Course guide
270422 - VO - Computer Vision

Last modified: 10/07/2024

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: 2024 **ECTS Credits:** 6.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: ISIAH ZAPLANA AGUT

Others: Primer quadrimestre:
ISIAH ZAPLANA AGUT - 11, 12

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 (with and without deep learning)
6.Correctly carry out experiments to evaluate the proposed methods, their limitations and weak points, based on objective results.

STUDY LOAD

Type	Hours	Percentage
Hours small group	30,0	20.00
Self study	90,0	60.00
Hours large group	30,0	20.00

Total learning time: 150 h

CONTENTS

Fundamentals of digital imaging

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

Linear, non-linear and morphological image processing

Description:
Linear processing. Operations with the intensity of the pixels. Geometric transformations. Image filtering. Digital derivatives. Morphological processing.

Image segmentation

Description:
Binarization. Contour and edge detection. Color clustering. Morphological segmentation.

Descriptors and features

Description:
Topological, geometric and statistical descriptors. The feature space. Histogram-based features, Hough and Harris transform. SIFT, ORB, and Haar key points.

Object recognition

Description:
Recognition through the use of templates. Recognition based on classifiers. Local registration. Global registration.

Deep learning computer vision

Description:
Recognition, detection and identification of objects. Architectures: YOLO, Fast/Faster R-CNN, Mask R-CNN. Visual transformers.

ACTIVITIES

Fundamental of the digital image

Description:
The digital image, properties and characteristics. Discretization and quantization. Color spaces Distances

Specific objectives:
1

Related competencies :
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.
CE04. To design and use efficiently the most appropriate data types and structures to solve a problem.

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

Linear, non-linear and morphological image processing (I)

Description:
Linear processing. Operations with intensity. Geometric transformations. Image filtering. Digital derivatives. Morphological processing.

Specific objectives:
2

Related competencies :
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.
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.
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.
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.
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.
CE04. To design and use efficiently the most appropriate data types and structures to solve a problem.
CE26. To design and apply techniques for processing and analyzing images and computer vision techniques in the area of artificial intelligence and robotics
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.

Full-or-part-time: 18h
Self study: 10h
Theory classes: 4h
Laboratory classes: 4h

Linear, non-linear and morphological image processing (II)

Description:
Linear processing. Operations with intensity. Geometric transformations. Image filtering. Digital derivatives. Morphological processing.

Specific objectives:
2

Related competencies :
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.
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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CE26. To design and apply techniques for processing and analyzing images and computer vision techniques in the area of artificial intelligence and robotics
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.

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

Image segmentation

Description:
Binarization. Contour extraction. Clustering by color. Morphological segmentation.

Specific objectives:
3

Related competencies :
CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy
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.
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CE26. To design and apply techniques for processing and analyzing images and computer vision techniques in the area of artificial intelligence and robotics
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.
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.
CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.

Full-or-part-time: 10h
Self study: 4h
Theory classes: 2h
Laboratory classes: 4h

First partial exam

Specific objectives:
1, 2, 3

Related competencies :
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.
CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy
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CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.

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

Second partial exam

Specific objectives:
4, 5, 6

Related competencies :
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
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.
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.
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.
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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.
CE26. To design and apply techniques for processing and analyzing images and computer vision techniques in the area of artificial intelligence and robotics
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.
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.
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.
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.
CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.
CG6. To identify opportunities for innovative applications of artificial intelligence and robotics in constantly evolving technological environments.
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.

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

Descriptors and features

Description:
Topological, geometric and statistical descriptors. The feature space. Histogram-based features, Hough and Harris transform. SIFT, ORB, and Haar key points.

Specific objectives:
4

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

Full-or-part-time: 22h
Self study: 10h
Theory classes: 6h
Laboratory classes: 6h

Object recognition

Description:
Recognition through the use of templates. Recognition using classifiers. Local registration. Global registration.

Specific objectives:
5, 6

Related competencies :
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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.

Full-or-part-time: 16h
Self study: 10h
Theory classes: 2h
Laboratory classes: 4h

Deep learning computer vision

Description:
Recognition, detection and identification of objects. Architectures: YOLO, Fast/Faster R-CNN, Mask R-CNN. Visual transformers.

Specific objectives:
5, 6

Related competencies :
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.
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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.

Full-or-part-time: 32h
Self study: 20h
Theory classes: 6h
Laboratory classes: 6h

GRADING SYSTEM

- There will be two partial tests P1 and P2 with grades NP1 and NP2. There is no final exam.

- There will be a minimum of one exercise set in class (theoretical) and one set in the computer labs (practical) with ET and EP grades.

- There will be a final project with an NPF grade.

The final mark will be obtained in the form NF = 0'3*NP1+0.3*NP2 + 0.05*ET + 0.05*EP + 0.3*NPF.

BIBLIOGRAPHY

Basic:
- Klette, R. Concise computer vision: an introduction into theory and algorithms. London: Springer, 2014. ISBN 1447163192.
- Szeliski, R. Computer vision: algorithms and applications. 2nd ed. Cham, Switzerland: Springer Nature Switzerland, 2022. ISBN 9783030343712.