



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## SYLLABUS DEL CORSO

### Unsupervised Learning

2627-1-F9103Q045-F9103Q04502

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#### Aims

To develop skills for solving real world unsupervised learning problems.

The goal is achieved by;

- Teaching how to design, train, deploy and monitor unsupervised learning models. **(DdD 1, DdD 2)**
- Exploiting open source platforms, languages and software, **(DdD 1, DdD 2)**
- Stimulating team working. **(DdD 4)**
- Reading and discussing scientific papers made available by the teacher **(DdD 3, DdD 5)**

#### Contents

The course contents are the following;

- **Data Types**; to list different types of data and to learn how they must be used for unsupervised learning.
- **Data Preprocessing**; to preprocess data in such a way it can be used by unsupervised learning tasks,
- **Clustering Learning**; to form homogeneous groups of observations and/or attributes using a given proximity measure,
- **Clustering Validation**; to evaluate and compare different clustering solutions to select the one to deploy.
- **Anomaly Detection**; to find anomalous observations, to discover outliers observations, under different theoretical settings.
- **Bayesian Networks**; to learn probabilistic/causal structure from data and to make decisions under uncertainty.

You will learn how to design, train, validate and deploy unsupervised learning models using Python.

## Detailed program

### 1. Data

- 1.1 Data types and attributes
- 1.2 Proximity measures for nominal, ordinal and continuous attributes
- 1.3 Data Pre-Processing

### 2. Cluster Analysis

- 2.1 Introduction
- 2.2 Clustering algorithms
  - 2.2.1 *Partitioning*
  - 2.2.2 *Hierarchical*
  - 2.2.3 *Graph-based*
  - 2.2.4 *Density-based*
  - 2.2.5 *Time-series*
- 2.3 Comparing clustering solutions
  - 2.3.1 *Performance measures*
  - 2.3.2 *Evaluation*
  - 2.3.3 *Comparison*

### 3. Anomaly Detection

- 3.1 Introduction
- 3.2 Anomaly detection algorithms
  - 3.2.1 *Statistical approaches*
  - 3.2.2 *Proximity-based approaches*
  - 3.2.3 *Clustering-based approaches*
  - 3.2.4 *One-class classification*
  - 3.2.5 *Information theoretic approaches*

### 4. Bayesian Networks

- 4.1 Introduction
- 4.2 Bayesian network models
  - 4.2.1 *Discrete variables*
  - 4.2.2 *Continuous variables*
  - 4.2.3 *Mixed variables*
- 4.3 Learning
  - 4.3.1 *Parameters*
  - 4.3.2 *Structure*
- 4.4 Inference
  - 4.4.1 *Exact*
  - 4.4.2 *Approximate*

## Prerequisites

Basic knowledge on: probability theory, statistics, mathematics.  
Good skills to design and develop computer programs.

## Teaching form

The course is organized as follows:

- 16 lectures of 2 hours each of theory in physical presence of erogative nature
- 12 lectures of 2 hours each of hands-on in physical presence of interactive nature

## Textbook and teaching resource

- **Introduction to Data Mining** (<https://www-users.cse.umn.edu/~kumar001/dmbook/index.php>)
- **Bayesian Networks and Decision Graphs** (<https://link.springer.com/book/10.1007/978-0-387-68282-2>)

## Semester

Spring Semester

## Assessment method

The exam consists of:

- **Project work**; The student is asked to apply and/or develop one or more algorithms for analyzing a case study assigned by the teacher. **(Awards a maximum of 13 points)**.
- **Interview on project work**; An interview on those topics that have been presented in classes and connected to the project works **(Awards a maximum of 20 points)**.

**No interim assessments are scheduled.**

## Office hours

To be agreed on by mail message [fabio.stella@unimib.it](mailto:fabio.stella@unimib.it)

## Sustainable Development Goals

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