Deadline: December 18th , 10:00 Upload a `.pdf` file via LearnWeb. (e.g. exported Jupyter notebook)

1. Neural Networks – Practice (10 points)

Consider the Neural Network depicted in Figure 1. Bias terms are omitted in this exercise.

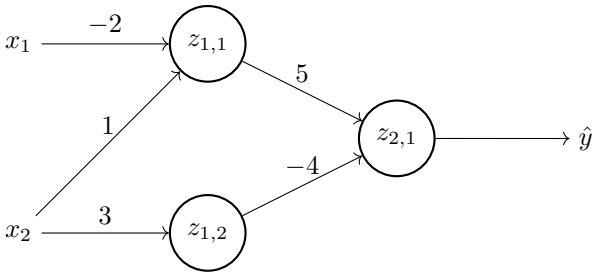

Figure 1: Neural Network model

A. [3p] Perform the forward pass for the single input datapoint $x = (2, 4)$.

B. [5p] Given the single training instance $x = (1, 2)$, $y = 1$ update all the weights once via back-propagation, using the log-likelihood objective function function $\ell = y \log(\hat{y}) + (1 - y) \log(1 - \hat{y})$, sigmoid activation function, learn rate $\eta = 1$ and without any regularization.

C. [2p] Perform another forward pass, using the updated weights. Comment on the result.

2. Neural Networks – Theory (10 points)

In tutorial 3 we have seen that a logistic regression model, i.e. a single artificial neuron with sigmoid activation function cannot solve the XOR dataset.

x_1	x_2	y
0	0	0
0	1	1
1	0	1
1	1	1

(a) OR

x_1	x_2	y
0	0	0
0	1	0
1	0	0
1	1	1

(b) AND

x_1	x_2	y
0	0	1
0	1	0
1	0	0
1	1	0

(c) NOR

x_1	x_2	y
0	0	1
0	1	1
1	0	1
1	1	0

(d) NAND

x_1	x_2	y
0	0	0
0	1	1
1	0	1
1	1	0

(e) XOR

Table 1: Some binary functions

A. [3p] Show that the binary XOR function can be realized as combination of the binary AND and OR functions plus negations.

B. [7p] Design a Neural Network consisting of 3 neurons which realizes the binary XOR function. Provide a full explicit description of the network! (activation function, weights, etc.)

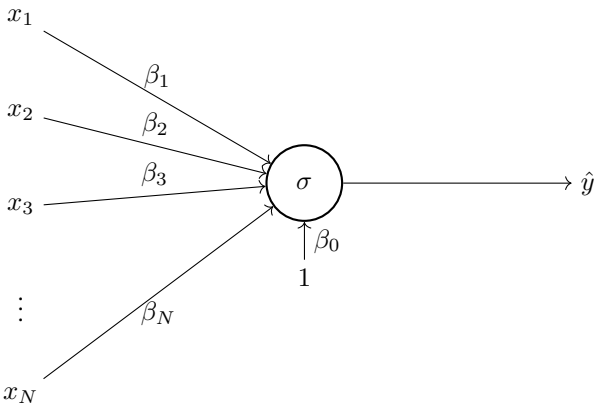

Figure 2: Perceptron model