Laurea Magistrale
Atmospheric Science and Technology (LMAST)

SUBJECT TITLE	**Machine Learning**
TEACHER NAME(S)	Elio Di Claudio
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Teacher meeting	As per appointment by mail or telephone
Teacher office address	DIET Department, 1st floor, room no. 112
DISCIPLINE (SSD)	ING-IND/31 (Elettrotecnica - Electrical Engineering)
Semester (1-4)	2
Credits (CFU/ECTS)	6
Lecture hours (h)	60
Prerequisite and learning activity	Fundamentals of Algebra, Computer Science and Probability Theory
Teaching language and method	English, room lectures and laboratory training
Assessment method	Homeworks and oral exams
SUBJECT WEBSITE	http://eliodiclaudio.site.uniroma1.it;

OBJECTIVES

The course will provide fundamentals about theoretical, technical and practical issues in the design and implementation of machine learning systems (classification, clustering, function approximation and prediction problems) based on Computational Intelligence techniques (neural networks, fuzzy logic, evolutionary algorithms), focusing the attention on data and big data analytics that are relevant to atmospheric science and technology applications.

OUTCOMES (Dublin descriptors: knowledge, understanding, explain, skill, ability)

Analysis and solution capabilities relevant to the problems of design, implementation and operation of machine learning systems, with particular regard to the analysis of data driven modelling problems and the available data; to the selection of suited pre-processing procedures; to the design and implementation of an appropriate modelling system for a given application; to measure the system performances.

PROGRAM CONTENT

INTRODUCTION TO MACHINE LEARNING. Data driven modelling. Soft Computing, Computational Intelligence. Basic data driven modelling problems: pattern recognition, clustering, classification, unsupervised modelling, function approximation, prediction.

OPTIMIZATION PROBLEMS. Optimization problem building; Optimality conditions. Linear interpolation and regression. Least Squares algorithms. Orthogonal data transforms. Principal Component Analysis. Numerical optimization algorithms: steepest descent and Newton's method.

ESTIMATION. Non parametric estimation techniques. Parametric estimators: Maximum likelihood, Maximum A Posteriori, Bayesian estimation techniques. Complexity and generalization capability (Occam razor, AIC, MDL, BIC).

FUZZY LOGIC. Fuzzy inference principle. Fuzzy Rules.

CLUSTERING ALGORITHMS. K-means, Gaussian mixtures. Clustering performance indexes. Hierarchical clustering. Agent based cluster mining.

CLASSIFICATION SYSTEMS. Decision surfaces and discriminant functions. Performance and sensitivity measures. Bayesian classifiers. Classification models based on cluster analysis. Decision trees.

DISTRIBUTED LEARNING FOR COMPUTATIONAL INTELLIGENCE APPLICATIONS. neural networks, fuzzy logic, evolutionary algorithms; middleware services and agents; grid computing and cloud computing.

DEEP LEARNING COMPUTING. Architectures and applications.

LABORATORY. Case studies on multispectral data fusion and image processing, object detection, distributed sensor networks, time series prediction, chaotic systems, Big Data Analytics and atmospheric science and technology applications.

REFERENCES AND MATERIAL

- R. Kruse, C. Borgelt, F. Klawonn, C. Moewes, M. Steinbrecher, P. Held, Computational Intelligence: a Methodological Introduction, Springer, 2013.
- B. Kosko, Neural Networks and Fuzzy Systems, Prentice-Hall.
- C.M. Bishop, Neural Network for Pattern Recognition, Oxford University Press.
- L. Deng, Deep Learning: Methods and Applications, Microsoft Research.
- Provided lecture notes and learning materials.