Course guide
270422 - VO - Computer Vision

Unit in charge: Barcelona School of Informatics
Teaching unit: 707 - ESAII - Department of Automatic Control.
Degree: BACHELOR'S DEGREE IN ARTIFICIAL INTELLIGENCE (Syllabus 2021). (Compulsory subject).
Academic year: 2023
ECTS Credits: 6.0
Languages: Catalan, Spanish

LECTURER

Coordinating lecturer:

Others:

PRIOR SKILLS

Linear algebra, vector calculus, and probability.
Data structures and Programming

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE01. To be able to solve the mathematical problems that may arise in the field of artificial intelligence. Apply knowledge from: algebra, differential and integral calculus and numerical methods; statistics and optimization.
CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems. To be able to apply all these for solving problems.
CE03. To identify and apply the basic algorithmic procedures of computer technologies to design solutions to problems by analyzing the suitability and complexity of the proposed algorithms.
CE04. To design and use efficiently the most appropriate data types and structures to solve a problem.
CE13. To evaluate the computational complexity of a problem, identify algorithmic strategies that can lead to its resolution and recommend, develop and implement the one that guarantees the best performance in accordance with the established requirements.
CE14. To master the foundations, paradigms and techniques of intelligent systems and to analyze, designing and build computer systems, services and applications that use these techniques in any field of application, including robotics.
CE15. To acquire, formalize and represent human knowledge in a computable form for solving problems through a computer system in any field of application, particularly those related to aspects of computing, perception and performance in intelligent environments or environments.
CE18. To acquire and develop computational learning techniques and to design and implement applications and systems that use them, including those dedicated to the automatic extraction of information and knowledge from large volumes of data.
CE19. To use current computer systems, including high-performance systems, for the processing of large volumes of data from the knowledge of its structure, operation and particularities.
CE26. To design and apply techniques for processing and analyzing images and computer vision techniques in the area of artificial intelligence and robotics.
Generical:
CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
CG6. To identify opportunities for innovative applications of artificial intelligence and robotics in constantly evolving technological environments.
CG8. Perform an ethical exercise of the profession in all its facets, applying ethical criteria in the design of systems, algorithms, experiments, use of data, in accordance with the ethical systems recommended by national and international organizations, with special emphasis on security, robustness, privacy, transparency, traceability, prevention of bias (race, gender, religion, territory, etc.) and respect for human rights.
CG9. To face new challenges with a broad vision of the possibilities of a professional career in the field of Artificial Intelligence. Develop the activity applying quality criteria and continuous improvement, and act rigorously in professional development. Adapt to organizational or technological changes. Work in situations of lack of information and / or with time and / or resource restrictions.

Transversal:
CT6. Autonomous Learning. Detect deficiencies in one’s own knowledge and overcome them through critical reflection and the choice of the best action to extend this knowledge.

Basic:
CB1. That students have demonstrated to possess and understand knowledge in an area of ??study that starts from the base of general secondary education, and is usually found at a level that, although supported by advanced textbooks, also includes some aspects that imply Knowledge from the vanguard of their field of study.
CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.
CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy.

TEACHING METHODOLOGY
The theoretical classes will be complemented by putting into practice on PC the techniques presented.
In the laboratory classes, real computer vision problems will be solved.
Problems of higher complexity will be raised as homework

LEARNING OBJECTIVES OF THE SUBJECT
1. Define and quantify the characteristics of an image
2. Compare and select the most appropriate image processing tools based on the problem to be solved.
3. To segment and label image regions
4. Find the most significant descriptors to characterize regions or points of interest of an object
5. Detect and recognize the presence of certain items in an image
6. Correctly carry out experiments to evaluate the proposed methods, their limitations and weak points, based on objective results.

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours small group</td>
<td>30,0</td>
<td>20.00</td>
</tr>
<tr>
<td>Self study</td>
<td>90,0</td>
<td>60.00</td>
</tr>
<tr>
<td>Hours large group</td>
<td>30,0</td>
<td>20.00</td>
</tr>
</tbody>
</table>

Total learning time: 150 h
## CONTENTS

### Fundamentals of digital imaging

**Description:**
The digital image, properties and characteristics. Discretization and quantification. Color spaces

### Image processing

**Description:**
Lineal processing. Image filtering. Morphological image processing. Scales space

### Image segmentation

**Description:**
Edge detection. Clustering. Morphological segmentation

### Descriptors

**Description:**
Feature space. Shape descriptors. Appearance based descriptors. Keypoint detection

### Recognition

**Description:**
Local matching. Global matching. Object models. distance measures and error quantification

### Deep learning based solutions

**Description:**
ACTIVITIES

**Digital images**

**Description:**
Properties and characteristics of digital images

**Specific objectives:**
1

**Related competencies:**
CE04. To design and use efficiently the most appropriate data types and structures to solve a problem.  
CB1. That students have demonstrated to possess and understand knowledge in an area of study that starts from the base of general secondary education, and is usually found at a level that, although supported by advanced textbooks, also includes some aspects that imply Knowledge from the vanguard of their field of study.

**Full-or-part-time:** 8h  
Theory classes: 2h  
Laboratory classes: 2h  
Self study: 4h

**Linear image processing**

**Description:**
Basic operations. Image sharpening and smoothing. Convolution

**Specific objectives:**
2

**Related competencies:**
CE03. To identify and apply the basic algorithmic procedures of computer technologies to design solutions to problems by analyzing the suitability and complexity of the proposed algorithms.  
CE19. To use current computer systems, including high-performance systems, for the processing of large volumes of data from the knowledge of its structure, operation and particularities.  
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**Full-or-part-time:** 18h  
Theory classes: 4h  
Laboratory classes: 4h  
Self study: 10h
Morphological image processing

Description:
Non linear image filters. Connected components

Specific objectives:
2

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Full-or-part-time: 16h
Theory classes: 4h
Laboratory classes: 4h
Self study: 8h
Image segmentation

Description:
binarization Contour detection. Clustering

Specific objectives:
3

Related competencies:
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
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Full-or-part-time: 8h
Theory classes: 2h
Laboratory classes: 2h
Self study: 4h
Specific objectives:
1, 2, 3

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Full-or-part-time: 14h
Guided activities: 2h
Self study: 12h
Specific objectives:

4, 5, 6

Related competencies:

CG9. To face new challenges with a broad vision of the possibilities of a professional career in the field of Artificial Intelligence. Develop the activity applying quality criteria and continuous improvement, and act rigorously in professional development. Adapt to organizational or technological changes. Work in situations of lack of information and / or with time and / or resource restrictions.

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CT6. Autonomous Learning. Detect deficiencies in one’s own knowledge and overcome them through critical reflection and the choice of the best action to extend this knowledge.

CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.

CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy.

Full-or-part-time: 14h
Guided activities: 2h
Self study: 12h
Descriptors

Description:
Shape descriptors. Keypoint detection and description. Face detection

Specific objectives:

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Full-or-part-time: 22h
Theory classes: 6h
Laboratory classes: 6h
Self study: 10h
Object detection and recognition

Description:
Classification in features space. Local matching. Global matching

Specific objectives:
5, 6

Related competencies:
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Full-or-part-time: 20h
Theory classes: 4h
Laboratory classes: 6h
Self study: 10h
Deep learning approaches

Description:
Category recognition. Item localization. Semantic segmentation

Specific objectives:
5, 6

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Full-or-part-time: 30h
Theory classes: 4h
Laboratory classes: 6h
Self study: 20h

GRADING SYSTEM

A grade NT will be obtained from the partial tests. There is no final exam.
An NL grade will be obtained from the exercises proposed in the laboratory class and the work done in class.
The final mark will be obtained in the form NF = 0'4*NT + = 0'6*NL
BIBLIOGRAPHY

Basic: