Course guide
230581 - ASI - Active and Spectral Imaging

Last modified: 19/06/2024

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 731 - OO - Department of Optics and Optometry.

Degree: MASTER'S DEGREE IN PHOTONICS (Syllabus 2013). (Optional subject).

Academic year: 2024 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Consultar aquí / See here:

Others: Consultar aquí / See here:

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE3. Know the fundamentals of laser physics, the types of lasers and their main applications.
CE4. Demonstrate knowledge of the fundamentals of image formation, propagation of light through different media and Fourier Optics.
CE6. Have carried out a set of advanced laboratory works, similar to that of future experimental research work.
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

Transversal:
CT4. SOLVENT USE OF INFORMATION RESOURCES. Manage the acquisition, structuring, analysis and visualization of data and information in the field of the specialty and critically assess the results of this management.
CT1. ENTREPRENEURSHIP AND INNOVATION. Knowing and understanding the mechanisms on which scientific research is based, as well as the mechanisms and instruments for transferring results between the different socioeconomic agents involved in R&D&I processes.
CT5. ENGLISH. Accredit an adequate level of this language, both orally and in writing, in line with the needs that the graduates will have.
CT3. TEAMWORK. Be able to work as a member of an interdisciplinary team, either as another member, or performing management tasks in order to contribute to developing projects with pragmatism and a sense of responsibility, assuming commitments taking into account the available resources.

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: - Laboratory/Research center visits
- Seminars

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

LEARNING OBJECTIVES OF THE SUBJECT

Active optical elements enable the implementation of imaging applications which overcome the classical approaches imposed by rigid optics. Active optical elements are characterized by presenting easy changes in its optical performance depending on a number of parameters, being the most common using variable electrical signals to modulate different properties of light.
Spectral imaging science 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. The use of more than three acquisition channels has an enormous potential and 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 to improve clinical diagnosis, and precise color measurement.
In the first part of the course we will study active optical elements, from LCD to liquid lenses, but also deformable mirrors, electrooptic and magnetooptic spatial light modulators. As the best-known example of imaging application, adaptive optics will be discussed.
The second part deals with the color and spectral imaging systems and the latest developments and applications in this exciting field.

STUDY LOAD

Type	Hours	Percentage
Self study	51,0	68.00
Hours large group	24,0	32.00

Total learning time: 75 h

CONTENTS

Active imaging

Description:
1. Introduction to active imaging: review of polarization in anisotropic media.
2. Active optical elements: revision of the different active optical elements and their performance, showing application examples of each. This includes electro-optic modulators, magneto-optic modulators, liquid-crystal modulators, acousto-optic modulators, liquid lenses and deformable mirrors.
3. Introduction to adaptive optics. Implementation in astronomic imaging. Components of an adaptive optical system. Optomechanical assembly. Non-astronomic adaptive optics.

Full-or-part-time: 12h 15m
Theory classes: 12h 15m

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Color and spectral imaging

Description:
1. Introduction to color science. Color specification and measurement. (2h)
2. Principles of color reproduction. (1h)
3. Digital color imaging systems and color management. (2h)
4. Introduction to spectral imaging science. Limitations of trichromacy. (1h)
5. 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. (1.25h)
4. Applications of multispectral imaging systems. Remote sensing, food and agriculture, forensics, paleontology, textile and wood industry, applications in art and cultural heritage. Use of spectral imaging in medical diagnosis: skin cancer and ophthalmology (2h)

Full-or-part-time: 2h 15m
Theory classes: 2h 15m

GRADING SYSTEM

- Homework assessments (50%)
- Written exam (40%)
- Oral presentation of a scientific journal paper (10%)

BIBLIOGRAPHY

Basic:
- Saleh, B.E.A.; Teich, M.C. Fundamentals of photonics. 3rd ed. Hoboken: John Wiley & Sons, 2019. ISBN 9781119506874.
- Liu, Jia-Ming. Photonic devices. Cambridge: Cambridge University Press, cop. 2005. ISBN 0521551951.
- Holst, Gerald C. CCD arrays, cameras, and displays. 2nd. ed. Winter Park, FL : Bellingham, Wash., USA: JCD ; SPIE Optical Engineering, cop. 1998. ISBN 0964000040.
- Tyson, Robert K. Introduction to adaptive optics [on line]. Washington: SPIE Press, cop. 2000 [Consultation: 20/04/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=728511. ISBN 9780819435118.
- Chigrinov, Vladimir G. Liquid crystal devices : physics and applications. Boston [etc.]: Artech House, cop. 1999. ISBN 0890068984.
- Porter, Jason. Adaptive optics for vision science : principles, practices, design and applications. Canadà: Wiley-Interscience, cop. 2006. ISBN 9780471679417.
- Hardeberg, Jon Yngve. Acquisition and reproduction of color images : colorimetric and multispectral approaches. Parkland, Florida: [Universal]/Dissertation.com, 2001. ISBN 1581121350.
- Grahn, Hans; Geladi, Paul. Techniques and applications of hyperspectral image analysis [on line]. West Sussex: John Wiley, 2007 [Consultation: 21/06/2017]. Available on: http://onlinelibrary.wiley.com/book/10.1002/9780470010884. ISBN 9780470010884.
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