FACULTY OF COMPUTER SCIENCE, HEINRICH-HEINE-UNIVERSITY DÜSSELDORF

Deep Learning

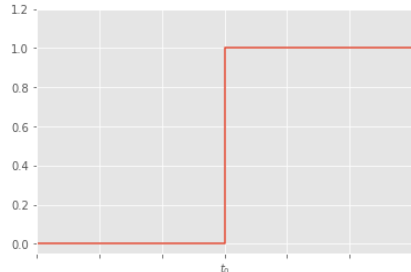Winter term 25/26 – Exercise Sheet 2

Submission Deadline: Monday, October 27, 2025, 2:00 PM

1. **Logistic Regression** (4P) Consider a logistic regression model of the form

$$\pi(x, \theta) = \mathbb{P}(y = 1 | x, \theta) = \frac{\exp(\theta^T x)}{1 + \exp(\theta^T x)}.$$

   Derive an expression for the log-likelihood of θ given a data set $(x^{(1)}, y^{(1)}), ..., (x^{(n)}, y^{(n)})$. Do not forget that logistic regression solves binary classification, so $y \in \{0, 1\}$.

2. **Universal approximation theorem** (3P) How can we model a step function in t_0 from 0 to 1 using a (Multi-Layer-)Perceptron? How many artificial neurons do we need and which activation function is well suited?

3. **Softmax** (3P)

   Show that the softmax function for a two-dimensional vector is equivalent to the logistic function.