Machine Learning – Test - December 16, 2019

Time limit: **2 hours**.

Last Name	First Name	Matricola

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Note: if you are not doing the regular exam for ML 2019/20, 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

A car driver in Rome has to move from one side of the Tiber river to the other very often every day. There are three possible alternative paths passing to three different bridges and the paths are known. The driver wants to minimize the time to reach the target location, but due to traffic conditions, it is not guaranteed that the shortest path is also the quickest way. Moreover, traffic conditions are unpredictable, fully observable and (quasi-)stationary.

1. Describe a complete model for this problem based on MDP, specifying all its elements.

2. Describe how to solve the problem based on Reinforcement Learning and determine the exact training rule to use to learn the best behavior.

3. Discuss the strategy for balancing exploration and exploitation.

EXERCISE 2

Describe the Markov property of Markovian models representing dynamic systems. Describe the difference between a Markov Decision Process (MDP) and a Hidden Markov Model (HMM). Draw and explain the graphical models of MDP and HMM.

EXERCISE 3

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 $\mathbf{y}$ are computed given an input vector $\mathbf{x}$ in terms of the weight matrices and the activation functions (you can ignore the bias terms).

EXERCISE 4

1. Briefly describe what is the architecture of an autoencoder and its purpose.

2. Draw an example of autoencoder.

EXERCISE 5

Simulate the execution of K-means in this 2-D data set with k=2 and initial centroids indicated by double circles: use one diagram for each step of the algorithm. Describe explicitly how each step is obtained and what is the termination condition of the algorithm. Drawing only the steps is not sufficient.
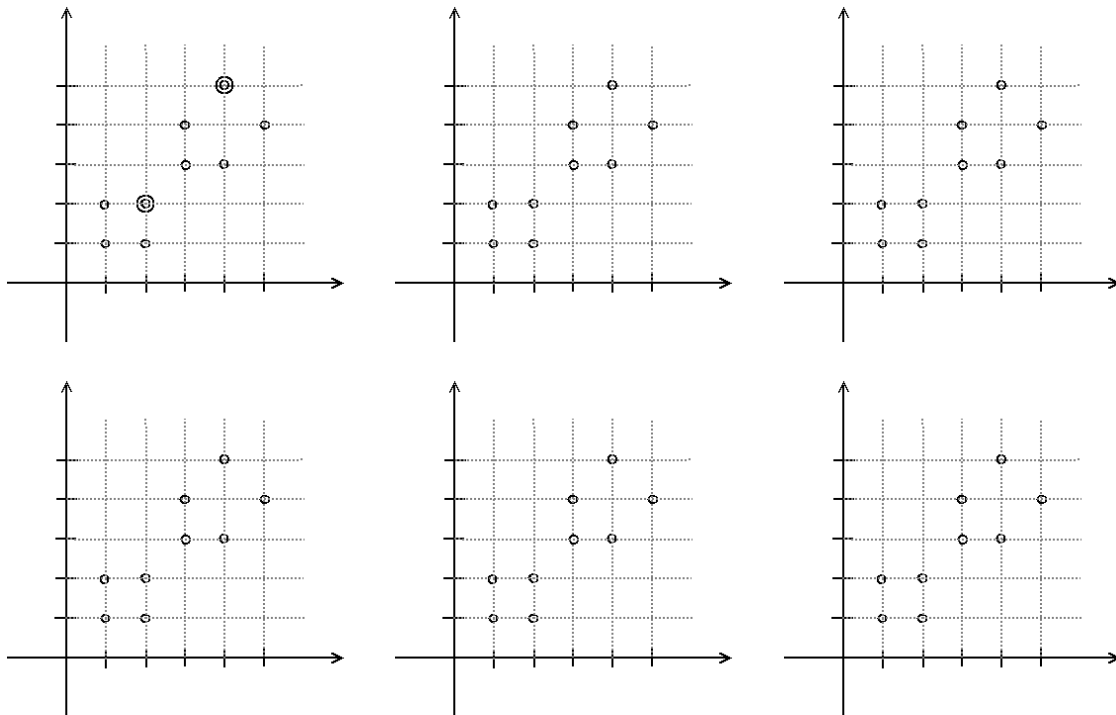
EXERCISE 6

1. Describe an ensemble method (at your choice) for combining multiple learners. Describe precisely all the elements of the method.

2. Assume you have 4 binary classifiers for images with medium-good classification accuracy, describe the application of the method illustrated in the previous point to these 4 classifiers.