Course guide
370040 - IMATGE - Digital Image Processing

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

Degree: BACHELOR'S DEGREE IN OPTICS AND OPTOMETRY (Syllabus 2020). (Optional subject).

Academic year: 2025 **ECTS Credits:** 3.0 **Languages:** Catalan, Spanish, English

LECTURER

Coordinating lecturer: María Sagrario Millán García-Varela
https://futur.upc.edu/MariaSagrarioMillanGarciaVarela

Others:

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Transversal:
CT7. Foreign language. Demonstrate knowledge of a foreign language, preferably English, at an oral and written level that is consistent with graduates' future needs.

CT4. (ENG) Teamwork. The ability to work as a member of an interdisciplinary team, as just another member or in a leadership role, who can contribute to developing projects pragmatically and with a sense of responsibility and make commitments that take into account the resources that are available.

Basic:
CB1-OPT. (ENG) Que los estudiantes hayan demostrado poseer y comprender conocimientos en un área de estudio que parte de la base de la educación secundaria general, y se suele encontrar a un nivel que, si bien se apoya en libros de texto avanzados, incluye también algunos aspectos que implican conocimientos procedentes de la vanguardia de su campo de estudio
CB5-OPT. (ENG) Que los estudiantes hayan desarrollado aquellas habilidades de aprendizaje necesarias para emprender estudios posteriores con un alto grado de autonomía

TEACHING METHODOLOGY

MD1- Participatory expository class of theoretical and practical contents.
MD2 - Active classroom methodologies (project-based learning (PBL), case studies, role-playing games, cooperative learning, ...)
MD3 - Practical resolution class, with the participation of the students, of practical cases and/or exercises related to the contents of the subject
MD5 - Reading of didactic material, texts and articles related to the contents of the subject
MD6 - Realization of problems, exercises, works and resolution of doubts through the Atenea virtual campus
MD7- Tutorials

LEARNING OBJECTIVES OF THE SUBJECT

Generic objective: Knowing the concept of digital image and its most relevant applications.
Knowing and understand the main operations to perform on a digital image: improvement, enhancement, restoration, contour extraction, segmentation, data extraction, filtering and noise reduction, among others.
Knowing and understand the processes for manipulating the information contained in an image and its algorithmic expression in the form of a sequence of operations.
Interpretation of results.
Knowing the potential of application in a wide variety of fields of knowledge and entertainment, with an emphasis on biomedical applications.

STUDY LOAD

Type	Hours	Percentage
Hours small group	15,0	20.00
Self study	45,0	60.00
Hours medium group	15,0	20.00

Total learning time: 75 h

CONTENTS

Digital image

Description:
- What is a digital image?
- Fundamentals and initial concepts for digital image description
- Digital image interpretation by the human visual system (amazing features)
– Image representation
– Image sensing and acquisition
– Sampling, quantization and resolution
- Image quality. Signal and noise

Related activities:
Practical session. Hands on an image processing application

Full-or-part-time: 10h
Practical classes: 2h
Laboratory classes: 2h
Self study : 6h

Digital image processing techniques.

Description:
– What is digital image processing?
– Historical overview of digital image processing
– State of the art. Fields of application in all kind of areas of knowledge and entertainment.
– Key stages in a digital image process.
- Algorithms. Examples
- From image processing to machine vision. Low-, mid- and high-level processes

Related activities:
Practical session. Greylevel image, colour image

Full-or-part-time: 10h
Practical classes: 2h
Laboratory classes: 2h
Self study : 6h

Image enhancement

Description:
- What is image enhancement? Distinguishing image enhancement from image analysis.
- Image interpretation. Spatial domain.
– Different kinds of image enhancement working in the spatial domain
– Histogram-based processing operations
– Point-based processing operations

Related activities:
Pràctical session. Point-based operations, Histogram-based operations

Full-or-part-time: 15h
Practical classes: 3h
Laboratory classes: 3h
Self study : 9h

Spatial filtering techniques. Neighbourhood operations

Description:
– Neighbourhood operations
– What is spatial filtering?
– Smoothing operations
– The image edges.
– Convolution
– Sharpening filters. Image sharpening and edge detectors.
1st derivative filters
2nd derivative filters
– Combining spatial filtering techniques

Related activities:
Practical session. Noise and smoothing

Full-or-part-time: 12h 30m
Practical classes: 3h
Laboratory classes: 2h
Self study : 7h 30m

Noise. Morphological processing

Description:
- Image degradation and restoration
- Noise models
- Noise removal using spatial domain filtering
- Periodic noise
- Noise removal using frequency domain filtering
- What is morphology?
- Basic morphological operations in binary images
- Compound operations
- Noise removal using morphological operations

Related activities:
Practical session. Edge detection. Applications: image segmentation and enhancement

Full-or-part-time: 12h 30m
Practical classes: 2h
Laboratory classes: 3h
Self study : 7h 30m

Filtering in the frequency domain

Description:
The imagen content: from the spatial domain to the frequency domain.
The Fourier series and the Fourier transform.
Interpretation of the Fourier transform of an image. Examples.
Operations based on suppression filters.
Low-pass filtering for image smoothing
High-pass filtering for image sharpening

Related activities:
Practical session. Operations in the frequency domain

Full-or-part-time: 15h
Practical classes: 3h
Laboratory classes: 3h
Self study : 9h

ACTIVITIES

Practical session. Hands on an image processing application

Description:
Installation of the program in the personal computer of students for their autonomous learning time.
Basic tools.
Image and pixel information
Point, line and area selection tools
Measuring tools
Intensity profile plots
Thresholding and binarization
ROI (region of interest), ROI manager
Annotations and overlays
Exercises to move freely with the application

Material:
Computer classroom

Delivery:
Report

Full-or-part-time: 5h
Laboratory classes: 2h
Self study: 3h

Practical session. Greylevel image, colour image

Description:
Pixelation. Grey levels
B/W image
Resolution and aliasing
RGB colour image
RGB channels, other channel systems.
RGB decomposition
RGB synthesis
Interpretation. A reference to the human visual system.

Material:
Computer classroom

Delivery:
Report

Full-or-part-time: 5h
Self study: 3h
Laboratory classes: 2h

Practical session. Point-based operations, Histogram-based operations

Description:
Practical exercises on:
Histogram of a greylevel image. Interpretation for a variety of types.
Histogram of a RGB colour image. Interpretation for a variety of types.
Histogram of a selection.
Double threshold. Binarization with double threshold
Contrast
Contrast and brightness change
Linear stretching of the image contrast
Histogram equalization

Material:
Computer classroom

Delivery:
Report

Full-or-part-time: 7h 30m
Laboratory classes: 3h
Self study: 4h 30m

Practical session. Noise and smoothing

Description:
Practical exercises on:
- Types of random noise: Gaussian, salt and pepper, etc.
- Non uniform illumination
- Background noise due to non-uniform illumination
- Smoothing an image. Smoothing filters based on the pixel neighbourhood

Material:
Computer classroom

Delivery:
Report

Full-or-part-time: 6h 30m
Self study: 4h 30m
Laboratory classes: 2h

Practical session. Edge detection. Applications: image segmentation and enhancement

Description:
Practical exercises on:
- Gradient (first derivative) based filters.
- The problem of noise. Sobel filter. Application: Edge detection
- Laplacian (second derivative) based filters. Application: Image sharpening

Material:
Computer classroom

Delivery:
Report

Full-or-part-time: 6h
Self study: 3h
Laboratory classes: 3h

Practical session. Operations in the frequency domain

Description:
Practical exercises on:
- Frequency domain of an image. Fourier transform. Interpretation
- Low-pass filters. Application: image smoothing
- High-pass filters. Application: edge enhancement

Material:
Computer classroom

Delivery:
Report

Full-or-part-time: 7h 30m
Self study: 4h 30m
Laboratory classes: 3h

GRADING SYSTEM

Individual exam (50%)
Reports (50%)
Re-evaluation for those students who have not reached a mark lower than 3,5 with the regular evaluation: Written exam (100%)
Basic skills: CB1 and CB5. They will be evaluated through the practical sessions (Active attendance, reports) and the individual exam.
Transversal skills: CT4 and CT7. They will be evaluated through the practical sessions (work team reports). Grading scale: A,B,C,D and NA (not applicable). Positive evaluation corresponds to A, B and C marks.

BIBLIOGRAPHY

Basic:
- González, Rafael C; Woods, Richard E. Digital image processing [on line]. Fourth edition, Global edition. New York, NY: Pearson, [2018] [Consultation: 16/09/2024]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=5573669. ISBN 9781292223070.
- Volker Baecker. "Image processing and analysis with Image J and MRI Cell image analyzer". Volker Baecker. Image processing and analysis with Image J. Montpelier RIO Imaging (workshop) [on line]. Montpellier, 2015. [Consultation: 09/06/2023]. Available on: https://www.yumpu.com/en/document/view/10578058/workshop-image-processing-and-analysis-with-mri-cnrs.- Mac Namee, Brian. Digital image processing. Course website [on line]. [Consultation: 09/06/2023]. Available on: http://www.comp.dit.ie/bmacnamee.

Complementary:
- Solomon, Chris; Breckon, Toby. Fundamentals of digital image processing: a practical approach with examples in Matlab. Chichester, UK: Wiley-Blackwell, 2011. ISBN 9780470844731.

RESOURCES

Computer material:
- Aula informática y programa libre de procesado de imagen instalado. Computer classroom with freeware installed