UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Intelligent Sensing and Remote Sensing

2627-1-F9103Q029-F9103Q02901

Aims

This module provides students with solid foundations in Remote Sensing for Earth Observation, focusing on data understanding, processing, and application to real-world problems. Students will learn how to effectively use different types of remote sensing data to monitor Earth surface phenomena. The course places special emphasis on advanced data processing techniques, the integration of Artificial Intelligence (AI) and Machine Learning (ML) approaches, and practical skills with cloud-based platforms such as Google Earth Engine for large-scale geospatial analysis.

Contents

This course offers an introductory but comprehensive overview of Earth Observation via Remote Sensing, enriched with modern data analysis techniques and AI-based information extraction. Special focus is given to optical data, but the integration of other modalities (e.g., radar) is also discussed. Hands-on exercises play a major role, enabling students to work directly on Earth Observation data using state-of-the-art cloud platforms and tools for data fusion, classification, and monitoring.

Detailed program

1. Basic Concepts

- Remote sensing fundamentals and physical principles
- Sensors and platforms: classification, orbits, spatial/spectral/temporal resolution
- Overview of major Earth Observation programs (NASA, ESA, Copernicus)

2. Sensors

- Types of sensors: optical, thermal, radar, hyperspectral
- Sensor networks: integration of spaceborne, airborne, and ground-based systems
- Sensor characteristics and trade-offs

3. Data Pre-processing and Management

- Structure and formats of remotely sensed data
- Radiometric and geometric corrections
- Enhancement techniques
- Dimensionality reduction (PCA, ICA)
- Data fusion: multisensor, multiresolution, multitemporal
- Change Detection and time series analysis

4. Analysis and Information Extraction

- Statistical, spatial, and spectral analysis
- Pixel-based vs. object-based analysis (OBIA)
- Supervised and unsupervised classification
- Feature extraction and semantic labeling
- Accuracy assessment and validation

5. Artificial Intelligence and Machine Learning in Remote Sensing

- ML concepts applied to Earth Observation
- Classification models: Random Forest, SVM, k-NN
- Deep Learning: Convolutional Neural Networks (CNN), U-Net for segmentation
- Unsupervised and semi-supervised learning
- Transfer learning and domain adaptation
- Integration of AI into operational pipelines for environmental monitoring

6. Applications

- Real-world use cases: agriculture, land use, urban monitoring, water and disaster management
- Copernicus program and Sentinel missions
- Big Data from Space: Earth Observation as a service

7. Practical Training and Cloud Platforms

- Google Earth Engine: hands-on labs for large-scale geospatial analysis
- Accessing and processing Sentinel/Landsat data in the cloud
- Cloud infrastructures and APIs (e.g., Amazon Web Services, Copernicus DIAS)
- Python and JavaScript scripting for automated data workflows
- Practical projects: end-to-end pipelines using AI and cloud resources

Prerequisites

Students should have a basic understanding of physics, chemistry, linear algebra, and mathematical analysis (as typically acquired during a Bachelor’s degree). Basic programming skills (preferably in Python) are recommended but not mandatory.

Teaching form

The course includes in-person lectures and seminars, integrated with practical labs and hands-on projects. A significant portion is dedicated to guided exercises using Google Earth Engine and other cloud platforms. Students will develop skills to process and interpret satellite data in real-world contexts. Active participation is strongly encouraged.

Course slides will be made available through the institutional channels.

Textbook and teaching resource

Core Textbooks

- Richards, J. A., & Jia, X. (2020). Remote Sensing Digital Image Analysis: An Introduction. Springer.
- Lillesand, T., Kiefer, R. W., & Chipman, J. (2015). Remote Sensing and Image Interpretation. Wiley.
- Jensen, J. R. (2015). Introductory Digital Image Processing: A Remote Sensing Perspective. Pearson.

AI and Machine Learning in Remote Sensing

- Gustau Camps-Valls, Devis Tuia, Xiao Xiang Zhu, Markus Reichstein (2021). Deep Learning for the Earth Sciences: A Comprehensive Approach to Remote Sensing, Climate Science, and Geosciences. Wiley. Especially part I and part II
- Ball, J. E., Anderson, D. T., & Chan, C. S. (2017). A Comprehensive Survey of Deep Learning in Remote Sensing. IEEE Geoscience and Remote Sensing Magazine.
- Zhang, L., Zhang, L., & Du, B. (2016). Deep Learning for Remote Sensing Data: A Technical Tutorial. IEEE GRSM.G. Cheng, X. Xie, J. Han, L. Guo and G. -S. Xia, "Remote Sensing Image Scene Classification Meets Deep Learning: Challenges, Methods, Benchmarks, and Opportunities" in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 13, pp. 3735-3756, 2020, doi: 10.1109/JSTARS.2020.3005403.
- Qiangqiang Yuan, Huanfeng Shen, Tongwen Li, Zhiwei Li, Shuwen Li, Yun Jiang, Hongzhang Xu, Weiwei Tan, Qianqian Yang, Jiwen Wang, Jianhao Gao, Liangpei Zhang, “Deep learning in environmental remote sensing: Achievements and challenges”, Rem. Sens. of Envir. Vol. 241, 2020, 111716, ISSN 0034-4257, https://doi.org/10.1016/j.rse.2020.111716.

Online Resources

- Google Earth Engine https://earthengine.google.com/
- ESA Copernicus Open Access Hub
- Radiant Earth Foundation https://radiant.earth/
- Copernicus DIAS platforms

Semester

Second Semester

Assessment method

The exam consists of an oral discussion on at least three different topics in the course, aimed at assessing the candidate's level of knowledge and understanding of the subject. The mark is expressed with a number between 18 (barely sufficient) and 30 with honours (excellent).

Office hours

9-18 by appointment, at the University of Pavia

Sustainable Development Goals

CLIMATE ACTION