UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

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230609 - RSEN - Remote Sensing for Earth Observation

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering

Teaching unit: 739 - TSC - Department of Signal Theory and Communications

Academic year: 2019

Degree: MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Teaching unit Optional)
MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Teaching unit Optional)
MASTER'S DEGREE IN INFORMATION AND COMMUNICATION TECHNOLOGIES (Syllabus 2009). (Teaching unit Optional)

ECTS credits: 5 Teaching languages: English

Teaching staff

Coordinator: ANTONI BROQUETAS

Others: ADRIANO CAMPS

Degree competences to which the subject contributes

Specific:

1. Ability to apply advanced knowledge in photonics, optoelectronics and high-frequency electronic

2. Ability to design radio-navigation and location systems, as well as radar systems.

3. Ability to develop, direct, coordinate, and technical and financial management of projects in the field of: telecommunication systems, networks, infrastructures and services, including the supervision and coordination of other's subprojects; common telecommunications infrastructures in buildings or residential areas, including digital home projects; telecommunication infrastructures in transport and environment; with corresponding energy supply facilities and assessment of electromagnetic emissions and electromagnetic compatibility.
4. Ability to develop electronic instrumentation, as well as transducers, actuators and sensors.

5. 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:

6. 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.
7. 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.
8. 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.
9. 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.
10. 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
- Laboratory classes
- Laboratory practical work
- Group work (distance)
- Individual work (distance)
- Exercises
- Extended answer test (Final Exam)

Learning objectives of the subject

Learning objectives of the subject

The course basic objective is training the students in the basic concepts, techniques and underlying technologies involved in the design and development of space-borne and air-borne sensors applied to Earth Observation and other imaging related fields. The contents of the course provide the technical information required to exploit remote sensing data in the different phases of the value chain: data acquisition, calibration, surface modeling, geophysical & biological parameters inversion, etc.

Learning results of the subject

- Ability to understand the principles of operation, limitations, advantages and disadvantages of alternative remote sensing techniques including active and passive systems using microwaves, THz, Infrared and visible ranges of the Electromagnetic Spectrum.
- Ability to analyze and design remote sensing systems with the required performance of the intended applications, including: spatial/radiometric resolutions, range of operation, calibration and processing subsystems, etc.
- Knowledge of the fundamentals of the physical interaction between waves and matter that can be used for obtaining information of bodies remotely, including scattering, emission, polarimetry and the associated mathematical models and approximations.
- Ability to analyze and propose the basic mission parameters related to space-borne, air-borne or ground-based platforms, including orbital design, downlink requirements and motion compensation subsystems.
- Ability to apply signal processing and inversion modeling techniques to the calibration, image formation, geocoding and geo/bio-physical parameters inversion from remote sensing images.

Study load

Total learning time: 125h	Hours large group:	26h	20.80%
	Hours medium group:	0h	0.00%
	Hours small group:	13h	10.40%
	Guided activities:	0h	0.00%
	Self study:	86h	68.80%

Content

1. Introduction.	Learning time: 3h Theory classes: 1h Self study : 2h

Description:
- The Remote Sensing sector and value chain
- Remote sensing active and passive techniques

2. Remote Sensing techniques	Learning time: 12h Theory classes: 3h Laboratory classes: 2h Self study : 7h

Description:
- Sensing at Microwave, THz, IR and Visible regions of the EM Spectrum
- Remote sensing platforms. Space-borne, air-borne and ground based systems.
- Space-borne missions. Orbital design

3. Radar sensors	Learning time: 29h Theory classes: 7h Laboratory classes: 2h Self study : 20h

Description:
- Radar Cross Section. Backscattering coefficients. Radar power equation
- Radar profiling. Altimeters. Wind scatterometers. Meteorological radars
- Synthetic Aperture Radar (SAR) techniques.
- Image reconstruction and spatial resolution
- Speckle noise. Multi-look techniques
- Radar polarimetry and interferometry. Applications

4. Lidar Sensors	Learning time: 8h Theory classes: 2h Self study : 6h

Description:
- Elastic Lidar. Rayleigh and Mie Scattering. DIAL Systems
- Inelastic Lidar. Raman and Fluorescence.
- Solid targets and atmospheric Lidar power equations
- Lasers and photo-detectors
- Lidar applications in atmosphere sounding, surface topography and 3D modeling

5. Optical Radiometers	Learning time: 28h Theory classes: 7h Laboratory classes: 2h Self study : 19h

Description:
- Planck's radiation law of the black body. Solar illumination. Impact of the atmosphere.
- Lens and mirrors. First order analysis of optical systems. IFOV and FOV.
- Imaging photo-detectors: linear and frame arrays CCD & CMOS technologies. Scanning systems.
- Multiespectral and hyperspectral cameras
- Radiometric resolution of optical systems. NEP and NET
- Classification of remote sensing images

6. Microwave Radiometers	Learning time: 23h Theory classes: 5h Laboratory classes: 2h Self study : 16h

Description:
- Rayleigh-Jeans approximation of radiation law.
- Surface emissivity of natural surfaces at microwaves. Impact of the atmosphere. Model inversion expressions.
- Microwave radiometers configurations: Total power, Dicke and Noise Injection systems.
- Calibration and radiometric resolution. Scanning systems
- Aperture synthesis radiometers

7. Remote Sensing with GNSS opportunity signals	Learning time: 9h Theory classes: 2h Self study : 7h

Description:
- Ambiguity functions: Waveforms and Delay-Doppler Maps
- Radio Occultation of GNSS signals: principles and application to the atmospheric observation.
- GNSS reflections: principles and applications in altimetry, sea state, soil moisture and vegetation.

8. Calibration and geocoding of remote sensing images	Learning time: 13h Theory classes: 2h Laboratory classes: 2h Self study : 9h

Description:
- Calibration and radiometric compensation of remote sensing images. Calibration surfaces and targets
- Geometric rectification of high resolution sensors
- Motion measurement and compensation in air-borne systems.
- Geocoding of remote sensing products
- Integration of Remote Sensing data in Geographic information systems

Planning of activities

LABORATORY

Description:
5 sessions using specialized software applications on real data devoted to the following topics:
- Orbital design
- Synthetic Aperture Radar.
- Optical Multispectral imaging
- Microwave radiometers
- Image Geocoding

WRITTEN WORK

Description:
The students will prepare a written work on proposed remote sensing missions (carried out in group of 2 students)

EXERCISES

Description:
The students have a collection of problems of past examinations with solutions to consolidate concepts and analysis /design methodologies. The exercises are for self-evaluation.

FINAL EXAMINATION

Description:
Based on short questions and problems.

Qualification system

Final examination: 50%
Laboratory assessments: 25%
Written work: 25%

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Bibliography

Basic:

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Elachi, C.; Van Zyl, J. Introduction to the physics and techniques of remote sensing. 2nd ed. New York: John Wiley, 2006. ISBN 0471475699.

Schott, J.R. Remote sensing: the image chain approach [on line]. 2nd ed. Oxford: Oxford University Press, 2007 [Consultation: 23/10/2017]. Available on: <http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10212103&p00=remote%20sensing%20the%20image%20chain%20approach>. ISBN 9780199724390.

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Cumming, I.G.; Wong, F.H. Digital processing of synthetic aperture radar data: algorithms and implementation. Boston: Artech House, 2005. ISBN 1580530583.

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

Kapp, S.; Sttots, L.B. Fundamentals of electro-optic systems design: communicatins, lidar, and imaging [on line]. Cambridge: Cambridge University Press, 2013 [Consultation: 01/10/2015]. Available on: <http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10634358>. ISBN 9781139612425.

Fischer, R.E.; Tadic-Galeb, B.; Yoder, P.R. Optical system design. 2nd ed. New York: McGraw Hill, 2007. ISBN 9780071472487.

Sandau, R. (ed.). Digital airborne camera: introduction and technology. Berlin: Springer, 2010. ISBN 9781402088773.

Skou, N.; Le Vine, D. Microwave radiometer systems: design and analysis [on line]. 2nd ed. Norwood, MA: Artech House, 2006 [Consultation: 22/06/2017]. Available on: <http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10160964>. ISBN 9781580539753.

Complementary:

Szekielda, K.H. Satellite monitoring of the earth. New York: John Wiley, 1988. ISBN 0471613304.