



Course guides

230561 - IMPROCES - Image Processing in Biophotonics

Last modified: 12/06/2020

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).
ERASMUS MUNDUS MASTER'S DEGREE IN PHOTONICS ENGINEERING, NANOPHOTONICS AND BIOPHOTONICS (Syllabus 2010). (Optional subject).

Academic year: 2020 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Artur Carnicer, UB.

Others:

PRIOR SKILLS

Students are expected to be familiar with Python or Matlab

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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 fòtonica 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:

Capacidad para entender el carácter generalista y multidisciplinario de la fòtonica 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.
4. **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.
5. **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.

Basic:

- 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.
- 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
- 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.

TEACHING METHODOLOGY

Problem-based learning

LEARNING OBJECTIVES OF THE SUBJECT

This subject overviews several topics on digital image processing focusing on biophotonics applications. This is a hands-on course that provides an in-depth treatment of image processing techniques, emphasizing software principles and practical implementation. Despite no previous knowledge on digital image processing is required, those students willing to attend this course should be familiar with Python or Matlab computing environments. No background on basic programming techniques will be provided.

STUDY LOAD

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

Total learning time: 75 h



CONTENTS

Lab #1

Description:

Python concepts for image processing

Related activities:

Installation of the The Anaconda Python distribution
Basic procedures in Python

Full-or-part-time: 1h 30m

Guided activities: 1h 30m

Lab #2

Description:

Basic image manipulation: channel processing, colormaps and cameras

Related activities:

Channel extraction
Luminance, colormaps and false color
Gamma and log contrast
Image acquisition using opencv

Full-or-part-time: 3h

Guided activities: 3h

Lab #3

Description:

Image binarization

Related activities:

Adaptive thresholding
Error diffusion binarization (dithering)
Color dithering. The HSV color model

Full-or-part-time: 3h

Guided activities: 3h

Lab #4

Description:

More on color and channel transformations.

Related activities:

RGB coordinates from spectrum data. The CIE 1931 XYZ color model.
Histogram equalization
Image entropy
Least-significant bits steganography
Visual encryption

Full-or-part-time: 3h

Guided activities: 3h



Lab #5

Description:

Fourier transforms and spatial filtering.

Related activities:

Basic operations

Fourier series and filtering of spatial frequencies

Relative importance of amplitude and phase of the Fourier Transform

Spatial filtering: Sharp cut-off low-pass filters, Laplacian filters, Gaussian filters, Butterworth filters, Quasi-periodic noise filtering

Spatial filtering in the image domain: Linear convolution kernels, the Kirsch compass kernel, Salt and Pepper noise and Roberts, Sobel and Prewitt filters

Full-or-part-time: 3h

Guided activities: 3h

Lab #6

Description:

Axial computer tomography

Related activities:

Radon Transforms

The Projection-Slide Theorem

The Filtered Back-Propagation Algorithm.

Full-or-part-time: 3h

Guided activities: 3h

Lab #7

Description:

Remote sensing image-segmentation using classification techniques

Related activities:

Spectral sensing

The k-nearest neighbors algorithm (kNN)

Full-or-part-time: 3h

Guided activities: 3h

Lab #8

Description:

Spherical aberration and out-of-focus images. Image restoration filters.

Related activities:

Calculation of the PSF of an optical system with spherical aberration

Image reconstruction: inverse and least squares filters

Out-of-focus images

Full-or-part-time: 3h

Guided activities: 3h



ACTIVITIES

If possible, a visit to a image processing unit will be scheduled

Full-or-part-time: 2h

Theory classes: 2h

GRADING SYSTEM

Exam. Students have to solve a practical problem based on the topics developed of the syllabus. Students can use documentation, notes and code discussed during the course. The use of their own computer is encouraged and access to the internet will be granted during the exam.

Those students who have not passed the test or prefer not to take the exam, will have to submit the code of all the problems discussed during the course. Grade 5 (pass) will be awarded if 80% of the problems are successfully solved.

BIBLIOGRAPHY

Basic:

- González, R.C.; Woods, R.E. Digital image processing [on line]. 4th ed., global ed. New York, NY: Pearson, 2018 [Consultation: 03/07/2020]. Available on: <https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=5573669>. ISBN 1292223049.

RESOURCES

Hyperlink:

- <http://scikit-image.org/>. The skimage library
- <http://docs.scipy.org/doc>. Scipy documentation
- https://docs.opencv.org/3.4.1/d6/d00/tutorial_py_root.html. OpenCV-Python Tutorials