UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

DOTTORATO DI RICERCA / PHD PROGRAM IN
INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING

Ad hoc course announcement

Title: **Machine Learning for Science and Engineering Research**

Lecturer: **Proff. Anna Corazza, Francesco Isgrò, Roberto Prevete, Carlo Sansone**

DIETI

Dott. Giovanni Pezzulo

CNR – giovanni.pezzulo@istc.cnr.it

Credits: 5 credits

Overview

The course introduces the main topics in machine learning for both supervised and unsupervised approaches. In addition to a general introduction to the field, we discuss a few topics that are widely considered very effective and promising. In particular, the concept of explainable AI will be discussed, with special attention to the case of neural networks.

Lessons will be held in blended modality: the room is given in the following table, while the Teams team is at the link .

There will be a final assessment.

Schedule

Lecture	Date	Time	Room	Lecturer
1	June 20, 2022	11:00 – 13:00	C2A	Anna Corazza
2	June 21, 2022	11:00 – 13:00	Softel	Anna Corazza
3	June 22, 2022	11:00 – 13:00	Softel	Roberto Prevete
4	June 23, 2022	**9:00 – 11:00**	Softel	Roberto Prevete
5	June 24, 2022	11:00 – 13:00	Softel	Giovanni Pezzulo
6	June 27, 2022	11:00 – 13:00	Softel	Anna Corazza
7	June 28, 2022	11:00 – 13:00	Softel	Francesco Isgrò
8	June 29, 2022	11:00 – 13:00	Softel	Anna Corazza
9	June 30, 2022	11:00 – 13:00	Softel	Carlo Sansone
10	July 1, 2022	11:00 – 13:00	Softel	Roberto Prevete

Content

Lecture I - Supervised machine learning: introduction to the course, definition of supervised machine learning with particular emphasis on classification, decision trees, example of classification approaches in the vector space model (Rocchio, kNN), statistical methods, Bayes classification rule and MLE, Naive Bayes classifiers. (Anna Corazza).

Lecture II - Support Vector Machines: performance assessment, overfitting and generalisation, linear versus non linear classifiers, hard margin support vector machines (SVM), soft margin support vector machines, kernels. (Anna Corazza)

Lecture III – From shallow networks to deep networks: Structure and behaviour of Multi-layer Feed-Forward Neural Networks. Shallow networks as universal approximators. Error Functions and Optimization methods based on gradient descent. Back-propagation algorithm to compute error gradient. Basic principles of Deep Learning. Unsupervised learning algorithms to pre-train multi-layered neural networks: Noised Stacked Auto-Encoders. (Roberto Prevete)

Lecture IV - Deep Learning: Deep Network without pretraining: Rectified Linear Units (ReLU) and its variants. Convolutional Neural Networks. Graph Convolutional Neural Networks. GANN (Generative Adversarial Neural Network). (Roberto Prevete)

Lecture V - Probabilistic inference in brains and machines (Giovanni Pezzulo)

Lecture VI - Unsupervised machine learning: introduction to clustering, flat clustering, K-means, clustering assessment, choice of the number of clusters. Hierarchical clustering: introduction, dendrograms, variants, discriminative cluster labelling, non discriminative cluster labelling. (Anna Corazza)

Lecture VII - Feature design: Introduction to the problem of dimensionality reduction; definition of the projection error; geometrical introduction to Principal Component Analysis and its statistical interpretation; introduction to the feature selection problem; the ada-boost algorithm; application to face detection. (Francesco Isgrò)

Lecture VIII - Selected topics in DL: Neural networks for sequences: Recurrent Neural Networks. Simple Recurrent Neural Networks (S-RNN). Problems with these simple models. Long Short Term Memory (LSTM) neural networks. Transformers. (Anna Corazza)

Lecture IX - Ensemble methods: Combining Multiple Models. Bagging. Randomization: Random Subspace Ensemble, Random Forest, Rotation Forest. Boosting, Additive Regression. Stacking. Error Correcting Output Codes. (Carlo Sansone).

Lecture X - XAI Basic concepts and definitions about interpretation and explanation of autonomous (or semi-autonomous) systems based on machine learning. Overview of explanation and interpretability methods for machine learning algorithms. LIME and Layer-wise Relevance Propagation (Roberto Prevete)

For information: **Prof. Anna Corazza - anna.corazza@unina.it**