

Course guide

230333 - MLSI - Machine Learning for Satellite Imagery

Last modified: 24/05/2024

Unit in charge:	Barcelona School of Telecommunications Engineering	
Teaching unit:	739 - TSC - Department of Signal Theory and Communications.	
Degree:	BACHELOR'S DEGREE IN TELECOMMUNICATIONS TECHNOLOGIES AND SERVICES ENGINEERING (Syllabus 2015). (Optional subject). BACHELOR'S DEGREE IN DATA SCIENCE AND ENGINEERING (Syllabus 2017). (Optional subject).	
Academic year: 2024	ECTS Credits: 2.0	Languages: English

LECTURER

Coordinating lecturer:	CARLOS LOPEZ MARTINEZ
Others:	Segon quadrimestre: ADRIANO JOSE CAMPS CARMONA - 11 CARLOS LOPEZ MARTINEZ - 11 MERCEDES MAGDALENA VALL-LLOSSERA FERRAN - 11

PRIOR SKILLS

- Basics of electromagnetism
- Basics of signal/data processing and/or image processing

TEACHING METHODOLOGY

- Master classes and/or talks by the teacher
- Practices in a laboratory
- Project-based learning
- Cooperative learning

LEARNING OBJECTIVES OF THE SUBJECT

Satellite imagery and remote sensing for Earth observation are used to acquire information about the Earth's surface and to analyze its physical characteristics. These technologies allow facing global risks affecting our society: climate change, extreme weather, biodiversity loss, human environmental damage or natural resources crisis [1]. Nevertheless, processing of satellite imagery is also emerging as an important technique in sectors like precision agriculture, hydrology, infrastructures management, maritime security and insurances or health, all together with a market size valued at USD 12.40 billion in 2019 and with an expectation to grow at a compound annual growth rate (CAGR) of 11.6% from 2020 to 2027 [2].

We are in the era of Big Earth Data or Remote Sensing 2.0, where the target is moving from the upstream segment focused on the launching services and the manufacturing of satellites to the mid-and downstream segments focused on data management infrastructures and data processing and exploitation. The Sentinel Data Access System of the European Union's Earth observation programme Copernicus [3] supports a daily publication rate of over 38,700 products/day, and an average daily download volume of 405 TB. A total of 405 million products had been uploaded since the start of data access operations, consisting of a total data volume of 240 PB, 82.8 PB only during 2020 [4]. The analysis and exploitation of this vast and varied data are facing new challenges and opportunities that require the use of Machine Learning tools for Big Data processing are emerging.

Motivated by these emerging needs in the private and public sectors, this seminar is designed for those who would like to improve their knowledge in the field of Machine Learning focusing on satellite imagery from a technical perspective and with a focus on the development and humanitarian practice, as exemplified UN's Sustainable Development Goals (SDG) [5]. Skills in Machine Learning are already ubiquitous for the 21st century Engineers and Data Scientists. In this seminar, you will be introduced to this field of science by covering the most popular topics and tasks in Machine Learning. Examples and programming material will be provided to illustrate the ideas presented in the seminar. These will be in Python using conventional Open Source libraries for Data Science and based on the use of interactive Jupyter Notebooks and/or Google Collab.

Objectives:

- Learn the basics of satellite imagery and remote sensing data interpretation
- Learn about the European Union's Earth observation programme Copernicus and the Sentinel satellites
- Learn to download, access and read remote satellite imagery and remote sensing data.
- Learn to process remote satellite imagery and remote sensing data.
- Learn to use cloud platforms for dealing with large volume of satellite imagery and remote sensing data.
- Understand the basics of Machine Learning and its application on satellite imagery and remote sensing data.
- Apply Machine Learning algorithms to satellite imagery and remote sensing data in a case study relevant in the frame of the UN's SDGs.

References:

- [1] "The Global Risks Report 2022", 17th Edition, World Economic Forum, 2022 [<https://www.weforum.org/reports/global-risks-report-2022>]
- [2] "Remote Sensing Technology Market Size (2020-2027)", Grand View Research, 2020 [https://www.grandviewresearch.com/industry-analysis/remote-sensing-technologies-market?utm_source=prnewswire&utm_medium=referral&utm_campaign=ict_23-sept-20&utm_term=remote-sensing-technologies-market&utm_content=rd]
- [3] Copernicus programme [<https://www.copernicus.eu/en>]
- [4] "Copernicus Sentinel Data Access Annual Report 2020", European Space Agency, 2021 [<https://sentinels.copernicus.eu/web/sentinel/-/copernicus-sentinel-data-access-annual-report-2020/1.0?redirect=%2Fweb%2Fsentinel%2Fsentinel-data-access>]
- [5] "Sustainable Development Goals", United Nations, 2022 [<https://sdgs.un.org/goals>]

STUDY LOAD

Type	Hours	Percentage
Hours large group	16,0	32.00
Hours small group	4,0	8.00
Self study	30,0	60.00

Total learning time: 50 h

CONTENTS

Introduction

Description:

- Course introduction and context
- What is Remote Sensing. Brief historical review
- What is Machine Learning. Brief historical review
- Current challenges and opportunities for satellite imagery and Earth observation applications

Full-or-part-time: 2h

Theory classes: 2h

Remote Sensing Systems and Imagery

Description:

- Electromagnetic spectrum, transmission and radiation
- Platforms and Sensors
- Earth observation missions

Full-or-part-time: 3h

Theory classes: 3h

Big Data Exploitation Cloud Platforms

Description:

- The new paradigm of Big Earth Data
- The Sentinel systems and the Copernicus Programme. The Copernicus Open Access Hub
- Large scale processing
- Exploitation cloud platforms: Google Earth Engine, openEO, WASDI

Full-or-part-time: 3h

Theory classes: 3h

Machine Learning for Satellite Imagery

Description:

- Practical introduction of Machine Learning and Deep Learning
- Lab session (1 hour)
- Supervised models classification
- Lab session (1 hour)
- Unsupervised models
- Lab session (1 hour)
- Self-supervised models
- Lab session (1 hour)

Full-or-part-time: 11h

Theory classes: 7h

Laboratory classes: 4h

External Contribution

Description:

Presentation by an external speaker expert in the domain

Full-or-part-time: 1h

Theory classes: 1h

GRADING SYSTEM

- Lecture participation/assistance (20% final qualification)
- Evaluation of short quizzes (20% final qualification)
- Evaluation of a short report on a practical case study focused in a relevant topic in the frame of the UN's SDGs (TBD, but an example could be determine the urban extend) (60% final qualification)

BIBLIOGRAPHY

Basic:

- Emery, William; Camps Carmona, Adriano José. Introduction to satellite remote sensing: atmosphere, ocean, land and cryosphere applications [on line]. Amsterdam: Elsevier, 2017 [Consultation: 23/09/2022]. Available on: <https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=5013967>. ISBN 0128092548.
- Igual, Laura; Vitrià, Jordi; Puertas, Eloi; Pujol, Oriol; Escalera, Sergio; Dantí, Francesc; Garrido, Lluís. Introduction to data science: A Python approach to concepts, techniques and applications [on line]. Cham: Springer, 2017 [Consultation: 23/09/2022]. Available on : <https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=6314089>. ISBN 9783319500171.