UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Machine Learning M

2324-1-F8204B006

Aims

The student will learn the most effective Machine Learning techniques, understanding the theoretical foundations of each technique and acquiring the know-how to successfully apply them to solving practical problems. An overview of the most innovative solutions for the identification of the best Machine Learning algorithm and its optimal configuration, given a dataset (Automated Machine Learning - AutoML), will also be provided. The reference tool for the course will be R, but some equivalent solutions will also be presented in Python (for example scikit-learn) and Java (for example WEKA, KNIME).

Contents

Machine Learning basics: types of data, instances, features, tasks and scenarios, parameters and hyper-parameters, performance measures

Unsupervised learning techniques

Supervised learning techniques: classification and regression

Modeling non-linearity in data: kernel-based techniques

Automated Machine Learning: automatic configuration of a Machine Learning model

Detailed program

Introduction

- Machine Learning scenarios & tasks, useful notations
- Types of data and problems: tabular, streams, text, time-series, sequences, spatial, graph, web, social

Unsupervised Learning

- Similarity and distance
- Clustering
- Outlier detection

Supervised Learning

- Classification and regression, metrics, validation techniques (hold-out, k fold-cross, leave-one-out)
- Model-free/instance-based approaches, a simple algorithm: the k-nearest neighbors (KNN)
- Model-based approaches: Support Vector Machine (lineari)

Supervised Learning for non-linear data

- Non-linearity, VC dimensions, kernel-trick
- Decision Tree and Random Forest
- Kernel-based learning: kernel-SVM and Gaussian Processes, for classification and regression
- Dimensionlity reduction: Principal Component Analysis (PCA) and kernel-based PCA (kPCA)

The connectionist approach

- Artificial Neural Networks: learning paradigm
- Deep Learning: *"a fraction of the connectionist tribe"*

Automated Machine Learning (AutoML): an overview

Exercises and examples

Prerequisites

Basic knowledge on computer science, applied math, probability calculus and statistics

Teaching form

Teaching is achieved by classes: lectures will be video-recorded in order to make them digitally available. Lectures will abbress both theory and hands-on, specifically the adoption of open data and software libraries.

Textbook and teaching resource

- Reference textbook: Mehryar Mohri, Afshin Rostamizadeh and Ameet Talwalkar (2018). Foundations of Machine Learning.
- Slides and materials provided by the lecturer

Other suggested texts:

- Charu C. Aggarwal (2015). Data Mining – the Textbook
- Carl Edward Rasmussen and Christopher K. I., Williams (2006). Gaussian Processes for Machine Learning.
- Robert B. Gramacy (2020). Surrogates – Gaussian Processes Modeling, Design, and Optimization for the Applied Statistics.

Semester

Secondo semestre

Assessment method

Assessment is organized on two tests:

- the development of a project along with the preparation of an associated technical report, similar to a scientific paper,
- an oral examination (individual and mandatory) aimed at assessing the degree of understanding of the course's topics.

The project can be performed by working in *team* (max 3 students per group) and the datasets to adopt, in agreement with the lecturer, will be selected among those available on open platforms such as OpenML, Kaggle or UCI Repository.
The quality of the project will be assessed according to the correct adoption of ML algorithms and the analysis of the results. Oral examination is devoted to assess the understanding of theoretical and methodological aspects of ML.
The project amounts for 60% of the final mark, while the oral examination amounts for the remaining 40%.

There are no mid-term review(s)

Office hours

On appointment

Sustainable Development Goals

QUALITY EDUCATION