UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Advanced Machine Learning

2526-2-F1801Q151

Aims

This machine learning advanced course is aimed especially for students who are already familiar with the basics of machine learning and wish to strengthen their knowledge and explore important advanced topics in order to posses in-depth and wide range capabilities at this so important field.
The course will cover some of the most important advanced topics in machine learning such deep learning and reinforcement learning, with their underlying theory but also a focus on modeling and practical implementation.
These advanced techniques will be applied to a number of applications, including: image recognition, natural language processing, recommendation systems.

Knowledge and Understanding
Students will acquire advanced knowledge in the field of machine learning, with a particular focus on deep learning and reinforcement learning. The theoretical foundations and mathematical models underlying these techniques will be explored in depth, together with an understanding of the main architectures and algorithms used in modern artificial intelligence applications.

Applying knowledge and understanding
Students will be able to model, implement, and optimize advanced machine learning systems using popular software frameworks. They will also be able to apply these models to different application areas, such as image recognition, natural language processing, and recommendation systems, with a focus on the quality and efficiency of the results.

Making judgments
Students will develop the critical skills necessary to evaluate the design and methodological choices adopted in advanced machine learning models, understanding their advantages and limitations in relation to application contexts. They will also be able to interpret the results obtained in light of the specific objectives and the constraints of the problem addressed.

Communication skills
Students will be able to present the solutions they have developed clearly and effectively, explaining their design

choices and illustrating the results through visualization tools, technical reports, and oral discussion, using language appropriate to the scientific and professional context.

Learning skills
The course will provide students with the theoretical and practical tools necessary to independently explore cutting-edge topics in the field of machine learning, allowing them to constantly update their skills in a rapidly evolving field.

Contents

Introduction to Deep Learning

Optimization techniques for training deep models

Convolutional Neural Networks

Unsupervised representation learning

Deep Learning for data sequences

Elements of explainable AI

Detailed program

Training Deep Networks:

- Objective functions
- Activation Functions
- Regularization
- Gradient-based optimization

Focus on Deep Networks:

- Autoencoders
- Convolutional Neural Networks
- Recurrent and Recursive Networks
- Transformers

Paradigmi di apprendimento:

- Supervised learning
- Reinforcement learning
- Unsupervised learning
- Self-supervised learning

Prerequisites

Basic Machine Learning techniques

Teaching form

The course includes a part of theoretical lessons that will be held in the classroom and a part of exercises that will be held in the laboratory and / or classroom and which will require the use of your PC (or the ones available at the University's computer labs). The two parts will be based both on delivery mode and interactive mode.
The practical implementation of case studies will require the basic knowledge of R and Python programming languages.

The course will be in English.

Textbook and teaching resource

Ian Goodfellow and Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016. http://www.deeplearningbook.org

Rasmussen, Gaussian Processes for Machine Learning, the MIT press 2006.

Francesco Archetti, Antonio Candelieri, Optimization and Data Science, SpringerBriefs, 2019

Further resource material will be made available on the e-learning platform.

Semester

First semester

Assessment method

There are two mutually exclusive exam modalities

1. Assignments [0-8 pt] + written test [0-10 pt] +Project/In Depth Study[0-15 pt]

- Along the course a number of assignments will be proposed to be resolved individually. Assignment **must be delivered on the established date**. No assignment will be considered after deadline.
- Two written tests, consisting closed questions or brief definitions, aimed at evaluating: Knowledge of Fundamental Concepts, Overall Understanding, Knowledge of specific models and methods about the course contents.
- A project/in depth study to be done in groups of 2/3 students. The project will be evaluated according to the following criteria:

- A structured report
- Oral presentation of the project/"In depth study" aimed also at evaluating argumentation ability

2. Written exam [0-15pt] + Project/In Depht Study [0-15pt]

- A written exam, consisting of both closed and open questions, aimed at evaluating: Knowledge of Fundamental Concepts, Overall Understanding, Knowledge of specific models and methods about the course contents.
- A project work/in depth study to be done in groups of 2/3 students. The project will be evaluated according to the following criteria:
- A structured report
- Oral presentation of the project/"In depth study" aimed also at evaluating argumentation ability

Office hours

by appointment

Sustainable Development Goals