October 13, 2025

Faculty of Computer Science, Heinrich-Heine-University Düsseldorf

Deep Learning

Winter term 25/26 – Exercise Sheet 1

Submission Deadline: Monday, October 20, 2025, 2:00 PM

Exercises

1. **Weight parameters** (5P)
   Consider a neuron in a hidden layer with input z_{in}, and output z_{out}. Let $x = (x_1, \ldots, x_m) \in \mathbb{R}^m$ denote the input values to the neuron, let $w = (w_1, \ldots, w_m)$ denote the connection weights from the inputs, and let b denote the bias weight:

$$z_{\text{in}} = \sum_{i=1}^{m} w_i \cdot x_i + b = w^T x + b$$

$$z_{\text{out}} = \sigma(z_{\text{in}}) = \frac{1}{1 + e^{-z_{\text{in}}}}.$$

   The output of the second neuron is equal to

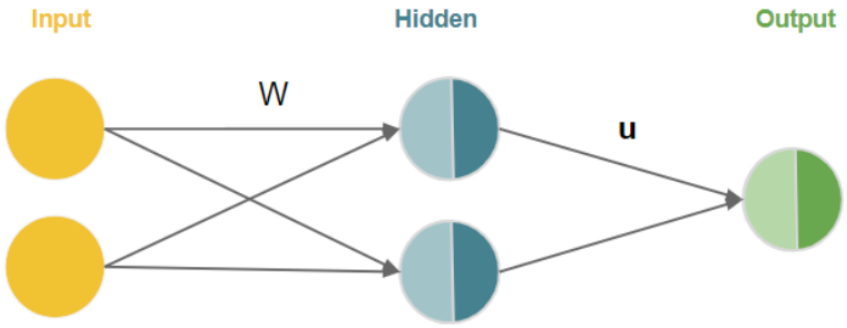
$$\tau(z_{\text{in}}) = \frac{1}{1 + e^{-2z_{\text{in}}}} \ .$$

   Express the parameters of the second neuron, i.e., w' and b', through the parameters of the first neuron, i.e., w and b. Observe the interplay between changing activation function (in this case making the sigmoid more steep) and adapting weights to achieve the same effect.

2. **XOR-Problem** (5P)
   Consider a simple neural network with two hidden neurons with ReLU activation functions and one output neuron with the step activation function

$$\tau(f_{\text{in}}) = \begin{cases} 1 & \text{if } f_{\text{in}} \geq 0 \\ 0 & \text{otherwise} \end{cases} \ ,$$

and let the parameters of the first and the second layer be given by $W = \begin{pmatrix} 1 & 1 \\ 1 & 1 \end{pmatrix}$, $b = \begin{pmatrix} 0 \\ -1 \end{pmatrix}$ and $u = \begin{pmatrix} 1 \\ -2 \end{pmatrix}$, $c = -0.5$, respectively.



a) Write the parameters into the corresponding positions in the figure so that the network models the XOR function. (1P)

c) Model OR and AND functions. (4P)