Machine Learning – January 18, 2019 - A

Time limit: **2 hours**.

Last Name ..... First Name ..... Matricola .....

Note: if you are not doing the exam for ML 2018/19, write below name of exam, CFU, and academic year (when you were supposed to attend the course). Please specify also if you are an Erasmus student.

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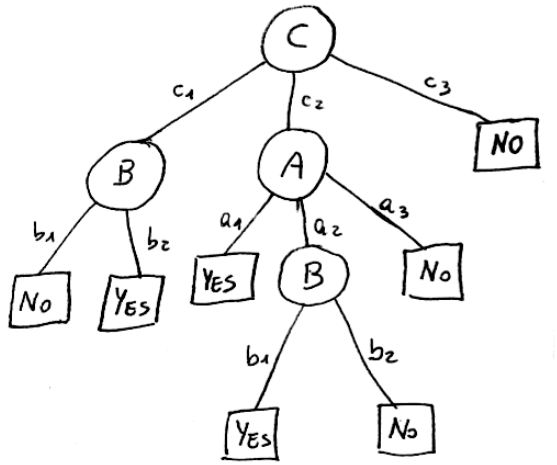
EXERCISE 1

Given a classification problem for the function $f : A \times B \times C \rightarrow \{+, -\}$, with $A = \{a_1, a_2, a_3\}, B = \{b_1, b_2\}, C = \{c_1, c_2, c_3\}$ and the following decision tree T that is the result of a learning algorithm on a given data set:



1. Provide a rule based representation of the tree T.
2. Determine if the tree T is consistent with the following set of samples $S \equiv \{s_1 = \langle a_1, b_1, c_1, No\rangle, s_2 = \langle a_2, b_1, c_2, Yes\rangle, s_3 = \langle a_1, b_2, c_3, Yes\rangle, s_4 = \langle a_2, b_2, c_2, Yes\rangle\}$. Show all the passages needed to get to the answer.

EXERCISE 2

In Bayesian Learning, given a data set D and a hypothesis h, we can express the following relationship between the probability distributions (Bayes theorem):

$$P(h|D) = \frac{P(D|h)P(h)}{P(D)}$$

In this context:

1. define *Maximum a posteriori* (MAP) hypotheses and *Maximum likelihood* (ML) hypotheses.
2. define the concept of *Bayes Optimal Classifier*
3. discuss about practical applcability of the *Bayes Optimal Classifier*

EXERCISE 3

1. Briefly describe the goal of linear regression and define the corresponding model.
2. Given a dataset $\mathcal{D} = \{(\mathbf{x}_1, t_1), \ldots, (\mathbf{x}_N, t_N)\}$ with $\mathbf{x}_n$ the input values and t_n the corresponding target values, explain how the parameters of the model can be estimated either in a batch or in a sequential mode.

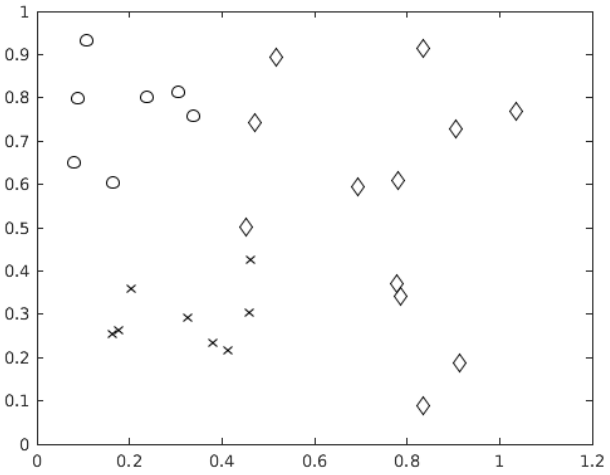
EXERCISE 4

Consider a regression problem for the target function $f : \Re^8 \rightarrow \Re^4$. Design a solution based on Artificial Neural Network for this problem: draw a layout of a suitable ANN for this problem and discuss the choices.

1. Determine the size of the ANN model (i.e., the number of unknown parameters).
2. Is Backpropagation algorithm affected by local minima? If so, how can we avoid or attenuate it?
3. Is Backpropagation algorithm affected by overfitting? If so, how can we avoid or attenuate it?

EXERCISE 5

Consider the data shown in the figure below:



Considering classification based on support vector machines (SVMs):

1. Explain if the data are separable and motivate your answer (only 'yes' or 'no' are not acceptable answers).
2. Explain what type of kernel function you would use in this case.
3. Describe what are the possible solutions for applying SVMs for classification of multiple classes.

EXERCISE 6

1. Describe the perceptron model for classification and its training rule.
2. Draw a graphical representation of a 2D data set for binary classification and provide a qualitative graphical example of a possible evolution of perceptron training (4 images showing a possible temporal evolution of the solution of the algorithm on the sketched data set).