

# Machine Learning

## Exercise Sheet 7

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Submission until January 18th, 2018(noon) by dropping at MACHINE LEARNING  
postbox

(please indicate in which tutorial are you participating!)

The postboxes is located inside the Samelsonplatz building to the right.

### Exercise 13: Basic Network Topologies (10 Points)

a) **2 points** Consider the binary linear regression model

$$\hat{y} := \sigma(\beta^T x)$$

, where  $\sigma$  is the logistic sigmoid. Show how this model is equivalent to a simple neural network. What kind of topology does this network have? (e.g. Recurrent, Feed-Forward, Hopfield)

b) **5 points** Let  $w_1$  and  $w_2$  be the weights of a perceptron (i.e. simple neural network) with two inputs  $x_1$  and  $x_2$ . Let  $AND(x_1, x_2)$  be the logical andfunction, let  $OR(x_1, x_2)$  be the logical orfunction. Design two single-layer perceptrons which correspond to the logical  $AND$  and  $OR$  functions.

| $x_1$ | $x_2$ | $y$ |
|-------|-------|-----|
| 0     | 0     | 0   |
| 0     | 1     | 0   |
| 1     | 0     | 0   |
| 1     | 1     | 1   |

Table 1: AND

| $x_1$ | $x_2$ | $y$ |
|-------|-------|-----|
| 0     | 0     | 0   |
| 0     | 1     | 1   |
| 1     | 0     | 1   |
| 1     | 1     | 1   |

Table 2: OR

c) **3 points** Consider the  $XOR(x_1, x_2)$  function, which models the behavior of the logical Exclusive Or. For two inputs we have:

| $x_1$ | $x_2$ | $y$ |
|-------|-------|-----|
| 0     | 0     | 0   |
| 0     | 1     | 1   |
| 1     | 0     | 1   |
| 1     | 1     | 0   |

Table 3: XOR

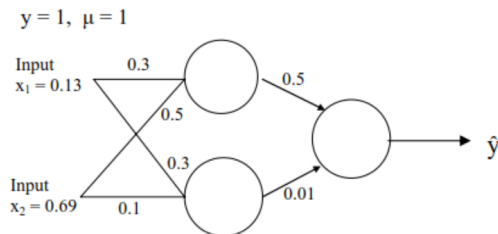
Show that a single-layer model cannot correctly model the  $XOR$  function, and then design a multi-layer perceptron does correctly model the function.

## Exercise 14: Back-Propagation (10 Points)

For this question, it will help immensely if you go through the worked example on page 20 of this tutorial PDF [https://www.fer.unizg.hr/\\_download/repository/BP\\_chapter3\\_-\\_bp.pdf](https://www.fer.unizg.hr/_download/repository/BP_chapter3_-_bp.pdf).

**a) 2 points** Briefly describe the steps involved in backpropagation for multi-layer neural networks.

**b) 6 points** Suppose you have been given the following single-layer network



- Perform a forward pass on the network.
- Perform a reverse pass with ( $y = 1.0$ )
- Perform a further forward pass and comment on the result.

**c) 2 points** Identify two potential pitfalls with the Backpropagation algorithm, and suggest solutions which can remedy those problems.

## Bonus Exercise

**a) 2 points (extra)** Give 4 examples of areas that benefit from Neural networks.

**b) 3 points (extra)** Research time! With 3 bullet points, answer each one of these questions (use 3 bullets for each):

What is Deep Learning?

What is a Convolutional Neural Network?

What is a Recurrent Neural Network?

Hint: <http://www.deeplearningbook.org> (it also contains useful short reviews on basic machine learning topics).