UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

Course guide
230356 - LIDARPRO - Lidar Processing and Inversion: Applications to Remote Sensing of Physical Parameters

Last modified: 13/05/2015

Unit in charge:	Barcelona School of Telecommunications Engineering
Teaching unit:	744 - ENTEL - Department of Network Engineering.

Degree: **Academic year:** 2015   **ECTS Credits:** 2.5
Languages: English

LECTURER

Coordinating lecturer:	Francesc Rocadenbosch
Others:	Constantino Muñoz and Michael Sicard

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE1. Ability to apply information theory methods, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing to communication and audiovisual systems.
CE13. Ability to apply advanced knowledge in photonics, optoelectronics and high-frequency electronic
CE14. Ability to develop electronic instrumentation, as well as transducers, actuators and sensors.
CE15. Ability to integrate Telecommunication Engineering technologies and systems, as a generalist, and in broader and multidisciplinary contexts, such as bioengineering, photovoltaic conversion, nanotechnology and telemedicine.

Transversal:
CT1a. 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.

CT2. 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.

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

CT4. 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.

CT5. 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.

TEACHING METHODOLOGY

- Lectures
- Application classes
- Individual work (distance)
- Exercises
- Other activities: End-to-end simulation, visit to the UPC multi-spectral lidar station (European Infrastructure, OPTIONAL ACTIVITY upon operational time-slot availability of the station, number of students, and course schedule).
- Extended answer test (Final Exam)

LEARNING OBJECTIVES OF THE SUBJECT

Learning objectives of the subject
The course seminar focuses on a tutorial discussion of the main basic techniques concerning signal, data processing and retrieval of atmospheric optical and physical parameters from LIDAR (laser-radar) remote sensing systems. Key application fields comprise atmospheric and environmental observation (pollution/aerosol concentration), monitoring of physical-variables and wind remote sensing. Simulation and customised inversion tools are used to analyse different case examples in a conceptual illustrative way.
The course benefits from previous courses/background on lidar but this is not a pre-requisite.

Learning results of the subject:
- Ability to develop LIDAR (laser-radar) remote-sensing systems for atmospheric sensing and chemical-species detection in the context of both ground-based and satellite-based systems.
- Ability to specify, analyse, and evaluate the performance of different types of LIDAR systems using end-to-end software simulation.
- Ability to model and interpret retrieved lidar data in terms of level-1 products (atmospheric reflectivity, attenuation) and level-2 products (pollution content and transport, gas-species concentration, and wind velocity).
- Ability to understand and forecast a wide range of LIDAR applications including pollution monitoring and gas detection in the environmental/regulatory field, wind retrieval in relation to eolic farms, telemetry, 3-D imaging and scanning in architecture, and bathymetry (sea surface and submarine investigation).
- Knowledge exposure to continental and world-wide network initiatives concerning both active and passive optical remote sensing instruments.
- Ability to develop laser-radar/optical-active remote-sensing systems: telescope ("optical antenna") and opto-electronic receiver design, equipment and subsystems, channel modeling, link budget, and architecture specification.
- Ability to design laser-radar remote sensing systems (LIDAR) for atmospheric environmental sensing (pollution) and chemical-species detection, either as ground-based or satellite-based systems.
- Ability to integrate Telecommunication Engineering technologies and systems, as a generalist, and in broader and multidisciplinary contexts, such as remote sensing, atmospheric probing, and imaging.
- Ability to develop signal processing methods and algorithms for data retrieval and interpretation in atmospheric, environmental and industrial LIDAR remote sensing.

STUDY LOAD

Type	Hours	Percentage
Self study	42,5	68.00
Hours large group	20,0	32.00

Total learning time: 62.5 h

CONTENTS

1. FONDATIONS OF LIDAR REMOTE SENSING (session 1)

Description:
1.1 Overview of Elastic-backscatter, Raman, Doppler, and DIAL systems
1.2 Visit to the UPC remote sensing LIDAR station

Full-or-part-time: 4h 30m
Theory classes: 1h 30m
Self study : 3h

2. ELASTIC/RAMAN LIDAR: ESTIMATION OF LEVEL-0 PRODUCTS (session 1)

Description:
2.1 Signal-to-noise ratio estimation

Full-or-part-time: 4h 30m
Theory classes: 1h
Practical classes: 0h 30m
Self study : 3h

3. ELASTIC/RAMAN LIDAR: RETRIEVAL OF LEVEL-1 ATMOSPHERIC PRODUCTS (session 2)

Description:
3.1 From instrument raw data to atmospheric extinction and backscatter profiles
3.2 Error simulation

Full-or-part-time: 9h
Theory classes: 1h 30m
Practical classes: 1h 30m
Self study : 6h

4. ELASTIC/RAMAN LIDAR: RETRIEVAL OF LEVEL-2 ATMOSPHERIC PRODUCTS (sessions 3, 4)

Description:
4.1 Inversion of aerosol products (session 3)
4.1.1 Inversion of the aerosol optical properties
4.1.2 Inversion of the aerosol microphysical properties
4.1.3 Inversion of the aerosol structural properties

4.2 Application (session 4)
4.2.1 Examples of scientific results based on lidar products and cooperative instrument

Full-or-part-time: 18h
Theory classes: 4h
Practical classes: 2h
Self study : 12h

5. COHERENT WIND LIDAR: LINK-BUDGET AND PROCESSING (sessions 5, 6)

Description:
5.1 Overview on Wind Lidar (session 5)

5.2 Link-budget (session 5)
5.2.1 Basic principles. Optical mixing
5.2.3 Coherent signal-to-noise ratio
5.2.3 Effective coherent receiving area and turbulence limit

5.3 Doppler-shift spectral estimation (session 6)
5.3.1 Estimation techniques. Practical exercise
5.3.2 Uncertainty in the velocity estimate
5.3.3 Retrieval of the speed direction: Vector-azimuth display (VAD)

5.4 Recent development: Mitsubishi?s all-fiber coherent DWL (session 6)

Full-or-part-time: 18h
Theory classes: 4h
Practical classes: 2h
Self study : 12h

6. EVALUATION (session 7)

Description:
6.1 Final exam

Full-or-part-time: 8h 30m
Theory classes: 2h
Self study : 6h 30m

GRADING SYSTEM

The teaching and learning methodology combines expositive classes with applied ones, where simulation/real case examples (Matlab based) are discussed along with literature reviews.
Simplified exercises (some of them with software support) will be posed and discussed in class to consolidate key learning topics.

Extended answer test (Final examination):
- Description: Final examination (multiple-answer test*).
* Test will include support/feedback from in-class discussed exercises.

Final examination: 100%

BIBLIOGRAPHY

Basic:
- Fujii, T.; Fukuchi, T. Laser Remote Sensing [on line]. Boca Raton [etc.]: Taylor & Francis, 2005 [Consultation: 12/05/2015]. Available on: http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10143572. ISBN 0824742567.

RESOURCES

Other resources:
Complementary:

E.D. Hinkley (Editor), R.T.H. Collis, H. Inaba, P.L. Kelley, R.T. Ku, S.H. Melfi, R.T. Menzies, P.B. Russell, V.E. Zuev. LASER MONITORING OF THE ATMOSPHERE. Springer-Verlag, 1976.