# Machine Learning - April 12, 2019

Time limit: 2 hours.

Last Name	First Name	Matricola
Note: if you are not doing the ex- when you were supposed to attend to	tam for ML 2018/19, write below na the course). Please specify also if yo	me of exam, CFU, and academic year m are an Erasmus student.
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## EXERCISE 1

- 1. Provide a formal (domain-independent and solution-independent) definition of overfitting.
- 2. Discuss the problem of overfitting in learning with Decision Trees and illustrate possible solutions to it.

#### EXERCISE 2

- Describe the Naive Bayes Classifier and highlight the approximation made with respect to the Bayes
  Optimal Classifier.
- 2. Provide design and implementation choices for solving the following problem through Naive Bayes Classifier:

Classification of scientific papers in categories according to their main subject. The categories to be considered are: ML (Machine Learning), KR (Knowledge Representation), PL (Planning). Data available for each scientific paper are: title, authors, abstract and publication site (name of the journal and/or of the conference).

## EXERCISE 3

Consider a dataset  $\mathcal{D} = \{\langle (a_1, s_1), p_1 \rangle, \dots, \langle (a_N, s_N), p_N \rangle \}$  containing the number of hours  $a_i$  a student has attended a course, the number of hours  $s_i$  s/he has studied for the course and whether or not s/he has passed the exam  $p_i = \{0, 1\}$ .

- Define a model based on logistic regression that, given the values of a and s, estimates whether a student passes the exam or not.
- 2. Discuss which are the parameters of the model that have to be learned based on the given data.
- 3. What is a suitable error function for learning the parameters of the model?

## EXERCISE 4

- 1. Briefly describe what is the architecture of an autoencoder and its purpose.
- 2. Draw an example of autoencoder.

### **EXERCISE 5**

- 1. Describe the concept of full observability in models representing dynamic systems.
- 2. Describe the difference between a Markov Decision Process (MDP) and a Partially Observable Markov Decision Process (POMDP), referring to their formal models.
- 3. Draw and explain the graphical models of MDP and POMDP.

#### **EXERCISE 6**

Consider a two-layers ANN which receives in input vectors  $\mathbf{x}$  of dimension 128 and produces output vectors  $\mathbf{y}$  of dimension 10. The hidden layer of the ANN is composed of 50 units which use the ReLU activation function. The output units use a linear activation function. The weight matrices of the hidden and output layers are denoted  $W_1$  and  $W_2$ , respectively.

- 1. Provide the dimensions of the weight matrices  $W_1$  and  $W_2$
- 2. Provide the formula explicitly stating how the values of y are computed given an input vector x in terms of the weight matrices and the activation functions (you can ignore the bias terms).