# Course guide
# 300265 - IMAGE - Applied Image Processing

**Last modified:** 11/05/2026

**Unit in charge:** Castelldefels School of Telecommunications and Aerospace Engineering
**Teaching unit:** 739 - TSC - Department of Signal Theory and Communications.

**Degree:** MASTER'S DEGREE IN APPLIED TELECOMMUNICATIONS AND ENGINEERING MANAGEMENT (MASTEAM) (Syllabus 2015). (Optional subject).
ERASMUS MUNDUS MASTER IN COMMUNICATIONS ENGINEERING AND DATA SCIENCE (CODAS 1) (Syllabus 2024). (Optional subject).
ERASMUS MUNDUS MASTER IN COMMUNICATIONS ENGINEERING AND DATA SCIENCE (CODAS 2) (Syllabus 2024). (Optional subject).

**Academic year:** 2026 **ECTS Credits:** 3.0 **Languages:** English

## LECTURER

**Coordinating lecturer:** Francesc Tarrés

**Others:** Francesc Tarrés

## PRIOR SKILLS

Signals and Systems, Digital Signal Processing, Digital audiovisual communications fundamentals

## REQUIREMENTS

Pre: No pre-requirements are identifyed in MASTEAM
Co: No co-requirements are identifyed in MASTEAM

## DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

**Generical:**
03 DIS. (ENG) Diseñar aplicaciones de alto valor añadido basadas en las Tecnologías de la Información y las Comunicaciones (TIC), aplicadas a cualquier ámbito de la sociedad.

**Transversal:**
03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

**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 will be able to apply the acquired knowledge and their ability to solve problems in new or little explored environments in broader (or multidisciplinary) contexts related to their study area.

## TEACHING METHODOLOGY

Teaching is based mainly on lectures and some case studies which are analyzed with some detail. Lectures introduce image processing concepts, mathematic tools, algorithms, methods and technologies which are involved in the design of practical image processing and computer vision systems. Lectures are based on a collection of slides and additional notes provided as accompanying hangouts to the lecture.

Every lesson is summarized with a collection of exercises or computer exercises that help the student to summarize the theoretical and practical concepts. Computer exercises are acompanied with practical study cases that the student has to analyze carefully and select the best solution to the problem. Solutions have to developed in high level languages such as Python, OpenCV or Matlab and are presented as guided activities in class. Assesment is evaluated through test questions, exams and reports of case studies solutions

## LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course the student should be able to:

To know the technologies and characteristics of camera systems, capture and representation technologies in computer vision systems

Be able to select between different algorithms for extraction the useful information in still images and video. Understand algorithms for image enhacement and segmentation based on local or global features.

Know, understand and be able to select possible alternatives for computer video analysis based on salient feature analysis and other low level descriptors such as color color, motion and shape.

Understand and be able to used several deep learning architectures and learning algoruthms for image classification and object detection.

Have a perspective of different software packages and hardware components for developing custumer solutions using computer visions systems

## STUDY LOAD

| Type | Hours | Percentage |
|---|---|---|
| Hours small group | 3,0 | 4.05 |
| Hours large group | 23,0 | 31.08 |
| Self study | 48,0 | 64.86 |

**Total learning time:** 74 h

## CONTENTS

### Introduction to Digital Image Processing

**Description:**
Presentation of algorithms and strategies for image enhancement

**Specific objectives:**
Point transforms. Histogram and Image equalization. Automatic Binarization: k-means, Otsu Methods. Image Linear Filtering. Gradient estimation filters. Contour estiomation using second derivatives: Marr-Hildreth. Non-linear filters. Basic morphological operations. Dilation, erosion, top-hat

**Related activities:**
Activity 1, 6, 7

**Full-or-part-time:** 11h
Theory classes: 4h
Self study : 7h

### Cameras, Optics and Acquisition Systems

**Description:**
content This chapter introduces some basic principles of image formation and optics to help selection of optical parameters in computer vision applications. A perspective on cameras, ilumination and acquisition devises is also provided

**Specific objectives:**
Fundamentals of optics. Selecting the optics in different computer vision aplications. Types of cameras. Light and principles of lighting in computer vision applications. Types of lighting. Capturing images and video: frame grabbers, digital interfaces.

**Related activities:**
Activity 2, 6, 7

**Full-or-part-time:** 8h
Theory classes: 3h
Self study : 5h

### Contour Detection and Segmentation

**Description:**
This chapter covers the classic algorithm for image segmentation based on contour or region analysis. It reviews the main techniques on image segmentation.

**Specific objectives:**
Canny method for contour detection. Hough Transform. Region Segmentation Techniques: Split & Merge, Region Growing, Watersheds. Region representation using contours. Graph Based segmentation. GraphCut

**Related activities:**
Activity 3, 6, 7

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

**Feature Extraction and Its Applications in Computer Vision**

**Description:**
This chapter presents different techniques for extracting automatic features of an image and discusses alternatives for using these features and their descriptors to object detection and recognition

**Specific objectives:**
Defiining interest points, saliencies, corners, etc. Basic methods for corner extraction: Moravec, Harris, shi-tomasi, Nobles, Trigg, Broen.

Detection of interest points: Kadir & Brady, SUSAN: edge and corner detection, FAST corner detector.

Blob Detection. Laplacian of a Gaussian and Difference of Gaussians. MSER

Scale Invariant Feature Detection (SIFT). SIFT Variants: SURF, GLOH, BRISK, ORB, etc.

Face and person detection. Adaboost and Histogram of Gradients.

**Related activities:**
Activity 4, Activity 7

**Full-or-part-time:** 24h
Theory classes: 6h
Laboratory classes: 2h
Self study : 16h

**Convolutional Neural Networks and Applications to Image Classification and Object Detection**

**Description:**
Fundamentals of neural networks and deep learning are presented in the context of image recognition. The main architectures for image classification and object detection are covered. Examples are presented using Tensorflow or Pytorch developing environments

**Specific objectives:**
Introduction to Neural Networks and history. Neuron models. Elemental clasifiers. Linear regression. Learning Models. Multilayer perceptrons. Backpropagation. Training, Test and Validation. Batches and Epochs. Loss functions. Regularization. Data augmentation. Convolutional Neural Networks and main architectures: AlexNet, ZF Net, VGG Net, Inception, Resnet. Object detection and segmentation: R-CNN, Fast R-CNN, Faster R-CNN, Yolo, SSD, Retina Net, Yolo V3.

**Related activities:**
Activity 5, Activity 7

**Full-or-part-time:** 25h
Theory classes: 6h
Practical classes: 2h
Self study : 17h

## ACTIVITIES

### Activity 1. Computer exercise: Image Enhancement and basic analysis techniques

**Description:**
This activity is a computer exercise. The student have the option of developing the exercise using Python with the library scikit images or Matlab. The activity covers different algorithm already covered in class: equalization, automatic binarization, labelling, non-linear filtering, etc.

**Specific objectives:**
The main objective is to emphasize and consolidate the knowledge on image enhancement techniques that are studied in the first chapter

**Material:**
Document describing the activity, software to be used and questions to solve

**Delivery:**
Report of the activity

**Related competencies :**
03 DIS. (ENG) Diseñar aplicaciones de alto valor añadido basadas en las Tecnologías de la Información y las Comunicaciones (TIC), aplicadas a cualquier ámbito de la sociedad.
03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
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 will be able to apply the acquired knowledge and their ability to solve problems in new or little explored environments in broader (or multidisciplinary) contexts related to their study area.

**Full-or-part-time:** 2h
Self study: 2h

### Activity 2. Exercises for cameras, optics and acquisition system

**Description:**
This exercise is a questionaire with different problems including concepts of cameras, geometric optics and acquisition systems

**Specific objectives:**
Emphasize and improve the knowledge on optics, cameras and acquisition systems

**Material:**
Documentation including the problems, questions and systems that the student has to obtain further information

**Delivery:**
The student has to deliver a report with her answers to the questionnaire

**Full-or-part-time:** 2h
Self study: 2h

**Activity 3. Computer Exercise. Contour Detection and Segmentation**

**Description:**
The activity consist in implementing a series of contour detection and sigmentation algorithm in practical cases using Python and the OpenCV library

**Specific objectives:**
The objective is to consolidate through a series of computer exercises the methods studied in module 3

**Material:**
Documentation including the different computer exercises to perform and a series of images to analyze

**Delivery:**
The student has to deliver a report with the activity performed

**Full-or-part-time:** 2h
Self study: 2h

**Activity 4. Computer Exercise. Feature Extraction.**

**Description:**
This activity proposes a series of computer exercises to analyze the performance of different algorithm for automatic feature extraction. The computer exercise is proposed in Matlab but students may implement it in any other language if they feel more comfortable

**Specific objectives:**
The objective is to consolidate through a series of computer exercises the methods studied in module 4

**Material:**
Documentation including the different computer exercises to perform and a series of images to analyze

**Delivery:**
The student has to deliver a report with the activity performed

**Full-or-part-time:** 2h
Self study: 2h

**Activity 5. Computer Exercise. Artificial Neural Networks for Image Classification**

**Description:**
The student has to program different architectures of artificial neural networks for recognizing different types of images. The first part of the exercise proposes to classify the MNIST handwritten digit database using 3 different approaches that cover a linear classifier a multilayer perceptron and a convolutional neural network. A second part of the exercise proposes to train and test a CNN to classify fruits.

**Specific objectives:**
The objective is to consolidate through a series of computer exercises the methods studied in module 5

**Material:**
Documentation including the different computer exercises and databases to perform and a series of images to analyze

**Delivery:**
The student has to deliver a report with the activity performed

**Full-or-part-time:** 2h
Self study: 2h

**Activity 6. Control Exam**

**Description:**
This exercise is an exam with questions about modules 1-2-3

**Specific objectives:**
Verify assessment of the first 3 modules

**Material:**
Question Sheet

**Delivery:**
After finishing the 90 min session

**Full-or-part-time:** 1h 30m
Practical classes: 1h 30m

**Activity 7. Final Exam**

**Description:**
This exercise is an exam with questions about all the course

**Specific objectives:**
Verify assessment of the course contents

**Material:**
Question Sheet

**Delivery:**
After finishing the exam

**Full-or-part-time:** 2h
Practical classes: 2h

## GRADING SYSTEM

Any academic fraud, plagiarism or use or possession of unauthorised means in an assessment activity leads to a mark of zero (0) for the affected test or assignment. Furthermore, in accordance with the University's regulations, if disciplinary proceedings are initiated the subject is recorded as "Pending Assessment" until a decision is reached. These incidents are managed in accordance with the **Action Framework for Academic Integrity in Assessment at the UPC**.

Evaluation takes into account the following topics

30 % Final Exam
20 % Control Exam
20 % Exercises and Computer Exercises Modules 1-2-3
20 % Exercises and Computer Exercises Modules 4-5
10 % Participation

## EXAMINATION RULES.

Exams consist on short questions, problems and a True/False Quiz.

The exercises and computer exercises have to be presented individually in a report and answering the different questions.

## BIBLIOGRAPHY

**Basic:**
- Shapiro, Linda G; Stockman, George C. Computer vision. Upper Saddle River: Prentice Hall, cop. 2002. ISBN 0130307963.
- Parker, J. R. Algorithms for image processing and computer vision. 2nd ed. New York, [etc.]: John Wiley & Sons, cop. 2011. ISBN 9780470643853.
- Géron, Aurélien. Hands-on machine learning with scikit-learn & tensorflow : concepts, tools, and techniques to build intelligent systems [on line]. Sebastopol, CA: O'Reilly Media, Inc, [2017] [Consultation: 26/07/2022]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=4822582. ISBN 9781491962299.