UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Physical Sensors and Systems for Environmental Signals

2526-2-F9102Q042

Aims

The course objective is to teach students the basics of instruments and signal processing techniques with application on Earth Observation and Environmental monitoring. The course aims to enable the students to understand: (i) the nature of remote/proximal sensing signal and how they are acquired; (ii) different types of instruments and measurement techniques (iii) basic signal representation and processing (iv) how to retrieve information from remote/proximal sensing data. Emerging AI based approaches are discussed together with state-of-art semi-empirical and physical-based model inversion methods.

Knowledge and Understanding

- The student will acquire a solid understanding of the physical principles behind remote and proximal sensing systems, including multispectral/hyperspectral sensors, seismic and acoustic instruments.
- The student will understand signal processing techniques and their application to environmental monitoring and Earth observation.

Applying Knowledge and Understanding

- The student will be able to apply signal processing methods to real-world environmental data.
- The student will develop and implement practical projects involving sensor data analysis, including the use of AI-based approaches and model inversion techniques.

Making Judgements

- The student will be able to critically evaluate the suitability of different sensing technologies and processing methods for specific environmental applications.
- The student will assess the quality and reliability of sensor data and derived geophysical variables.

Communication Skills

- The student will be able to clearly present and discuss technical concepts and project results, both orally and in written form.
- The student will demonstrate the ability to communicate effectively with both specialists and non-specialists in the field of environmental monitoring.

Learning Skills

- The student will develop autonomous learning skills through the analysis of scientific literature, practical project development, and the use of advanced tools and software.
- The student will be prepared for further studies or professional work in the field of environmental sensing and signal processing.

Contents

The course covers fundamental concepts about the acquisition, interpretation, and processing methods of different type of signals ranging from multispectral and hyperspectral spectroradiometer, to seismic, acoustic, and other electromagnetic data. The course also includes applied remote sensing topics aimed to characterize Earth surfaces and Environmental variables and processes.

Detailed program

REMOTE SENSING FUNDAMENTALS
? Physical principles for Earth Remote Sensing
? Remote sensing systems and resolutions
? Multispectral/Hyperspectral spectroradiometers
? Multi-scale sensing (satellite, drone, ground-based)

SIGNAL PROCESSING METHODS FOR EARTH REMOTE SENSING
? Spectral signature of Earth surfaces in the optical domain
? Radiometric/spectral/atmospheric processing
? Examples of Radiative Transfer model simulations
? Spectral indices and spectral transformations
? Retrieval of Earth surface geophysical variables
? Time-series analysis

SIGNAL PROCESSING METHODS FOR PROXIMAL SENSING OF ENVIRONMENT
? Sensors for Environmental monitoring
? Pressure and thermal sensors
? Vibration and electromagnetic sensors: seismometers, accelerometers, microphones, antennas
? Acoustic and seismic digital signal processing: time and frequency domain
? Analysis of the sensors data and correlation with geophysical variables
? Noise decorrelation utilizing multiple sensors
? Application of AI for the data analysis and perspectives

Prerequisites

Basic knowledge on physics, computer programming, mathematical and statistical analysis, usually acquired from Bachelor-level courses.

Teaching form

The course is structured in classroom lectures and a computing laboratory. Although not strictly required, attendance to the lectures and practical sessions is strongly recommended. Lectures will be generally held in presence, unless further COVID-19 related restrictions are imposed.

Textbook and teaching resource

? Shunlin Liang, Xiaowen Li and Jindi Wang (2012) Advanced Remote Sensing: Terrestrial Information Extraction and Applications. [S.l.]: Academic Press.
? Slides, scientific manuscripts and handouts are available on the course website.

Semester

First

Assessment method

Practical and oral exam. The student develops a practical project based on the course topics on an environmental application. The oral examination consists in a discussion of the project and an assessment of the theoretical foundations knowledge.

Office hours

Via appointment by email.

Sustainable Development Goals

CLIMATE ACTION | LIFE ON LAND