UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Signal and Imaging Acquisition and Modelling in Environment

2526-1-F9103Q017

Aims

The goal of this class are:

1. Knowledge and understanding

To provide students with an in-depth understanding of signal and imaging acquisition and analysis techniques relevant to environmental applications, with a focus on advanced methodologies such as remote sensing, hyperspectral imaging, and satellite or telescope-based observation systems.

2. Applying knowledge and understanding

To enable students to apply signal and image processing techniques to high-resolution data acquired through complex remote sensing systems, and to extract meaningful features using state-of-the-art Machine Learning and Artificial Intelligence tools.

3. Making judgements

To develop students' ability to critically assess the quality and reliability of acquired environmental data, to select appropriate AI models and processing pipelines, and to interpret results in light of application-specific constraints and objectives.

4. Communication skills

To enhance students' capacity to effectively communicate complex signal and image analysis processes and results, through technical reports, visual presentations, and interdisciplinary collaboration, using appropriate terminology and data visualization tools.

5. Learning skills

To foster autonomous learning in the rapidly evolving fields of environmental sensing, imaging technologies, and AI-based data analysis, enabling students to keep pace with emerging tools, methodologies, and scientific literature.

Contents

Basic theory of signal and imaging detectors, statistics and signal to noise ratio optimization, identification of sources and signals in noisy data. Analysis of time series and imaging data with ML methods (e.g. random forest classifier/regressors, self organizing maps, deep learning methods) using Python. Forecasts and tests of ML predictions.

Detailed program

- Operation and characterization of imaging detectors (focusing on optical CCDs), description of the calibrations needed.
- Characterization and description of other detectors for remote sensing of the environment.
- Statistics of photon counting experiments, noise and background sources, techniques for the detection of signals above the noise.
- Data handling packages in Python language, brief description of data visualization methods and ML implementations.
- Hands-on projects will be proposed where the students will learn how to extract relevant data and images from multi-petabyte catalogs and how to analyze them.
- Acquire imaging data from Bicocca Telescope and use ML with the aim to identify and characterize sources in the sky and the effects of light pollution.

Prerequisites

Classes of the first semester

Teaching form

Lectures followed by hands-on sessions. The students will use their laptop in the classroom. Coding and analysis platforms will be accessible through the GMail account of the Bicocca campus (Google Colab).
All activities will be in English.

Textbook and teaching resource

Relevant material will be provided via handouts.

Semester

Second semester.

Assessment method

Written individual scientific report on the activities performed in the lab and oral exam on the topics presented in the lab and discussed during the lessons.

Office hours

By appointment (via email).

Sustainable Development Goals