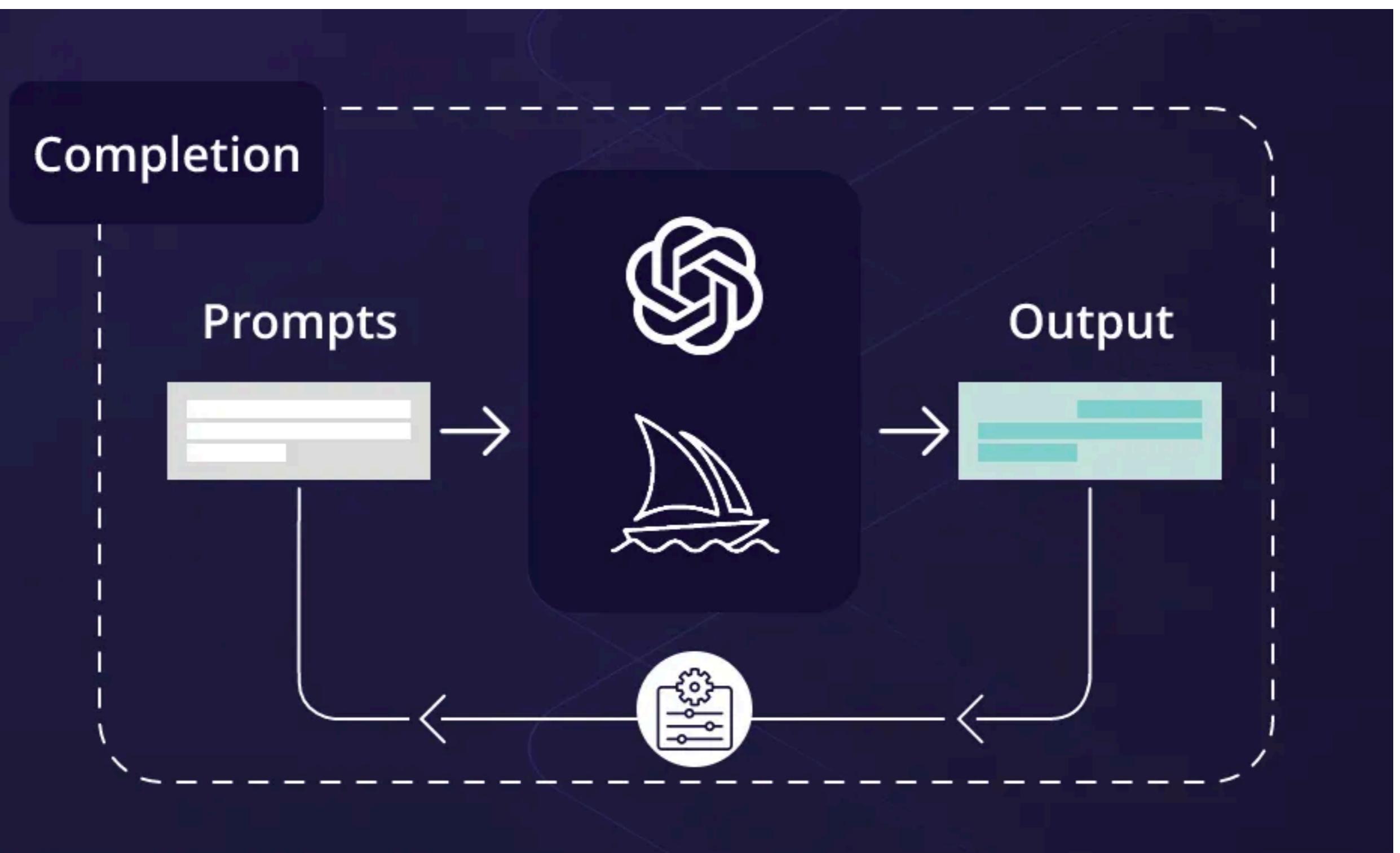


Language models

The task of predicting the next word based on the previous words.

$$P(w_n | w_1, w_2, \dots, w_{n-1}, L)$$

Prompt engineering



What next?

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



Machine Learning Prague

Thank you for your attention

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