Course guide
295106 - 295II022 - Computer Vision

Last modified: 02/10/2025

Unit in charge: Barcelona East School of Engineering
Teaching unit: 707 - ESAII - Department of Automatic Control.
749 - MAT - Department of Mathematics.
717 - DEGD - Department of Engineering Graphics and Design.

Degree: MASTER'S DEGREE IN INTERDISCIPLINARY AND INNOVATIVE ENGINEERING (Syllabus 2019). (Compulsory subject).
ERASMUS MUNDUS MASTER IN SUSTAINABLE SYSTEMS ENGINEERING (EMSSE) (Syllabus 2024). (Optional subject).
MASTER'S DEGREE IN ADVANCED BIOMEDICAL TECHNOLOGIES (Syllabus 2025). (Optional subject).

Academic year: 2025 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: KEVIN IVAN BARRERA LLANGA

Others: Primer quadrimestre:
KEVIN IVAN BARRERA LLANGA - Grup: T1
ANTONI GRAU SALDES - Grup: T1
EDMUNDO GUERRA PARADAS - Grup: T1
JORDI TORNER RIBE - Grup: T1

PRIOR SKILLS

Programming. Basic statistics.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEMUEII-10. Design and implement image analysis systems for the advanced characterization of complex systems in engineering.

Generical:
CGMUEII-01. Participate in technological innovation projects in multidisciplinary problems, applying mathematical, analytical, scientific, instrumental, technological and management knowledge.

Transversal:
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
06 URI. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.
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.

LEARNING RESULTS

Knowledges:
K5. Describe advanced knowledge of analysis and interpretation of biomedical signals.
K7. Infer advanced knowledge of digital biomarkers and artificial intelligence techniques in health technologies.
K1. Relate advanced knowledge of biomechanics, biomaterials, implants and prostheses to the design of medical devices.
K8. Demonstrate advanced knowledge of digital and mobile health applications (mHealth).

Skills:
S7. Design advanced computer vision and robotics applications in healthcare.
S01. Communicate effectively in oral, written and graphic form with others regarding learning, the development of ideas and decision making, and participate in discussions using interpersonal skills such as active listening and empathy, which foster teamwork.
S05. Apply pattern recognition, artificial intelligence and statistical data analysis techniques to make objective, quantitative and reproducible decisions in multidisciplinary problems.
S06. Use appropriate computational techniques to simulate engineering systems, and adapt and apply optimisation algorithms to engineering problems.

Competences:
C6. Integrate the values of sustainability and understand the complexity of systems, with the aim of undertaking or promoting actions that restore and maintain the health of ecosystems and improve justice, thereby generating visions of sustainable futures.
C2. Apply management methodologies to projects, teams and biomedical products and technologies that are appropriate to the type of project.
C3. Identify and analyse problems that require making autonomous, informed and reasoned decisions in order to act with social responsibility following ethical values and principles.

TEACHING METHODOLOGY

LEARNING OBJECTIVES OF THE SUBJECT

• Recognize different image modalities and their applications.
• Perform advanced manipulations of digital images stored in different file formats.
• Perform automatic segmentation and extraction of descriptors.
• Develop and implement algorithms for the automatic recognition of special patterns in images based on machine and deep learning methods.
• Getting an overview to VR development with Unity and introducing VR elements and user input.
• Introducing to different VR technologies and building an application.
• Publishing apps in Unity and exporting to mobile devices.
• Design and implement appropriate pipelines for specific real problems, including input datasets, decision on the most appropriate techniques and interpretation of the results.
• Generate high level reports including developments, evaluations and conclusions.

STUDY LOAD

Type	Hours	Percentage
Hours large group	27,0	18.00
Self study	96,0	64.00
Hours small group	27,0	18.00

Total learning time: 150 h

CONTENTS

Image processing

Description:
• Image preprocessing: intensity transformations, spatial and statistical filters, filtering in the frequency domain
• Image segmentation: Otsu, watersehed, morphological operations
• Feature extraction: geometrical descriptors, color spaces, texture analysis

Specific objectives:
Understand the essential steps from an original image to its final representation by means of quantitative descriptors.

Related activities:
Laboratory session 1: Image preprocessing
Laboratory session 2: Segmentation and features

Full-or-part-time: 12h
Theory classes: 8h
Laboratory classes: 4h

Pattern recognition in images

Description:
• Machine learning based on features: Linear discriminant analysis, Bayes classifier, principal component analysis, decision trees and support vector machines.
• Deep learning: blocks of deep neural networks, convolutional filters, training, forward and backward propagation, parameters and hyperparameters.
• Specialized architectures and codes for structured implementations.

Specific objectives:
Understand the theoretical background, formulate problems in biomedical and other application areas, develop and implement computer codes and be able to decide which algorithms perform better for each problem.

Related activities:
Laboratory session 3: Machine learning
Laboratory session 4: Convolutional neural networks 1
Laboratory session 5: Convolutional neural networks 2

Full-or-part-time: 16h
Theory classes: 10h
Laboratory classes: 6h

Virtual reality

Description:
• Overview of virtual reality (VR) hardware and software to learn different ways to get started with this technology.
• Practical cases of current applications ongoing in the biomedical sector.

Specific objectives:
Develop and publish VR apps using Unity 3D platform. Presenting biomedical applications practical cases: Rehabilitation, surgical planning, 3D reconstruction, cognitive training, and others.

Related activities:
Laboratory session 6:
Laboratory session 7:
Laboratory session 8:
Laboratory session 9:

Full-or-part-time: 12h
Theory classes: 4h
Laboratory classes: 8h

Applications

Description:
Applications of the methodologies to practical problems in areas like:
Robotics
Medical images
Satellite images
Virtual reality

Specific objectives:
Understand and solve specific problems using real data.

Related activities:
Laboratory session 10: Application.

Full-or-part-time: 14h
Theory classes: 12h
Laboratory classes: 2h

GRADING SYSTEM

Partial exam 45%
Projects 55%
The students will be able to access the re-assessment test that meets the requirements set by the EEBE in its Assessment and Permanence Regulations (https://eebe.upc.edu/ca/estudis/normatives-academiques/documents/eebe-normativa-avaluacio-i-permanencia-18-19-aprovat-je-2018-06-13.pdf)

BIBLIOGRAPHY

Basic:
- González, Rafael C.; Woods, Richard E. Digital image processing. 3rd ed., international ed. Upper Saddle River: Pearson Education Internacional, cop. 2010. ISBN 9780132345637.
- Webb, Andrew R. Introduction to biomedical imaging. Hoboken (N.J.): Wiley, cop. 2003. ISBN 0471237663.
- James, Gareth. An introduction to statistical learning : with applications in R. New York: Springer, 2013. ISBN 9781461471370.
- Géron, Aurélien. Hands-on machine learning with Scikit-Learn and TensorFlow : concepts, tools, and techniques to build intelligent systems [on line]. Sebastopol, CA: O'Reilly Media, 2017 [Consultation: 21/04/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=4822582. ISBN 9781491962299.
- Raschka, Sebastian; Mirjalili, Vahid. Python machine learning : machine learning and deep learning with Python, scikit-learn, and TensorFlow [on line]. 2nd ed. Birmingham, UK: Packt Publishing, 2017Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=5050960. ISBN 9781787126022|.

RESOURCES

Other resources:
Contents and software uploaded to Atenea