Lecture Note - 07: Neural Network

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1 A Single Neuron

An artificial neuron is the basic computing unit in an artificial neural network. There are different way to define a neuron. The most common one is shown in Figure 1.

Input: A neuron receives multiple inputs x_1, x_2, ..., x_n. The signals are summed up after modulated by a set of weights w_1, w_2, ... w_n. Let us denote the weighted sum z

$$z = \sum_{i=1}^{n} w_i x_i \tag{1}$$

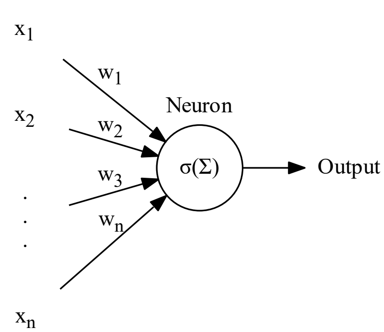

Figure 1: Schema: a single neuron with activation function σ

Usually a biased term w_0 is added to the summation and we have

$$z = \sum_{i=1}^{n} w_i x_i + w_0 \tag{2}$$

Output: The weighted sum is further transferred via an activation function σ and becomes the final output of the neuron

$$o = \sigma(z) = \sigma(\sum_{i=1}^{n} w_i x_i + w_0) \tag{3}$$

Activation: The activation function can of different types. Below is a list of common activation functions. Almost all activation functions have an S-shape except for the ReLu function.

Name	Definition
Step Function	$\sigma(z) = \begin{cases} 0 & \text{for } z < 0 \\ 1 & \text{for } z \geq 0 \end{cases}$
Logistic or sigmoid	$\sigma(z) = \frac{1}{1+e^{-z}}$
hyperbolic tangent	$\sigma(z) = \frac{(e^z - e^{-z})}{(e^z + e^{-z})}$
ReLU	$\sigma(z) = \begin{cases} 0 & \text{for } z \leq 0 \\ z & \text{for } z > 0 \end{cases}$

2 Neural Network

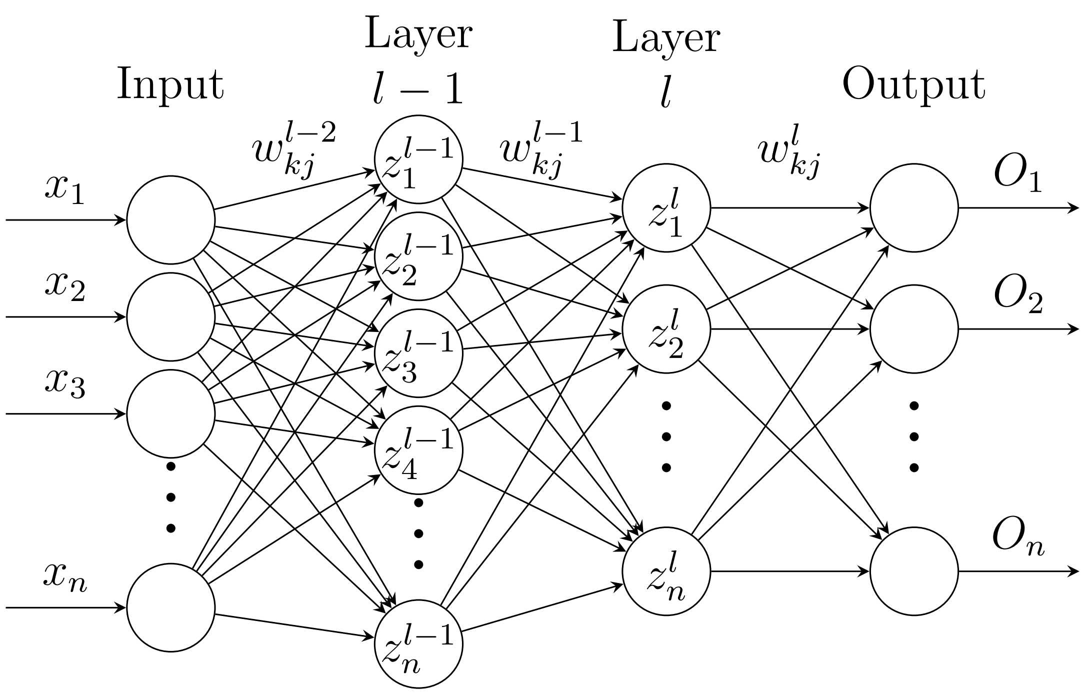

Figure 2: A neural network of multiple layer structures. The hidden layers before layer $l-1$ and after layer l are not shown.