Course guide
230561 - IMPROCES - Image Processing in Biophotonics

Last modified: 14/12/2023

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: 2023 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

PRIOR SKILLS

Students are expected to be familiar with Python or Matlab

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:
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. 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.
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
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

Problem-based learning

LEARNING OBJECTIVES OF THE SUBJECT

This subject overviews several basic 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 of 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
Hours large group	24,0	32.00
Self study	51,0	68.00

Total learning time: 75 h

CONTENTS

Lab #1

Description:
Python concepts for image processing

Related activities:
Installation of the Anaconda Python distribution
Basic procedures in Python

Full-or-part-time: 1h
Guided activities: 1h

Lab #2

Description:
Basic image manipulation: channel processing, color maps.

Related activities:
Channels, luma, color maps and false color, look-up tables (LUT).

Full-or-part-time: 3h
Guided activities: 3h

Lab #3

Description:
Image binarization

Related activities:
Adaptive thresholding binarization
Error diffusion binarization (dithering)

Full-or-part-time: 3h
Guided activities: 3h

Lab #4

Description:
Color models: RGB, CIE, YCbCr, HSV

Related activities:
RGB coordinates from spectrum data. The CIE 1931 XYZ color model.
The YCbCr color model. Chroma subsampling.
The HSV color space. Use in image fusion.
Histogram equalization. Image entropy.

Full-or-part-time: 3h
Guided activities: 3h

Lab #5

Description:
K-means clustering.

Related activities:
Clustering of aerial images
Indexed color
Applications in biomedicine

Full-or-part-time: 3h 30m
Guided activities: 3h 30m

Lab #6

Description:
Mathematical morphology: Segmentation

Related activities:
Morphology to the rescue
Distance and Watershed transforms
Segmentation, labeling and counting of cells.

Full-or-part-time: 3h 30m
Guided activities: 3h 30m

Lab #7

Description:
Fourier transforms and spatial filtering.

Related activities:
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
Image alignment by cross-correlation.

Full-or-part-time: 3h 30m
Guided activities: 3h 30m

Lab #8

Description:
Applications of Fourier filtering: image restoration and axial computer tomography

Related activities:
Point spread function of an optical system.
Image restoration filters.
Computer tomography. Radon transform.

Full-or-part-time: 3h 30m
Guided activities: 3h 30m

GRADING SYSTEM

Continuous assessment: Students must solve a total of 6 tasks (one per week). The weight of this part is 60% of the final grade.

Exam. Students must solve the proposed practical problem. Students can use the documentation, notes, and code discussed during the course. The use of their computer is encouraged and access to the internet will be granted during the exam. The weight of this part is 40% of the final grade.

Reassessment: Those students who have not passed the subject must submit the code of the totality of the problems discussed during the course. Grade 5 (pass) will be awarded if 80% of the exercises are successfully solved.

EXAMINATION RULES.

The exam will be practical, with full internet access and to the course documentation. The use of automatic code generators is not allowed.

BIBLIOGRAPHY

Basic:

- González, R.C.; Woods, R.E. Digital image processing [on line]. 4th ed., global ed. New York, NY: Pearson, 2018 [Consultation: 28/05/2021]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=5573669. ISBN 1292223049.

RESOURCES

Hyperlink:

- ttps://scikit-learn.org/stable/. Resource
- 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