Machine Learning – A – February 11, 2020

Time limit: **2 hours**.

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

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.

....

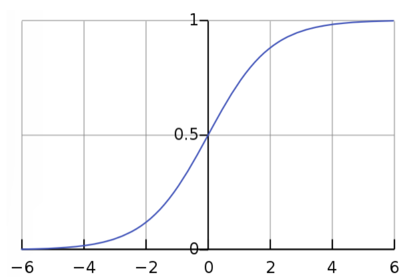
EXERCISE A1

1. Explain the difference between regression and classification.
2. Provide a mathematical formulation of linear regression.
3. Provide an example of a linear regression model that overfits a dataset of your choice, and discuss how this can be mitigated.

EXERCISE A2

1. Define mathematically the problem solved by logistic regression
2. Consider the following dataset and the sigmoid function:

x_1	x_2	x_3	t
0	0	1	1
1	2	3	1
4	4	1	0



Which one among the following solutions fits the data better? Why?

$$\vec{w}_1^T = (1, 0, -1) \qquad \vec{w}_2^T = (-1, -1, 2)$$

A plot of the sigmoid function is reported above. You do not need to compute explicit values of the model.

EXERCISE B1

1. Give a short explanation of the *kernel trick/kernel substitution*. What is the necessary condition for applying the kernel trick?

2. Provide an example of its application. In detail:

   - draw a suitable dataset for binary classification in 2D;
   - discuss which kernel you would use for this dataset;
   - show graphically a possible solution of such a kernel-based model.

EXERCISE B2

Consider the structure of a recurrent neural network (RNN):

1. Design a generic RNN model (or give the relative formula).

2. Explain the concept of 'unfolding' (or 'unrolling') an RNN.

3. For what type of input would you use an RNN? Describe a specific use case of your choice providing details both for the input and output of the RNN.

EXERCISE C1

1. Describe the difference between supervised learning and reinforcement learning with a formal definition of the two problems.

2. Describe the full observability property of Markov Decision Processes and its relation with non-deterministic outcomes of actions.

EXERCISE C2

1. Describe the K-means algorithm in a formal way (i.e., with precise mathematical formulas and equations), including: input and output of the algorithm, its main steps, and the termination condition.

2. Draw a suitable 2-D data set for K-means.

3. Simulate the execution of K-means in such 2-D data, showing at least three steps of the algorithm and the final output.