Machine Learning – Test 1

Time limit: **2 hours**.

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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

The following data have been collected and we want to learn the general concept *Acceptable*, by using Decision Tree Learning.

House	Furniture	Nr rooms	New kitchen	Acceptable
1	No	3	Yes	Yes
2	Yes	3	No	No
3	No	4	No	Yes
4	No	3	No	No
5	Yes	4	No	Yes

1. Formalize the learning problem: decribe exactly the target function to learn and the dataset.
2. Describe qualitatively how attributes are chosen when building a Decision Tree.
3. Simulate the execution of ID3 algorithm on the data set above and generate the corresponding output tree.

Note: point 3 can be answered even if point 2 is not properly addressed, by using any invented method (or invented numbers) for the selection of the variables.

EXERCISE 2

1. Provide a formal definition of a maximum likelihood (ML) hypothesis, explaining in details all the terms used in the formula.
2. Comment the following statement: *in a classification problem, the class returned by the ML hypothesis on a new instance x is always the most probable class.*

EXERCISE 3

Briefly describe a linear classification method and discuss its performance in presence of outliers. Use a graphical example to illustrate the concept.

EXERCISE 4

Given input values $\mathbf{x}_i$ and the corresponding target values t_i with $i = 1, \ldots, N$, the solution of regularized linear regression can be written as:

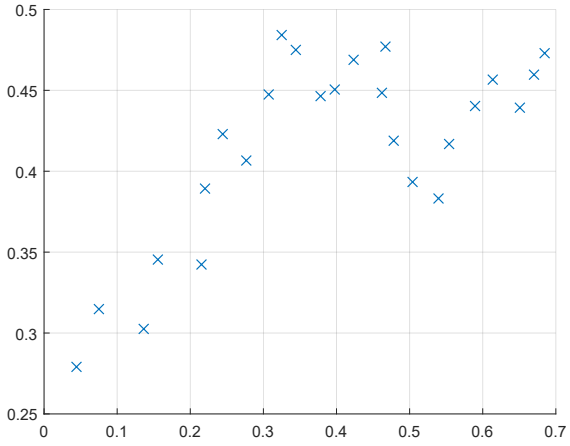
$$y(\mathbf{x}) = \sum_{i}^{N} \alpha_i \mathbf{x}_i^T \mathbf{x},$$

with $\boldsymbol{\alpha} = (XX^T + \lambda I)^{-1}\mathbf{t}$, $X = [\mathbf{x}_1, \ldots, \mathbf{x}_N]^T$ and λ the regularization weight.

1. Explain how a kernelized regression model can be obtained based on the equations provided above.
2. Provide a definition of the Gram matrix for the kernelized regression model.

EXERCISE 5

Consider the learning problem of estimating the function $f : \Re \mapsto \Re$ with dataset $D = \{(x_i, y_i)\}$ plotted in the figure below:



1. Describe how to perform regression based on these data using a method of your choice. Specifically, provide a mathematical formulation of the model, highlighting the model parameters.
2. Considering the method you have chosen describe a way to reduce overfitting.
3. Draw a plausible plot of the learned model based on your choices.

EXERCISE 6

1. Provide the main steps of classification based on K-nearest neighbors (K-NN).
2. Draw an example for a 4-classes classification problem in 2D. Use symbols (*,x,+,-) for the four classes. Graphically show the application of the K-NN algorithm with $K = 3$ for the classification of 3 different query points.