UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Physical Sensors and Systems for Environmental Imaging

2627-2-F9103Q021

Aims

The course aims to provide fundamentals of Remote Sensing techniques and applications for Earth Observation in the optical domain. The objective of the course is to teach students the basics of remote sensing using instruments on satellite, airborne, drone and ground-based set-ups. State-of-the-art semi-empirical regression and physical-based model inversion are discussed together with novel AI based approaches.

1. Knowledge and understanding.
The student will acquire a solid understanding of:
-the physical principles underlying Earth remote sensing,
-characteristics and types of remote sensing systems, spatial/spectral resolutions, and data acquisition platforms (satellites, aircraft, drones),
-major space programs (e.g., Copernicus) and their data products,
-representation and interpretation of multispectral and hyperspectral imagery,
-pre-processing techniques (radiometric, spectral, geometric corrections; atmospheric correction),
-the fundamentals of digital image enhancement, statistical analysis, and AI-based processing methods,
-applications of spectral indices and bio-geophysical parameter extraction,
-creation of thematic maps and geospatial data visualization across scales.

2. Applying knowledge and understanding.
Upon completion of the course, students will be able to:
-handle and pre-process remote sensing data from multiple sources (satellite, aerial, drone),
-apply correction techniques to improve image quality and comparability,
-use image classification algorithms (including AI-based methods) for tasks such as land use and vegetation mapping,
-compute and interpret spectral indices for environmental monitoring,
-retrieve bio-geophysical parameters and assess their spatial variability,
-generate thematic maps for practical applications in agriculture, forestry, inland water monitoring, and geology,
-work with multi-scale geospatial data and integrate them into environmental decision-making.

3. Making judgements.
Students will develop the ability to:
-critically evaluate the suitability of different remote sensing techniques and processing methods for specific environmental applications,
-assess the quality and limitations of remote sensing data,
-select appropriate processing workflows for extracting meaningful information depending on the spatial and spectral characteristics of the data,
-judge the reliability and significance of thematic products derived from remote sensing imagery.

4. Communication skills.
Students will be able to:
-clearly communicate remote sensing concepts, methods, and results using appropriate scientific and technical terminology,
-present geospatial data and thematic maps in a clear and interpretable format,
-prepare concise reports and visual materials for both technical and non-technical audiences.

5. Learning skills.
Students will develop:
-the ability to independently learn new tools and techniques in remote sensing and AI-based image processing,
-skills to consult scientific literature and technical documentation related to environmental Earth observation,
-readiness to engage in advanced studies or professional roles in geospatial analysis, environmental science, or data-driven decision support.

Contents

The course includes lectures about the fundamental concepts of Remote Sensing techniques applied to Earth Observation and Environmental monitoring. The processing and interpretation of imaging data to quantitatively study the Environment. The course includes applied remote sensing topics aimed at characterizing major Earth surfaces characteristics and processes (e.g., vegetation, snow, water, atmosphere).

Detailed program

REMOTE SENSING FUNDAMENTALS
• Physical principles for Earth Remote Sensing
• Remote sensing systems and resolutions
• Space missions and the Copernicus program
• Multispectral/Hyperspectral image representation and interpretation
• Multi-scale remote sensing (satellite, airborne, drone spectral imaging)

IMAGE PRE-PROCESSING
• Radiometric/spectral/geometric processing
• Atmospheric correction methods

STATE-OF-THE-ART AND AI-BASED IMAGE PROCESSING METHODS
• Digital imaging enhancement and statistical analysis
• Image classification (land use classification)
• Spectral indices
• Bio-geophysical parameters retrieval
• Thematic maps of environmental parameters

MULTI-SCALE GEOSPATIAL MAPPING APPLICATIONS
• Agriculture
• Forestry
• Inland water
• Geology

Prerequisites

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

Teaching form

Frontal Lectures in English with slides in power point (Instructional teaching, 4CFU)
Computing Laboratory (Interactive teaching, 2 CFU)
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.
• Thomas M Lillesand, Ralph W Kiefer, Jonathan W Chipman (2015) Remote sensing and image interpretation, , 7th Edition, Wiley
• An Introduction to Statistical Learning. Robert Tibshirani
• Hands-On Machine Learning with Scikit-Learn, Keras, and Tensorflow: Concepts, Tools, and Techniques to Build Intelligent Systems. O'Reilly
• Slides, scientific manuscripts and handouts are available on the course website

Semester

First

Assessment method

ORAL EXAM AND PROJECT WORK
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.

There are no partial tests. The final grade on a 30-point scale will be equally determined by:

-the evaluation of the discussion of the project
-the evaluation of the knowledge of the different topics covered during the frontal lessons
Additionally, the following will be assessed:
-the use of appropriate technical terminology
-the ability to present concepts in a clear, logical, and coherent manner
-the command of scientific language

Office hours

Via appointment by email.

Sustainable Development Goals

QUALITY EDUCATION | GENDER EQUALITY | DECENT WORK AND ECONOMIC GROWTH | INDUSTRY, INNOVATION AND INFRASTRUCTURE