Course guide
240AR015 - 240AR015 - Computer Vision

Last modified: 16/05/2023

Unit in charge:	Barcelona School of Industrial Engineering
Teaching unit:	707 - ESAII - Department of Automatic Control.

Degree:	MASTER'S DEGREE IN AUTOMATIC CONTROL AND ROBOTICS (Syllabus 2012). (Compulsory subject).
	MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Optional subject).

Academic year: 2023 **ECTS Credits:** 4.5 **Languages:** English

LECTURER

Coordinating lecturer:	ALBERTO SANFELIU CORTES
Others:	Primer cuatrimestre:
	JUAN ARANDA LÓPEZ - 10, 10, 10
	ALBERTO SANFELIU CORTES - 10, 10, 10

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. The student know selecting appropriate software and hardware elements to implement a solution in a system wardrobe.
2. The student will be able to recognize and represent problems in the area by automatic and robotic techniques optimization, and then apply analytical methods / numerical resolution.
3. The student will be able to select, plan, and evaluate different techniques to detect, extract and analyze data an image or sequence of images.

Generical:
4. Have adequate mathematical skills, analytical, scientific, instrumental, technological, and management information.
5. Ability to conduct research, development and innovation in the field of systems engineering, control and robotics, and as to direct the development of engineering solutions in new or unfamiliar environments, linking creativity, innovation and transfer of technology
6. Ability to reason and act based on the so-called culture of safety and sustainability

Transversal:
7. 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.

8. 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.

9. 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.

10. 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.

Basic:
CB 7. (ENG) Que els estudiants sàpiguen aplicar els coneixements adquirits i la seva capacitat de resolució de problemes en entorns nous o poc coneguts dintre de contextos més amplis (o multidisciplinars) relacionats amb la seva àrea d'estudi.
CB 8. (ENG) Que els estudiants siguin capaços de d'integrar coneixements i enfrentar-se a la complexitat de formular judicis a partir d'una informació que, essent incompleta o limitada, inclogui reflexions sobre les responsabilitats socials i ètiques vinculades a l'aplicació del seus conexicements i judicis.

TEACHING METHODOLOGY

The methodology of the course will be of master classes of 2 h/session, where the teacher will explain the theory and will introduce exercises to improve the understanding of the subject. Moreover, there will be laboratory classes of 2 h/session, where the student will use cameras and illumination systems and will practise with software computer vision techniques on predefined images.

LEARNING OBJECTIVES OF THE SUBJECT

The computer vision goal is to model real world and to recognise objects from digital images. These images can be acquired using cameras and video cameras, infrared cameras, radars, or specialised sensors such as those used in the medical field. The students will learn the fundamentals of the design of computer vision techniques and their applications for detection, identification, recognition, classification, tracking, etc. The students will acquire theoretical and practical knowledge in computer vision techniques to process and analyse images and sequence of images (videos). They will apply some of these techniques in a short project where they will have to prove their acquired knowledge.

Learning Outcomes:
- Use probabilistic models applied to robotics and computer vision.
- Understand the mechanisms of digital imaging and digital processing characteristics thereof.
- Extract information from digital images which are being processed, segment them and extract features.
- Use techniques for the analysis and interpretation of objects in images and tracking of moving objects.

Mandatory Contents:
- Digital imaging and processing
- Image segmentation
- Detection and description of features
- Modelling 2D and 3D objects
- Stereo vision
- Correspondence and motion detection

STUDY LOAD

Type	Hours	Percentage
Guided activities	8,1	6.76
Hours small group	8,1	6.76
Hours large group	22,5	18.78
Hours medium group	9,1	7.60
Self study	72,0	60.10

Total learning time: 119.8 h

CONTENTS

Problem domain

Description:
This topic will deal with:
- Basic concepts
- Image formation

Specific objectives:
CB1, CB2, CB3, CB4, CB5, CG1, CG3, CG8, CT2, CT3, CT4, CT5, CT7, CE7, CE9, CE13

Related activities:
Lectures

Full-or-part-time: 4h
Theory classes: 2h
Self study : 2h

Digital image processing

Description:
This topic deals with:
- Geometric transformations
- Linear and nonlinear filtering
- Image enhancement and smoothing
- Scale space
- Mathematical morphology

Specific objectives:
CB1, CB2, CB3, CB4, CB5, CG1, CG3, CG8, CT2, CT3, CT4, CT5, CT7, CE7, CE9, CE13

Related activities:
Master class, lab practices, resolution of problems and independent learning through exercises

Full-or-part-time: 12h
Theory classes: 4h
Practical classes: 2h
Self study : 6h

Segmentation and feature extraction

Description:
This topic deals with:
- Region based segmentation (binarization, watershed, mean-shift, normalized cuts)
- Contour detection (Canny, LoG, DoG)
- Connectivity analysis and labelling
- Basic edge and region feature extraction

Specific objectives:
CB1, CB2, CB3, CB4, CB5, CG1, CG3, CG8, CT2, CT3, CT4, CT5, CT7, CE7, CE9, CE13

Related activities:
Master class, lab practices, resolution of problems and independent learning through exercises

Full-or-part-time: 10h 30m
Theory classes: 3h
Practical classes: 1h 30m
Self study : 6h

Feature detection and descriptors

Description:
This topic deals with:
- Concepts on feature invariants
- Point feature detection and descriptors (Harris, HoG, Random Ferns, SIFT)
- Line feature detection and descriptors (Hough transform)

Specific objectives:
CB1, CB2, CB3, CB4, CB5, CG1, CG3, CG8, CT2, CT3, CT4, CT5, CT7, CE7, CE9, CE13

Related activities:
Master class, lab practices, resolution of problems and independent learning through exercises

Full-or-part-time: 12h
Theory classes: 4h
Practical classes: 2h
Self study : 6h

Representation and description

Description:
This topic deals with:
- Contour descriptors (Freeman chain, Fourier descriptors, shape context)
- Region and texture description (concurrence matrix, image moments, PCA)

Specific objectives:
CB1, CB2, CB3, CB4, CB5, CG1, CG3, CG8, CT2, CT3, CT4, CT5, CT7, CE7, CE9, CE13

Related activities:
Master class, lab practices, resolution of problems and independent learning through exercises

Full-or-part-time: 7h
Theory classes: 2h
Practical classes: 1h
Self study : 4h

Classification and Recognition

Description:
This topic deals with:
- Basic concepts
- Type of classifiers
- Matching
- Classifiers (Bayes, Mahalanobis, Fisher, K-nearest neighborhood)
- Boosting

Specific objectives:
CB1, CB2, CB3, CB4, CB5, CG1, CG3, CG8, CT2, CT3, CT4, CT5, CT7, CE7, CE9, CE13

Related activities:
Master class, lab practices, resolution of problems and independent learning through exercises

Full-or-part-time: 12h
Theory classes: 4h
Practical classes: 2h
Self study : 6h

Motion detection

Description:
This topic deals with:
- Basic concepts
- Image difference
- Optical flow
- Point correspondence
- Tracking

Specific objectives:
CB1, CB2, CB3, CB4, CB5, CG1, CG3, CG8, CT2, CT3, CT4, CT5, CT7, CE7, CE9, CE13

Related activities:
Master class, lab practices, resolution of problems and independent learning through exercises

Full-or-part-time: 12h
Theory classes: 4h
Practical classes: 2h
Self study : 6h

GRADING SYSTEM

Along the course, the student will have to solve specific exercises of the different topics of the subject. The exercises will be evaluated by the professor. There will also be a short project that will be selected by the student, where he/she will have to demonstrate the acquired knowledge. This short project will be presented and evaluated in an oral presentation. For the solution of some of the exercises and the complete project, the students will use a programming language.

For this course 2020-2021, due to the impact of the Convid-19 at the teaching of the subject and his evaluation, the evaluation will modify of the following form.â□¨â□¨

The final note will compound from four partial notes:â□¨â□¨

- Evaluation of the laboratory exercises of practices in Matlab: 25% of the noteâ□¨
- Evaluation of the short-projects: 25% of the noteâ□¨
- Evaluation of the class exercises: 15% of the note
- Evaluation of the final exam: 35% of the note

EXAMINATION RULES.

For this course 2020-2021, because of the impact that is having the Convid-19 at the teaching of the subject and his evaluation, the final examination will be of the following form:â□¨â□¨

- The final examination will consist of a combination of conceptual questions and exercises

BIBLIOGRAPHY

Basic:

- Sonka, Milan; Hlavac, Vaclav; Boyle, Roger. Image processing, analysis and machine vision. 4th ed. Pacific Grove: Cengage, cop. 2015. ISBN 9781133593690.
- Duda, Richard O; Peter E. Hart ; David G. Stork. Pattern classification [on line]. 2nd ed. New York: John Wiley & Sons, cop. 2001 [Consultation: 29/06/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=699526. ISBN 0471056693.
- Szeliski, R. Computer vision : algorithms and applications [on line]. 2nd ed. Cham, Switzerland: Springer, 2022 [Consultation: 03/04/2023]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=973471. ISBN 9783030343729.
- González, Rafael C ; Woods, Richard E. Digital image processing [on line]. 4th ed. New York: Pearson Prentice Hall, 2018 [Consultation: 19/10/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=5573669. ISBN 9781292223049.

Complementary:

- Bunke, Horst; Sanfeliu, Alberto. Syntactic and structural pattern recognition : theory and applications. Singapore ; New Jersey: World Scientific, cop. 1990. ISBN 9971505525.
- Klette, Reinhard; Schlüns, Karsten; Koschan, Andreas. Computer vision : three-dimensional data from images. Singapore: Springer-Verlag, 1998. ISBN 9813083719.
- Trucco, Emanuele; Verri, Alessandro. Introductory techniques for 3-D computer vision. Upper Saddle River: Prentice Hall, cop. 1998. ISBN 0132611082.
- Forsyth, David A; Ponce, Jean. Computer vision : a modern approach [on line]. 2nd ed. Boston, Mass: Pearson Education, cop. 2012 [Consultation: 07/10/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=5173504. ISBN 9780273764144.
- González, Rafael C; Woods, Richard E; Eddins, Steven L. Digital Image processing using MATLAB. 2nd ed. s.l: Gatesmark Publishing, 2009. ISBN 9780982085400.

RESOURCES

Other resources:

MatLab program to do lab practices