UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

# SYLLABUS DEL CORSO

# Geometry Processing and Machine Learning for Geometric Data

**2526-114R-2-01**

## Titolo

Geometry processing and machine learning for geometric data

## Docente(i)

Simone Melzi

## Lingua

Inglese

## Breve descrizione

**Course Organization:**
The course will consists of four days lessons with 4 or 6 hours in the morning (8.30 - 12.30 or 10.30 - 12.30) or in the afternoon (14.00 - 18.00).

**Course Overview:**
After an introduction to geometric data and related applications (respectively sections 1 and 2) the rest of the course will be divided in five sections (sections from 3 to 7) each of which consists of 2 hours of theory and 2 hours of lab in which an implementation of the main algorithms and results discussed in the related theory will be

rpovided and discussed witht he teachers. At the end of the course, each student will own a personal implementation/demo of at least one architecture or algorithm related to the topic of each section.

**Table of Contents:**

1. Introduction to 3D data, possible representations and geometric quantities (2h):
   1.1 point clouds
   1.2 meshes
   1.3 graphs
   1.4 volumetric
   1.5 implicit surfaces

2. Applications (2h):
   2.1 retrieval/classification
   2.2 segmentation
   2.3 matching
   2.4 look for appropriate representation/features

3. Spectral graph\geometry processing (2h+2h LAB):
   3.1 introduction to graph Laplacian
   3.2 LBO (cotangent weights)
   3.3 eigendecomposition
   3.4 spectral representation
   3.5 exploit spectral quantities

4. Point-based architecture (2h+2h LAB):
   4.1 missed connectivity, problems and desired properties
   4.2 permutation invariance and rigid-transformations invariance
   4.3 PointNet
   4.4 Pointnet++
   4.5 pointMLP

5. Convolution on 3D data (2h+2h LAB):
   5.1 introduction to convolution
   5.2 pooling, unpooling and properties
   5.3 extrinsic convolutions
   5.4 geometric data and missing fixed template
   5.5 spectral and alternative convolutions
   5.6 diffusion based convolutions

6. Other architectures on 3D data (2h+2h LAB):
   6.1 limitations of Points and Meshes and Explicit access to geometry
   6.2 implicit representations as possible solutions
   6.3 conversions: implicit vs explicit
   6.4 use cases and applications
   6.5 learning on grids
   6.6 neural fields

7. Graphs as geometric data and Graph Neural Networks (2h+2h LAB):
   7.1 introduction to graphs
   7.2 tasks on graph retrieval/classification, scene understanding, segmentation
   7.3 the problem of learning on graphs
   7.4 GNN as MLP on Graphs,
   7.5 convolution on a mesh is a convolution on a graph
   7.6 other graphs networks: Graph Attention Networks and Set transformers

**Final Evaluation**
Evaluation will be based on a simple project to realize in a dedicated day (like a brief hackathon)

- topic selected by the student in coordination with lecturer(s)
- may be theoretical, practical, or a combination
- may start from one of the demo presented in the labs

The evaluation based on the following criteria:

- quality: of the work, presentation, and report
- significance: of the topic chosen
- novelty: of the techniques and results

## CFU / Ore

2 / 20

## Periodo di erogazione

June-July

## Sustainable Development Goals

ISTRUZIONE DI QUALITÁ