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:	2016
Degree:	ERASMUS MUNDUS MASTER'S DEGREE IN PHOTONICS ENGINEERING, NANOPHOTONICS AND BIOPHOTONICS (Syllabus 2010). (Teaching unit Optional) MASTER'S DEGREE IN PHOTONICS (Syllabus 2013). (Teaching unit Optional)
ECTS credits:	3 Teaching languages: English

Teaching staff

Coordinator:	Meritxell Vilaseca, UPC.
Others:	Jaume Pujol, UPC

Degree competences to which the subject contributes

Basic:

CB6. (ENG) Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación

CB7. (ENG) Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.

CB8. (ENG) Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicio.

CB10. (ENG) Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

Specific:

CE3. (ENG) Màster en Fotònica:

Conocer los fundamentos de la física del láser, los tipos de láser y sus principales aplicaciones

CE4. (ENG) Màster en Fotònica:

Demostrar que conoce los fundamentos de la formación de imagen, de la propagación de la luz a través de los diferentes medios y de la Óptica de Fourier.

CE6. (ENG) Màster en Fotònica:

Haber realizado un conjunto de prácticas de laboratorio de nivel avanzado, similar al de futuros trabajos experimentales de investigación

CE9. (ENG) Màster en Fotònica:

Capacidad para sintetizar y exponer los resultados de investigación en fótonica según los procedimientos y convenciones de las presentaciones científicas en inglés.

Generical:

CG1. (ENG) Màster en Fotònica:

Capacidad para proyectar, diseñar e implantar productos, procesos, servicios e instalaciones en algunos ámbitos de la fotónica como los relacionados con la ingeniería fotónica, la nanofotónica, la óptica cuántica, las telecomunicaciones y la biofotónica

CG2. (ENG) Màster en Fotònica:

Capacidad para la modelización, cálculo, simulación, desarrollo e implantación en centros de investigación, centros tecnológicos y empresas, particularmente en tareas de investigación, desarrollo e innovación en todos los ámbitos relacionados con la Fotónica.

CG4. (ENG) Màster en Fotònica:

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Capacidad para entender el carácter generalista y multidisciplinario de la fótonica viendo su aplicación por ejemplo a la medicina, biología, energía, comunicaciones o la industria

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.

CT3. (ENG) Màster en Fotònica:

TRABAJO EN EQUIPO. Ser capaz de trabajar como miembro de un equipo interdisciplinar ya sea como un miembro más, o realizando tareas de dirección con la finalidad de contribuir a desarrollar proyectos con pragmatismo y sentido de la responsabilidad, asumiendo compromisos teniendo en cuenta los recursos disponibles

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.

Learning objectives of the subject

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, 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 refraction correction, such as intraocular lenses and refractive surgery, the evaluation of the ocular aberrations and retinal image quality, the study of optical and photonic tools currently used for the diagnosis of diseases related with ocular structures (cornea, lens and retina), and concludes with the study of therapeutic lasers used in ophthalmology. 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:	22h 30m	30.00%
	Hours medium group:	0h	0.00%
	Hours small group:	0h	0.00%
	Guided activities:	2h 15m	3.00%
	Self study:	50h 15m	67.00%

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Content

1. Visual biophotonics	Learning time: 14h
	Theory classes: 14h

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

Multispectral imaging:
1. Introduction to color and spectral science. Limitations of trichromacy. (1.5h)
2. Multispectral and hyperspectral imaging systems. Components. Spectral sampling techniques. (2h)
3. Managing spectral data. Spectral dimensionality. Methods for spectral reconstruction. Metrics to evaluate spectral reconstruction. (1h)
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. (2h)

2. Multispectral imaging	Learning time: 8h 30m
	Theory classes: 8h 30m

Description:
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.

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Planning of activities

Laboratory and vision center visits	Hours: 2h 18m Theory classes: 2h 18m

Qualification system

- Homework assessments (35%)
- Written exam (50%)
- Oral presentation of a scientific journal paper (15%)

Bibliography

Basic:

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Porter, Jason. Adaptive optics for vision science : principles, practices, design and applications. Canadà: Wiley-Interscience, 2006. ISBN 9780471679417.

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Grahn, Hans; Geladi, Paul. Techniques and applications of hyperspectral image analysis [on line]. West Sussex: John Wiley, 2007 [Consultation: 15/09/2015]. Available on: <http://onlinelibrary.wiley.com/book/10.1002/9780470010884>. ISBN 9780470010860.

Popp, Jürgen. Handbook of biophotonics. Weinheim, Germany : [Chichester: Wiley-VCH ; John Wiley, distributor, cop. 2011- . ISBN 9783527410477.

Berns, Roy S. Billmeyer and Saltzman's Principles of color technology. 3rd ed. New york, [etc.]: John Wiley & Sons, 2000. ISBN 047119459X.

Lee, Hsien-Che. Introduction to color imaging science. Cambridge [etc.]: Cambridge University Press, 2005. ISBN 9780521103138.

Gulrajani, M. L. Colour measurement : principles, advances and industrial applications. Cambridge ; Philadelphia: Woodhead, 2010. ISBN 1845695593.

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Kang, Henry R. Computational color technology. Bellingham: SPIE, 2006. ISBN 0819461199.