Course guide
230704 - ORS - Optical Remote Sensing: Lidar (Laser Radar)

Last modified: 14/12/2023

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications.

Degree: MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).

Academic year: 2023 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

PRIOR SKILLS

Basic knowledge of remote-sensing radar systems and signal processing foundations is of advantage. Good knowledge is gained during the course. ERASMUS and visiting students are admitted.

REQUIREMENTS

No previous requirements.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE2. Demonstrate the understanding of the peculiarities of the quantum model for light-matter interaction.
CE4. Demonstrate knowledge of the fundamentals of image formation, propagation of light through different media and Fourier Optics.
CE9. Ability to synthesize and present photonics research results according to the procedures and conventions of scientific presentations in English.

Generical:
CG1. Ability to project, design and implement products, processes, services and facilities in some areas of photonics, such as photonic engineering, nanophotonics, quantum optics, telecommunications and biophotonics.
CG4. Ability to understand the generalist and multidisciplinary nature of photonics, seeing its application, for example, to medicine, biology, energy, communications or industry
CG2. Ability to modeling, calculate, simulate, develop and implement in research and technological centers and companies, particularly in research, development and innovation tasks in all areas related to Photonics.

Transversal:
1. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

2. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding how companies are organised and the principles that govern their activity, and being able to understand employment regulations and the relationships between planning, industrial and commercial strategies, quality and profit.

3. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

4. SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.

Basic:
CB6. Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context
CB7. Students should know how to apply the knowledge acquired and their problem-solving ability in new or little-known environments within broader (or multidisciplinary) contexts related to their area of ¿¿study.
CB8. Students should be able to integrate knowledge and face the complexity of formulating judgments based on information that, being incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of their knowledge and judgment.
CB10. Students should possess the learning skills that allow them to continue studying in a way that will be largely self-directed or autonomous.

TEACHING METHODOLOGY

- Lectures
- Activities: Simulation project, problems

LEARNING OBJECTIVES OF THE SUBJECT

The course addresses the main techniques, systems and subsystems related to remote-sensing laser-radar sensors (LIDAR). The Foundations of Remote Sensing, Technological and Systems Architecture are presented with emphasis on the different types of laser radars, transmission equation, signal processing and retrieval of data products, as well as applications in atmospheric observation from terrestrial and space LIDARs. Examples comprise the detection and monitoring of chemical species in the industry field as well as atmospheric observation and monitoring of pollution, gases (water vapor) and temperature, among others.

The subject combines expository classes with application classes, where the different types of lidar systems are simulated and discussed taking into account present technological state of the art. The course also addresses a transversal objective of lidar systems software simulation of as a guided intensification work.

STUDY LOAD

Type	Hours	Percentage
Hours large group	39,0	31.20
Self study	86,0	68.80

Total learning time: 125 h

CONTENTS

1.- Elastic lidar systems.

Description:
1.1.- Foundations and architecture.
1.2.- Basic design parameters: Lidar equation. Optical overlap factor. Background radiance .
1.3.- Examples of terrestrial and air- and satellite-borne systems.

Full-or-part-time: 4h 30m
Theory classes: 4h 30m

2.- Link budget and SNR: Foundations and simulation.

Description:
2.1.- Lidar receiver: Opto-electronic conversion and reception chain. Temporal and spatial resolution. Signal conditioning and acquisition (analog-to-digital conversion and and photon counters).
2.2.- Generalised Signal-to-Noise Ratio (SNR). Noise-dominant modes.
2.3.- Problem I: Elastic lidar.
2.4.- Lidar range estimation.
2.5.- Simulation project (problem II): Power budget and SNR for an elastic-Raman lidar system.

Full-or-part-time: 4h 30m
Theory classes: 4h 30m

3.- Raman systems.

Description:
3.1.- Raman Lidar: Foundations.
3.2.- Atmospheric probing and system design (I): temperature measurement.
3.3.- Atmospheric probing and system design (II): molecular species detection (gases, water vapor).
3.4.- Elastic-Raman systems. Simulation project revision (Sect. 2.5).

Full-or-part-time: 6h
Theory classes: 6h

4.- Wind lidar systems.

Description:
4.1.- Doppler Wind Lidar: foundations, applications and detection techniques.
4.2.- Coherent Doppler Lidar: link budget, architecture and signal processing. Practical examples of systems and recent developments.
4.3.- Direct-detection Doppler Lidar: detection techniques and developments. Practical examples of systems and recent developments.

Full-or-part-time: 7h 30m
Theory classes: 7h 30m

5.- Lidar inversion: Retrieval of atmospheric products.

Description:
5.1.- Atmospheric aerosols/particles.
5.2.- Inversion of atmospheric optical properties: Inversion of backscatter lidar data (slope method, Klett's, lidar ratio estimation by combining solar photometer and lidar sensors). Inversion of Raman lidar and High Spectral Resolution Lidar (HSRL) data. Two-dimensional methods.
5.3.- Inversion of physical products: Aerosol microphysical properties. Atmospheric structural properties (boundary layer, clouds, ...).
5.4.- Applications: Cooperative instrumentation. Examples of interest.

Full-or-part-time: 7h 30m
Theory classes: 7h 30m

6.- DIAL and other laser-radar systems

Description:
6.1.- DIfferential Absoprtion Lidar (DIAL): Detection of chemical contaminant species.
6.2.- Other laser radar systems and industrial applications.

Full-or-part-time: 3h
Theory classes: 3h

ACTIVITIES

Computer-based simulation of lidar systems.

Full-or-part-time: 3h
Theory classes: 3h

GRADING SYSTEM

- 50 % Final exam (multiple answer test)
- 50 % Guided research work (computer-based project/problem nos. 1-2 + Interview).
Course attendance (80% minimum).

BIBLIOGRAPHY

Basic:
- Hinkley, E.D. Laser monitoring of the atmosphere. Berlin: Springer-Verlag, 1976. ISBN 354007743X.
- Fujii, Takashi; Fukuchi, Tetsuo. Laser remote sensing [on line]. Boca Raton: Taylor&Francis, 2005 [Consultation: 17/06/2016]. Available on: http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10143572. ISBN 0824742567.

Complementary:
- Measures, Raymond M. Laser remote sensing : fundamentals and applications. Malabar, Fla: Krieger, 1992. ISBN 0894646192.