# Machine Learning June 30, 2022

### Exercise 1 Grundlagen

Answer the following questions:

1. In general, we can distinguish between two forms of machine learning. Which are these and how can we characterize them?
2. Which traditional forms of machine learning do you know?
3. Define the following terms: Hyperparameter, Bias, Classifier, Dataset, Clustering, Loss-Function, Class, Parameter, Datapoint, Variance, Regression, Training

### Exercise 2 Traditional Machine Learning Procedures

Familiarize yourself with the provided script `polynomial_fit.ipynb`. Discuss strengths and weaknesses of the methods shown.

## Understanding Neural Networks

Let $x = (x_1, \dots, x_n)$ be the input vector und $g(x) = (g(x)_1, \dots, g(x)_m)$ the output vector of a neural network. We denote the loss function (Cost-Funktion) with $C$ and with $L$ the number of layers. The weights between layer $l-1$ and $l$ and between node $j$ of layer $l$ and node $k$ of layer $l-1$ are written as $W^l = w^l_{jk}$. The number of nodes per layer $l$ is given by $\sigma_l$. Figure 1 shows an example for such a neural network. The total function $g$ of the layer can be split along the function of the individual layers $f^l$. We can thus write

$$g(x) = f^L(W^L f^{L-1}(W^{L-1} \dots f^1(W^1 x) \dots)) \tag{1}$$

We inspect the first layer of our example in figure 1. Here, the result at the first hidden layer will be

$$t^1_j = f^1\left(w^1_{j1}x_1 + w^1_{j2}x_2 + \dots + w^1_{jn}x_n\right) \tag{2}$$

$$t^1_j = f^1\left(\sum_{k=0}^{n} w^1_{jk}x_k\right) \tag{3}$$

or generally speaking for a larger neural network

$$t^{l+1}_j = f^{l+1}\left(\sum_{k=0}^{\sigma_l} w^{l+1}_{jk}t^l_k\right). \tag{4}$$

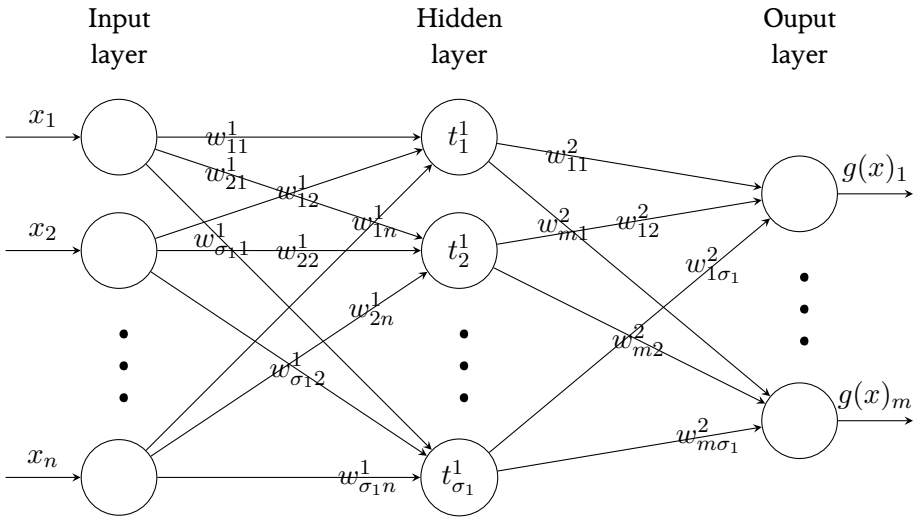

Figure 1: Example of a neural network with only one hidden layer.

## Exercise 3 Building Neural Networks

1. Build a neural network with one input node and one output node and no hidden layers. We fix the This network should return double its input value.