230560 - VISUAL - Visual Biophotonics and Multispectral Imaging

Coordinating unit: 230 - ETSETB Barcelona School of Telecommunications Engineering
Teaching unit: 731 - OO Department of Optics and Optometry
Academic year: 2015 - 2016
Degree: Master's Degree in Photonics
Erasmus Mundus Master's Degree in Photonics Engineering, Nanophotonics and Biophotonics
ECTS credits: 3 **Teaching languages:** English

Academic staff

Coordinator: Meritxell Vilaseca (UPC) mvilasec@oo.upc.edu
Other professors: Jaume Pujol (UPC) pujol@oo.upc.edu

Degree competences to which the subject contributes

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. 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.
3. 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.
4. 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.

Teaching methodology

Lectures
Activities:
- Laboratory and vision center visits
- Seminars

The student will have the possibility of performing measurements using experimental setups and commercial instruments.

Objectives and short description of the course

Visual Biophotonics is an innovative and multidisciplinary area that uses light-based technologies to image, examine and treat the eye and its visual performance, improving diagnosis, therapy, and follow-up care of certain diseases. Therefore, it plays a crucial role for a better visual healthcare. Examples include lasers being used routinely in laser-refractive surgery, clinical instruments developed to measure aberrations and retinal image quality, and advanced image techniques using adaptive optics, which can provide high resolution images of the ocular structures. Multispectral imaging is a sophisticated and powerful technology that was developed to overcome the problems of conventional color (RGB) imaging systems, reaching a great spectral and spatial resolution. Its enormous potential opens a wide-field of applications including remote sensing, fine arts/museum analysis and archiving, Hi-Fi printing and displays, textiles, industrial inspection and quality control, medical imaging, and precise color measurement. The course focuses on the main topics covered by Visual Biophotonics and Multispectral Imaging. The first part of course includes the new methods for ocular correction, such as

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intraocular lenses and refractive surgery, the evaluation of the ocular aberrations, retinal image quality and intraocular scatter, and concludes with the study of high resolution retinal images. The second part deals with the multispectral systems and the latest developments and applications in this exciting field.

Study load

Total learning time: 75h	Hours large group:	22.5h	30%
	Hours medium group:	0h	0%
	Hours small group:	0h	0%
	Guided activity:	2.25h	3%
	Self study:	50.25h	67%

Course index

Visual biophotonics:

1. Introduction to visual optics and biophotonics. An overview of the human eye. Schematic and advanced eye models.
2. Refractive anomalies and accommodation. Presbyopia. Means of correction: ophthalmic, contact, and intraocular lenses. Refractive surgery.
3. Human eye aberrations and measurement techniques. Evaluation of ocular aberrations. Wavefront sensors for the eye: Hartmann-Shack Wavefront sensor and Laser Ray tracing.
4. Retinal image quality measurement. Double pass technique and intraocular scatter measurements.
5. Adaptive Optics for vision. Customized vision correction.
6. Measurement of the optical properties of the cornea and lens. Basic optical instrumentation. Corneal topography, Scheimpflug and Purkinje images.
7. Conventional and high resolution retinal imaging. Ophthalmoscopy, scanning laser ophthalmoscope (SLO) and Optical Coherence Tomography (OCT).

Multispectral imaging:

1. Introduction to color and spectral science. Limitations of trichromacy.
2. Multispectral and hyperspectral imaging systems. Components.Spectral sampling techniques.
3. Managing spectral data. Spectral dimensionality.Methods for spectral reconstruction.Metrics to evaluate spectral reconstruction.
4. Applications of multispectral imaging systems. Remote sensing, food and agriculture, forensics, paleontology, textile and wood industry, applications in art and cultural heritage, medical applications.Spectral imaging of structures of the eye.
5. Commercial spectral imaging systems.

Qualification system

Homework assessments (40%)
Written exam (30%)
Oral presentation of a scientific journal paper (15%)
Attending seminars, lab visits, class attendance (15%)

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Bibliography

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- BERNS R.S.: Principles of color technology. John Willey and Sons, Inc. New York, 2000.
- *LEE H-C.: Introduction to color imaging science. Cambridge University Press. Reino Unido, 2005.*
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- GRAHN H.F., GELADI P.: Techniques and applications of hyperspectral image analysis. John Willey and Sons, Inc. England., 2007.