Course guide
2301123 - COLIM - Color and Spectral Imaging

Last modified: 28/05/2025

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: 2025 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: MERITXELL VILASECA RICART

Others: FRANCISCO JAVIER BURGOS FERNÁNDEZ

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.
CG2. Ability to modeling, calculate, simulate, develop and implement in research and technological centers and companies, particularly in research, development and innovation tasks in all areas related to Photonics.
CG4. Ability to understand the generalist and multidisciplinary nature of photonics, seeing its application, for example, to medicine, biology, energy, communications or industry

Transversal:
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.
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.
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.
CT5. ENGLISH. Accredit an adequate level of this language, both orally and in writing, in line with the needs that the graduates will have.

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 (CD6-Center for Sensors, instruments and Systems Development)
- Laboratory measurements using experimental setups and commercial instruments.
- Seminars on trending topics
- Paper read and discussion on trending, hot, emerging topics
- Numerical exercises and short questions to illustrate the applications of the topics. To be worked by students, and then, solved and commented in class or through the platform.

LEARNING OBJECTIVES OF THE SUBJECT

From everyday consumer devices to cutting-edge industrial systems, color imaging technology plays a central role in how we capture, reproduce, and interact with visual information. Across industries such as digital photography, printing, textiles, plastics, and electronics, there is an increasing demand for precise control over how color is captured, processed, and reproduced. As technology evolves, ensuring accurate color representation becomes ever more complex—driving the need for innovative solutions and a deeper scientific understanding of color systems.

This course offers students a unique gateway into the exciting and interdisciplinary world of Color and Spectral Imaging. The first block, Color Imaging, introduces the foundational concepts of color science: color specification, measurement (colorimetry and spectrophotometry), reproduction, and quality assessment. We explore how devices like cameras, scanners, displays, and printers interpret and reproduce color, and how color management systems ensure consistent results across platforms. With the digital era reshaping how we interact with images, engineers must now master the full chain—from image capture to display—with accuracy and perceptual fidelity.

The second block, Spectral Imaging, brings us to the frontier of imaging technology. Unlike traditional RGB systems, spectral imaging captures detailed information across many wavelengths, unlocking unprecedented precision in color representation. This technology powers applications ranging from remote sensing and medical diagnostics to industrial inspection, art conservation, and high-end printing. By combining high spectral and spatial resolution, it provides deeper insights than ever before—opening new avenues for research and innovation.

With demand for skilled professionals rising across sectors, expertise in color and spectral imaging positions students at the forefront of technological, scientific, and industrial transformation. This course not only builds a strong theoretical foundation but also connects students with real-world applications and the latest advances in the field.

STUDY LOAD

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

Total learning time: 75 h

CONTENTS

Color imaging

Description:
1. Color specification
Physical stimulus (light sources, illuminants, objects)
Color perception
Color appearance
Metamerism
CIE color specification systems
Color order systems

2. Color measurement
Basic principles for measuring color
Instruments for color measurement
Advanced instrumentation for color measurement
Precision and accuracy of measurement
Choosing a color-measuring instrument

3. Color differences
Development of color-difference equations
The CIELAB and CIELUV color-difference equations
Advanced color-difference equations

4. Digital color imaging systems
Color input devices (cameras, scanners)
Color output devices (projectors, displays, printers)

5. Principles of color reproduction
Color mixing laws
Types of color reproduction
Color reproduction objectives
Color reproduction strategies

6. Color management systems
Conceptual stages of color management
ICC profiles

Related activities:
- Exercises and practical cases
- Experimental work
- Visit to a reseacrh center
- Paper read and discussion

Full-or-part-time: 14h
Theory classes: 14h

Spectral imaging

Description:
1. Limits of RGB imaging and colorimetry
2. Components of multispectral systems
3. Spectral sampling techniques
4. Methods for spectral reconstruction
5. Hyperspectral systems
6. Industrial and medical applications of color and spectral 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

Related activities:
- Exercises and practical cases
- Experimental work
- Visit to a reseacrh center
- Paper read and discussion

Full-or-part-time: 10h
Theory classes: 10h

GRADING SYSTEM

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

BIBLIOGRAPHY

Basic:
- Berns, Roy S; Billmeyer, Fred W.; Saltzman, Max. Billmeyer and Saltzman's Principles of color technology . 3rd ed. New york, [etc.] : John Wiley & Sons, cop. 2000. ISBN 047119459X.
- Lee, Hsien-Che. Introduction to color imaging science . Cambridge [etc.] : Cambridge University Press, 2005. ISBN 052184388X.
- Schanda, János. Colorimetry : understanding the CIE system . Hoboken, New Jersey : Wiley-Interscience, cop. 2007. ISBN 9780470049044.
- 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 [Recurs electrònic] . West Sussex : John Wiley, cop. 2007. ISBN 9780470010884.
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- Green, Phil. Understanding digital color . 2nd ed. Pittsburgh : GATFpress, cop. 1999. ISBN 9780883622339.
- Fernandez-Maloigne, Christine. Advanced color image processing and analysis . New Yok: Springer , 2013. ISBN 1441961895.
- Ohta, Noboru; Robertson, Alan A. Colorimetry : fundamentals and applications . Chichester, England ; Hoboken, NJ : Wiley, cop. 2005. ISBN 978-0-470-09472-3.
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