Introduction to Artificial Intelligence

UNIZG FER, AY 2021/2022

Exercises, v1

11 Artificial neural networks

1 (T) The McCulloch-Pitts's artificial neuron model was invented in 1943. **Which of the following *is not* true for this model**?

A Given a fixed set of weights, the neuron will always give the same output for the same input

B The functioning of the axon fiber is modeled by the transfer function

C The speed of propagation of electrical impulses is modeled by weights

D The neuron body alongside input dendrites is modeled by a weighted sum

2 (T) Consider Rosenblatt's perceptron learning rule. Let t denote the neuron's target value and o its output value. **What is the rule for updating neuron's weights?**

A $w(i+1) = w(i) + \eta(t+o)x(i)$

B $w(i+1) = w(i) - \eta(t-o)x(i)$

C $w(i+1) = w(i) + \eta(t-o)x(i)$

D $w(i+1) = w(i) - \eta(t+o)x(i)$

3 (P) We're implementing a feedforward fully connected multilayered artificial neural network of the $3 \times 20 \times 10 \times 5 \times 2$ architecture. The neurons use the rectified linear unit (ReLU) as the transfer function. The network weights are stored in memory as values of the `double` type, which occupies 8 bytes. **What is the total memory consumption for the parameters of this network?**

A 2856 B 5096 C 2560 D 4218

4 (C) The set of training examples $\{(x_2, x_1, y)\}$ is as follows:

$$\big\{(1,1,-1),(2,4,1),(1,2,-1),(3,3,1),(2,1,-1),(4,2,1)\big\}$$

Training is done using the TLU perceptron with output values -1 and 1 and with learning rate $\eta = 1$. The weights are initialized to $(w_2, w_1, w_0) = (1.3, 1.2, -3.2)$. Train the TLU using Rosenblatt's algorithm. **How many times during training will the weights be updated and what are their final values?**

A 3 times, $(1.3, 1.2, -5.2)$

B 2 times, $(3.3, 2.8, -10)$

C Training doesn't converge

D 4 times, $(1.3, -2.5, 12)$

5 (P) We have available two datasets (of the same dimensionality) for a binary classification problem. A TLU-perceptron is used as a classifier. When applied to each dataset separately, Rosenblatt's learning algorithm can successfully find a solution. Let n_1 be the number of steps it takes to find the solution on the first dataset, and n_2 the number of steps on the second dataset. Now consider a third dataset, created as a union of examples from the first and the second dataset. **How many**

steps will it take for Rosenblatt's learning algorithm to successfully find a solution on this third dataset?

A There is no guarantee that learning will succeed

B At least n_1 steps

C Between n_1 and n_2 steps

D $\max(n_1, n_2)$ steps

6 (P) We are considering four Boolean functions of two variables: $f_1(A,B) = \bar{A}\cdot\bar{B}+\bar{A}\cdot B$, $f_2(A,B) = \bar{A}\cdot\bar{B}+A\cdot B$, $f_3(A,B) = \bar{A}\cdot B+A\cdot\bar{B}+A\cdot B$,$f_4(A,B) = (\bar{A}+\bar{B})\cdot(A+B)$. Let's encode Boolean values of variables A and B for false and true as 0 and 1, respectively. We now use a TLU-perceptron and attempt to learn these functions. **Which functions will the TLU-perceptron be able to learn?**

A $f_1(A,B)$ and $f_3(A,B)$

B $f_1(A,B)$ and $f_4(A,B)$

C $f_2(A,B)$ and $f_4(A,B)$

D All four of them

7 (C) Consider a feedforward fully-connected multilayer artifical neural network of a $3 \times 2 \times 2$ architecture with a sigmoidal transfer function. We train this network to learn a mapping $R^3 \to R^2$, i.e., the training dataset contains examples of form $(x_1, x_2, x_3) \mapsto (y_1, y_2)$. The current values of the weights are:

$$w^{(1)}_{0,1} = -1, w^{(1)}_{1,1} = 0.1, w^{(1)}_{2,1} = 1, w^{(1)}_{3,1} = 1, w^{(1)}_{0,2} = 0.5, w^{(1)}_{1,2} = 0.4, w^{(1)}_{2,2} = -2, w^{(1)}_{3,2} = 0.8,$$
$$w^{(2)}_{0,1} = -0.4, w^{(2)}_{1,1} = -2, w^{(2)}_{2,1} = 1, w^{(2)}_{0,2} = 0.4, w^{(2)}_{1,2} = 1, w^{(2)}_{2,2} = 0.3.$$

Let the current example under consideration be $(0.2, -0.1, 0.2) \mapsto (1, 0)$. The network training is performed using the error backpropagation algorithm based on a single example. Let the learning rate be 10. Perform one step of training for this example. **Find the sum $w^{(1)}_{1,2} + w^{(1)}_{3,1}$ after the weights are corrected.** (The answers are rounded to 4 decimal places.)

A 1.4752 B 1.3521 C 1.2627 D 1.3137