



UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

PHD PROGRAM IN INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING

PHD PROGRAM IN INFORMATION AND COMMUNICATION TECHNOLOGY FOR HEALTH

PhD Course announcement

Title: Machine Learning for Science and Engineering Research

Lecturers: Proff. Anna Corazza, Roberto Prevete, Carlo Sansone

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Prof. Antonio Lieto

University: of Salerno

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Credits: 5

Short bio notes:

Anna Corazza is associate professor of Computer Science at the Dipartimento di Ingegneria Elettrica e Tecnologie dell'Informazione (DIETI) of the University of Naples Federico II. Since 1989 to 2000 she worked at the ITC-irst (today FBK) in Trento, in the Speech Processing group. Since 2000 to 2003 she has been an assistant professor at the University of Milan, Polo Didattico e di Ricerca di Crema, in the Information Technology Department. In 1993 she visited for four months the Speech Laboratory of McGill University, in Montreal, Canada, directed by Prof. Renato De Mori. In 1994 she visited for six months the Center of Language and Speech Processing, at the Johns Hopkins University, Baltimore, MD, USA, directed by prof. F. Jelinek. Her main research interests are in natural language processing and information retrieval, machine learning, privacy-preserving data mining, machine learning applications in software engineering.

Antonio Lieto is Associate Professor in Computer Science at University of Salerno (Italy) and a researcher at the ICAR-CNR in Palermo (Italy). His research interests are at the intersection of AI, Cognitive Science and Human-Machine Interaction and his main research topics include commonsense reasoning, language and knowledge technologies, cognitive architectures for intelligent interactive agents (embodied and not). He is currently a member of the Scientific Board of the Italian Association for Artificial Intelligence (AI*IA) and has been Vice-President of the Italian Association of Cognitive Sciences (AISC, 2017-2022). He has authored the book "Cognitive Design for Artificial Minds" (Routledge/Taylor & Francis, 2021) and over 100 peer-reviewed scientific publications.

Roberto Prevete (1994: MSc in Physics, 2000: PhD in Mathematics and Computer Science at University of Naples Federico II) is an Assistant Professor of Computer Science at the Dept. of Electrical Engineering and Information Technologies (DIETI), University of Naples Federico II, Italy. His main research interests concern computational models of brain mechanisms, theoretical aspects of



machine learning, artificial neural networks, deep learning and their applications. His research has been published in international journals such as Neurocomputing, Neural Networks, Pattern Recognition Letters, Pattern Recognition, Knowledge-Based Systems, Scientific Reports, Biological Cybernetics, Experimental Brain Research, and Behavioral and Brain Sciences.

Carlo Sansone is currently Full Professor of Computer Engineering at the Dipartimento di Ingegneria Elettrica e Tecnologie dell'Informazione of the University of Naples Federico II, where he coordinates the Master in Human-Centered Artificial Intelligence. His research interests cover the areas of image analysis and recognition, machine learning and deep learning. From an applicative point of view, his main contributions were in the fields of biomedical image analysis, biometrics, intrusion detection in computer networks and image forensics. He coordinated several projects in the areas of biomedical images interpretation, network intrusion detection and cyberbullying detection by using artificial intelligence techniques.

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.

There will be a final assessment.

Schedule

Lecture	Date	Time	Class	Topics	Lecturer
1	8/7/2024	11-13	T5	Intro. Supervised ML	Corazza
2	9/7/2024	11-13	T5	Unsupervised ML	Corazza
3	10/7/2024	11-13	T5	Features design	Corazza
4	11/7/2024	11-13	I4	SVM	Corazza
5	12/7/2024	11-13	T5	From shallow to deep networks	Prevete
6	15/7/2024	11:13	I4	Deep Learning	Prevete
7	16/7/2024	11-13	II2	XAI	Prevete
8	17/7/2024	11-13	T5	Selected topics in DL	Corazza
9	18/7/2024	11-13	II1	Ensemble Methods	Sansone
10	19/7/2024	11-13	T5	Invited talk.	Lieto
Assessment test					

Content details

Lesson 1 – Introduction to the course. Supervised machine learning: 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).

Lesson 2 – 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)

Lesson 3 – Feature design: Introduction to the problem of dimensionality reduction; geometrical introduction to Principal Component Analysis and its statistical interpretation; introduction to the feature selection problem. (Anna Corazza)



Lesson 4 – 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)

Lesson 5 – 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)

Lesson 6 – 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)

Lesson 7 – 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)

Lesson 8 – 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)

Lesson 9 – 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 10 – Invited talk by Prof. Antonio Lieto. The enormous success of modern AI systems (e.g., in computer vision, natural language processing etc.) has led to the formulation of the hypothesis that such systems—since are able to obtain human or superhuman level performances in a number of tasks—actually have acquired the underlying competence that we humans possess in order to exhibit the same kind of behavior. This hypothesis, I argue, is however based exclusively on a behavioristic analysis of (some of) the output produced by them. And, as such, it is methodologically problematic. In this talk I will show how by using a tool known as Minimal Cognitive Grid (MCD) it is possible to avoid this behavioristic trap and, in addition, to compare and rank, in a non-subjective way, different types of artificial systems based on their biological or cognitive plausibility.

By July 4th, 2024, participants are requested to join the following MS Teams group:

[Machine Learning for Science and Engineering Research | General | Microsoft Teams](#)

Once accepted in the Teams group, students **must fill the following .xlsx file** with their information:

https://communitystudentiunina-my.sharepoint.com/:x:/r/personal/anna_corazza_unina_it/_layouts/15/Doc2.aspx?action=editNew&sourcedoc=%7B0a23b1f1-cc62-4149-a869-d1a55d01306f%7D&wdOrigin=TEAMS-WEB.teamsSdk_ns.rwc&wdExp=TEAMS-TREATMENT&wdhostclicktime=1718202351966&web=1

The course is in presence. However, students pursuing their PhD period abroad (for research purposes) have the option to request remote attendance for classes via MS Teams.

For information: Prof. Anna Corazza (DIETI, UniNA) – anna.corazza@unina.it (organizer)