Course guide
270181 - VC - Computer Vision

Last modified: 30/01/2024

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

Degree: BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: JUAN CLIMENT VILARÓ

Others: Primer quadrimestre:
JUAN CLIMENT VILARÓ - 11, 12

Segon quadrimestre:
MANEL FRIGOLA BOURLON - 11, 12

PRIOR SKILLS

It is recommended that the student has passed the courses Probability and Statistics (PE) and Programming Project (PROP).

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CCO2.2. Capacity to acquire, obtain, formalize and represent human knowledge in a computable way to solve problems through a computer system in any applicable field, in particular in the fields related to computation, perception and operation in intelligent environments.
CCO2.3. To develop and evaluate interactive systems and systems that show complex information, and its application to solve person-computer interaction problems.
CCO2.4. To demonstrate knowledge and develop techniques about computational learning; to design and implement applications and system that use them, including these ones dedicated to the automatic extraction of information and knowledge from large data volumes.
CT1.2A. To interpret, select and value concepts, theories, uses and technological developments related to computer science and its application derived from the needed fundamentals of mathematics, statistics and physics. Capacity to solve the mathematical problems presented in engineering. Talent to apply the knowledge about: algebra, differential and integral calculus and numeric methods; statistics and optimization.
CT2.5. To design and evaluate person-computer interfaces which guarantee the accessibility and usability of computer systems, services and applications.
CT4.1. To identify the most adequate algorithmic solutions to solve medium difficulty problems.
CT4.3. To demonstrate knowledge and capacity to apply the fundamental principles and the basic techniques of the intelligent systems and its practical application.
CT5.2. To know, design and use efficiently the most adequate data types and data structures to solve a problem.
CT5.5. To use the tools of a software development environment to create and develop applications.
CT8.1. To identify current and emerging technologies and evaluate if they are applicable, to satisfy the users needs.

Generical:
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

TEACHING METHODOLOGY

The teaching methodology will be in general deductive. Attempt to flee the classic lecture methodology. The approach is always the same
- to propose a problem
- trying to solve it
- add pieces of theory needed to solve the problem.
During practices we'll work also cooperative learning and independent learning by the resolution of a shortproject.

LEARNING OBJECTIVES OF THE SUBJECT

1.Understanding the mechanisms of digital imaging and their features thereof.
2.Compare and select the proper tools for image preprocessing based on the problem to solve.
3.Understand, design and implement in an efficient way the most suitable descriptors for the characterization of regions, singular points or edges of an image.
4.Detect and identify the presence of certain items in a picture.
5.Successfully perform experiments designed to evaluate the chosen or proposed methods, their limitations and weaknesses, based on objective results .
6.Detect moving targets in a scene and tracking them.
8.Segment and label the parts of an image from its common characteristics and / or differences.

STUDY LOAD

Type	Hours	Percentage
Self study	84,0	56.00
Hours large group	30,0	20.00
Hours small group	30,0	20.00
Guided activities	6,0	4.00

Total learning time: 150 h

CONTENTS

The digital image

Description:
Digital image properties. Discretization and quantification. Colour spaces

Digital image processing

Description:
Grey-level transformations.
Geometric transformations
Linear operators. Convolution. Image smoothing and enhancement
Edge detection
Non linear operators. Morphological filters.
Scale space

Image segmentation

Description:
Binarization.
Region based segmentation: region growing, split & merge, watershed, k-means, normalized cuts....
Edge based segmentation: LoG, DoG, Canny...
Connectivity analysis and labelling, adjacency graph

Shape descriptors

Description:
Edge based descriptors
Region based descriptors
Translation, rotation, illumination, affine transformation, and/or scale invariance

Recognition

Description:
Feature vectors classification.
Clustering and learning.
Distance functions.
Classifiers: Bayes, Mahalanobis, Fisher, K-nearest,...
Methods for evaluating a classification.
PCA. Dimensionality reduction.

Local features

Description:
Histogram based descriptors: Colour histograms, HOGs.
Hough transform.
Keypoint detectors and descriptors: Harris, SIFT.
Haar-like features. Face Detection using Viola-Jones

Motion analysis

Description:
Difference image. Optical flow. Keypoint correspondence. Tracking.

ACTIVITIES

What is an image? What information does it contain?

Description:
Capturing digital images, properties and features. Image Formation.

Specific objectives:
1

Full-or-part-time: 8h
Practical classes: 4h
Self study: 4h

Digital image processing

Description:
Image histogram, modifications, enhancement. Spatial and frequency filtering. Morphological filters. Geometric transformations. Scale space

Specific objectives:
2

Full-or-part-time: 38h
Practical classes: 18h
Self study: 20h

Image segmentation

Description:
Techniques based on regions: Binarization, watershed, mean-shift, normalized cuts .... Techniques based on contours: Gradients, LoG, DoG, Canny ... Connectivity and labeling analysis, adjacency graph.

Specific objectives:
5, 8

Related competencies :
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

Full-or-part-time: 18h
Practical classes: 8h
Self study: 10h

Feature detection and description.

Description:
Local and global features. REgion descriptors, contours and keypoints. Concept of invariance in translation, rotation and scale

Specific objectives:
3, 5

Related competencies :
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

Full-or-part-time: 20h
Practical classes: 14h
Self study: 6h

Recognition

Description:
Basic concepts. Classification by means of descriptor vectors. Construction of classes (Clustering, learning ...) Distance functions. Types of classifiers: Bayes, Mahalanobis, Fisher, K-nearest, ... Identification of objects. Category recognition.

Specific objectives:
4, 5

Related competencies :
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

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

Motion detection and analysis

Description:
Image difference. Optical flow. Point correspondence. Object tracking.

Specific objectives:
4, 5, 6

Related competencies :
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

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

Design and develop a simple computer vision application (short-project).

Description:
The student will have to choose and combine the methods and techniques that he finds more suitable to give solution to the presented problem. You will need to evaluate your work by designing test sets and delineating the scope of the proposed solution.

Specific objectives:
1, 2, 3, 4, 5, 8

Related competencies :
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

Full-or-part-time: 30h
Practical classes: 6h
Self study: 24h

Goal achievement control.

Description:
Knowledge test.

Specific objectives:
1, 2, 8

Full-or-part-time: 5h
Guided activities: 1h
Self study: 4h

Monitoring control of the short-project

Description:
The student must present a partial report on the evolution of the mini-project: design decisions and initial tests if any, as well as a temporary planning of the missing work. This is a test to monitor the correct evolution of the mini-project. It also serves to re-orient the student if necessary.

Specific objectives:
2, 3, 5, 8

Related competencies :
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

Full-or-part-time: 1h
Self study: 1h

Presentation of the results of the short-project

Description:
The student makes a presentation of his short-project.

Specific objectives:
2, 3, 4, 5, 8

Related competencies :
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

Full-or-part-time: 3h
Self study: 3h

Goal achievement test

Specific objectives:
3, 4, 5, 6, 8

Related competencies :
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

Full-or-part-time: 11h
Guided activities: 1h
Self study: 10h

GRADING SYSTEM

Throughout the course, a series of exercises will be requested to evaluate the student. There will be no final exam.
NL will be obtained from the practices done compulsorily in class personally and the deliveries of the homework.
NT will be obtained from the partial exams.

The final mark of the subject will be calculated as follows: NF = 0'7NL+ 0'3NT

The evaluation of the transversal competence (Autonomous Learning) will be calculated taking into account the capacity of the student by :
. detect one's own lack of knowledge about the proposed problem
. look for possible solutions to the problem posed (search for bibliography-study of the state of the art) .
. know how to assess when you have enough information to solve the problem posed .
. choose the right solution (adapting or improving an existing one) or know how to assess whether it is necessary to create a new one
. defend the chosen solution against other solutions based on objective arguments (results).

BIBLIOGRAPHY

Basic:
- Szeliski, R. Computer vision : algorithms and applications. Springer, 2011. ISBN 9781848829343.
- Sonka, M.; Vaclav, H.; Roger, B. Image processing, analysis, and machine vision. 4th ed. Cengage Learning, 2014. ISBN 1133593690.

Complementary:

- González, R.C.; Woods, R.E.; Eddins, S.L. Digital image processing using Matlab. 2nd ed. McGraw Hill, 2010. ISBN 9780070702622.
- Gonzalez, R.C.; Woods, R.E. Digital image processing. 4th ed, global ed. Pearson, 2018. ISBN 1292223049.
- Jain, R.; Kasturi, R.; Schunck, B.G. Machine vision. McGraw-Hill, 1995. ISBN 0070320187.