Module Announcement

PhD inInformation Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

Module Title: Data Science and Optimization

Lecturers:

Prof. Manlio Gaudioso

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Dip. di Ingegneria Informatica, Modellistica, Elettronica e Sistemistica

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Dates and Locations (room is located in ed. 2, via Claudio 21, Napoli)

Lessons	Date	Hours	Room
I	5th February, 2019	10.00-11.00	Room I6 - I floor
II	5th February, 2019	11:30-12:30	Room I6 - I floor
III	6th February, 2019	10:00-11:00	Room I6 - I floor
IV	6th February, 2019	11:30-12:30	Room I6 - I floor
V	7th February, 2019	10:00-11:00	Room I6 - I floor
VI	7th February, 2019	11:30-12:30	Room I6 - I floor

ECTScredits: 1.2

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Content

I Lesson - Mathematics for Machine Learning: Some basic issues related to learning from data are listed. The focus is on learning as a decision making process. Distinction between unsupervised, supervised and semi-supervised models is then provided. The core of the seminar is classification, which, from a mathematical point of view, is about separating sets in the Euclidean space associated to object attributes (features). Geometric separation conditions are highlighted.

II Lesson - Optimization and Classification: We introduce linear classifiers based on the objective of minimizing a measure of the classification error. The concept of classification margin, which leads to the definition of the Support Vector Machine (SVM) paradigm, is analysed. The idea of kernel transformation is briefly discussed and the relevance of Feature Selection methods is pointed out. Some elements on the use of nonlinear separation surfaces, together with the corresponding nonlinear optimization problems, are provided. Finally, the problem of classifying bags of objects instead of single ones is formulated as a mixed integer nonlinear programming model.

III lesson - Optimization in Deep Learning: Mathematical optimization plays a pillar role in Machine Learning (ML). Indeed, learning from available data means that parameters of a chosen system must be computed by solving to optimality a learning problem. We focus on methods for Deep Networks (DN) in a regression setting. We first recall the learning optimization paradigm for DN and we briefly discuss schemes for the joint choice of the network topologies and of the network parameters. The main part of the talk focuses on the core subproblem which is the continuous unconstrained (regularized) weights optimization problem with the aim of reviewing theoretical and practical aspects of widely used online gradient methods.

IV Lesson - Machine Learning in Optimization & Applications: Machine Learning can be used as a tool in Optimization in different ways. The simplest use consists in using ML models within Black Box optimization to construct surrogate models that speed up the optimization process. This is particularly well suited for hard engineering nonlinear models which are available only by measured or simulated samples. A even more interesting role can be the use of ML for developing new optimization algorithms. Some cases will be presented.

V Lesson - Optimization Problems in Cluster Analysis: Clustering can be considered the most important unsupervised learning problem aimed at finding a structure in a collection of unlabeled data. Loosely speaking clustering is “the process of organizing objects into groups whose members are similar within a group and dissimilar to the members in other groups”. But how to decide what constitutes a good clustering? There are a number of different methods that can be used to carry out a cluster analysis and the choice among them is driven by the final aim of the clustering and by the type of available data. The objective of this talk is to give a comprehensive and systematic description of the data clustering process, starting from data representation to the cluster validation, with an emphasis on the basic optimization problems involved.

VI Lesson - Constrained Clustering and Applications: Existing models for cluster analysis are typically aimed at finding one single latent variable that represents the clusters by looking for one way to cluster data that is jointly defined by all the attributes. However, for complex data with many attributes, it is reasonable to consider multidimensional clustering, i.e., to partition data along multiple dimensions. In this talk we outline a constrained clustering approach aimed at solving clustering problems in which data can be partitioned in two dimensions. Some applications in life sciences and social networks will be discussed.

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Notes

Researchers and students interested in attending the module are requested to send an email to the organizer, Claudio Sterle, specifying their names and, in case, name of the PhD course and cycle.

Info:**Claudio Sterle-** tel. 081 7685911 – claudio.sterle@unina.it

Lecturers biosketch:

Short C.V.: ManlioGaudioso received his “Laurea” degree in Electrical Engineering from the Università di Napoli in 1973. Since 1995 he is Professor of Operations Research at Universitàdella Calabria. His research interests include numerical methods for nonsmooth optimization, optimization models for logistic chain management and applications of nonlinear optimization in machine learning. He is Associate Editor of the journals “Optimization” and “Vestnik of Saint-Petersburg University”. He has served in the Administrative Board of Universitàdella Calabria.

Short C.V.: Laura Palagi graduated in Electronic Engineering summa cum laude at Sapienza University of Rome in 1990 and she received a PhD in "Operations Research'' from Sapienza University of Rome in 1995. Since 2005 she is Professor in Operations Research at Sapienza University of Rome (Department of Computer, Control, and Management Engineering « Antonio Ruberti »). Her research activity is focused on analysis and development of methods of solution for both integer and continuous nonlinear optimization arising both in engineering application and in machine learning.

Short C.V.: Enza Messina, graduated in Computer Science in 1990 and received a PhD in Computational Mathematics and Operations Research from the University of Milano in 1994. Since 1998 she is Professor in Operations Research at the University of Milano-Bicocca (Department of Informatics Systems and Communications), where she leads the research laboratory MIND (Models in Decision Making and Data Analysis). Her research activity is focused on the development of probabilistic models decision making under uncertainty and statistical relational models for data analysis.