Course guide
270408 - IR - Introduction to Robotics

Last modified: 02/02/2024

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: 2023   **ECTS Credits:** 6.0   **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: ANAÍS GARRELL ZULUETA

Others: Segon quadrimestre:
JOSE FERNÀNDEZ RUZAFA - 13
ANAÍS GARRELL ZULUETA - 11, 12, 13
ISIAH ZAPLANA AGUT - 11, 12, 13

PRIOR SKILLS

Mathematics

* To know and be able to apply the concept of derivative and partial derivative.
* To know the basic methods of graphical representation of functions (asymptotes, maxima, minima, ...).
* To know the elementary properties of trigonometric functions.
* To know the basic concepts of manipulation and operation with matrices.

Programming and Data Structure

* To know how to specify, design and implement simple algorithms with an imperative programming language.
* To know how to build correct, efficient and structured programs.
* To know the concepts of interpreted languages and compiled languages.
* To know search algorithms on data structures (tables, lists, trees, ...).

Computer Architecture and Technology

* To know at a functional level the different types of logic gates.
* To know how to analyze and implement simple combinational and sequential logic systems.
* To know the basic structure of a computer.
* To know the input / output and interruption subsystem of computers.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
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.

CE17. To develop and evaluate interactive systems and presentation of complex information and its application to solving human-computer and human-robot interaction design problems.

CE24. To ideate, design and build intelligent robotic systems to be applied in production and service environments, and that have to be capable of interacting with people. Also, to create collaborative and social intelligent robotic systems.

CE25. To ideate, design and integrate mobile robots with autonomous navigation capability, fleet formation and interaction with humans.

CE28. To plan, ideate, deploy and direct projects, services and systems in the field of artificial intelligence, leading its implementation and continuous improvement and assessing its economic and social impact.

Generical:
CG3. To define, evaluate and select hardware and software platforms for the development and execution of computer systems, services and applications in the field of artificial intelligence.

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.

CG5. Work in multidisciplinary teams and projects related to artificial intelligence and robotics, interacting fluently with engineers and professionals from other disciplines.

CG6. To identify opportunities for innovative applications of artificial intelligence and robotics in constantly evolving technological environments.

CG7. To interpret and apply current legislation, as well as specifications, regulations and standards in the field of artificial intelligence.

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:
CT1. Entrepreneurship and innovation. Know and understand the organization of a company and the sciences that govern its activity; Have the ability to understand labor standards and the relationships between planning, industrial and commercial strategies, quality and profit.

CT2. Sustainability and Social Commitment. To know and understand the complexity of economic and social phenomena typical of the welfare society; Be able to relate well-being to globalization and sustainability; Achieve skills to use in a balanced and compatible way the technique, the technology, the economy and the sustainability.

CT8. (ENG) Perspectiva de gènere. Conèixer i comprendre, des del propi àmbit de la titulació, les desigualtats per raó de sexe i gènere a la societat; Integrar les diferents necessitats i preferències per raó de sexe i de gènere en el disseny de solucions i resolució de problemes.

TEACHING METHODOLOGY

The teaching methodology will be generally of a deductive nature. Attempts will be made to avoid the expository method / Master class. The approach will always be the same:
¿ Propose a problem
¿ try to solve it
¿ add the necessary pieces of theory to be able to solve the problem properly.

No distinction will be made between theory and problem classes, as the presentation of concepts and the solution of application problems are interspersed in the classroom sessions. Laboratory classes are the complement where students put the concepts into practice with the use of simulators and / or real robotic systems.

In addition to the activities in the classroom and in the laboratory, students must solve and deliver to the teachers for their evaluation a set of exercises, which allow to consolidate the acquired knowledge, be a mechanism of self-evaluation and work in equipment.

![Universitat Politècnica de Catalunya - BarcelonaTech Logo]

LEARNING OBJECTIVES OF THE SUBJECT

1.To know robot components and what's the difference againts other authomatic machines
2.To know the different types of robots that are in the market and their characteristics. Understand their manuals and specifications, as well as regulations and standards according to current legislation.
3.To know the different sources of sensory information and their characteristics.
4.To be able to merge different sources of information to obtain, formalize and represent the physical environment in a computable way for problem solving.
5.To learn how to coordinate actions between robots.
6.To be able to make judgments that include a reflection on relevant issues of a social, scientific or ethical nature, related to current robotics and its potential applications.
7.To learn how to program robots and design robotic applications.

STUDY LOAD

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

Total learning time: 150 h

CONTENTS

Introduction

Description:
Robots and Robotics. Evolution of robots. Incidence of robotics in today's society.

Robot morphology.

Description:
Components. Structures and characteristics of robots.

Mobile robots

Description:
Mechanisms of locomotion. Types of mobile robots. Direct and inverse kinematics. Maneuverability.

Perception of the environment

Description:
Sensor classification. Characteristics. Depth sensors. Orientation sensors.

Mobile robot navigation

Description:
Reactive navigation. Obstacle escape. Map-based planning.

Location of mobile robots

Description:
Location systems (GPS, US, IR, fixed routes). Navigation based on reference points.

Manipulator robots

Description:
Architectures and features

Cinemática de los robots manipuladores.

Description:
Geometric transformations. Direct and Reverse Kinematics. Redundancy. Singularities.

Generation of trajectories

Description:
Paths and trajectories. Trajectories in the joint space. Trajectories in Cartesian space.

Robot Programming and Control

Description:
Joint space control. Manipulator control architecture. Robot programming environments and languages.

Applications of robotics

Description:
Industrial Robotics. Service robotics. Exploration robotics. Medical and healthcare robotics.

ACTIVITIES

¿Qué es un robot?

Description:
Robots and Robotics. Evolution of robots. Incidence of robotics in today's society.

Specific objectives:
1, 6

Related competencies :
CG5. Work in multidisciplinary teams and projects related to artificial intelligence and robotics, interacting fluently with engineers and professionals from other disciplines.
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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.
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CT2. Sustainability and Social Commitment. To know and understand the complexity of economic and social phenomena typical of the welfare society; Be able to relate well-being to globalization and sustainability; Achieve skills to use in a balanced and compatible way the technique, the technology, the economy and the sustainability.

Full-or-part-time: 2h
Theory classes: 2h

Robot morphology.

Description:
Components. Structures and characteristics of robots.

Specific objectives:
1, 2

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

Mobile robots

Description:
Mechanisms of locomotion. Types of mobile robots. Direct and inverse kinematics. Maneuverability.

Specific objectives:
2, 7

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

Perception of the environment

Description:
Sensor classification. Characteristics. Depth sensors. Orientation sensors.

Specific objectives:
3, 4

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Full-or-part-time: 14h
Theory classes: 2h
Laboratory classes: 4h
Self study: 8h

Mobile robot navigation

Description:
Reactive navigation. Obstacle escape. Map-based planning.

Specific objectives:
4, 7

Related competencies :
CG5. Work in multidisciplinary teams and projects related to artificial intelligence and robotics, interacting fluently with engineers and professionals from other disciplines.
CG6. To identify opportunities for innovative applications of artificial intelligence and robotics in constantly evolving technological environments.
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: 16h
Theory classes: 4h
Laboratory classes: 4h
Self study: 8h

Location of the mobile robot

Description:
Location systems (GPS, US, IR, fixed routes). Navigation based on reference points

Specific objectives:
4, 5, 7

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Full-or-part-time: 14h
Theory classes: 2h
Laboratory classes: 4h
Self study: 8h

Manipulator robots

Description:
Architectures and features

Specific objectives:
2, 3

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

Kinematics of manipulating robots

Description:
Geometric transformations. Direct and Reverse Kinematics. Redundancy. Singularities.
Generation of trajectories

Specific objectives:
2, 7

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

Generation of trajectories

Description:
Paths and trajectories. Trajectories in the joint space. Trajectories in Cartesian space.

Specific objectives:
5, 7

Related competencies :
CG6. To identify opportunities for innovative applications of artificial intelligence and robotics in constantly evolving technological environments.

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

Robot Programming and Control

Description:
Joint space control. Manipulator control architecture. Robot programming environments and languages

Specific objectives:
4, 5, 7

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Full-or-part-time: 22h
Theory classes: 4h
Laboratory classes: 6h
Self study: 12h

Aplicaciones de la robótica

Description:
Industrial Robotics. Service robotics. Exploration robotics. Medical and healthcare robotics

Specific objectives:
6, 7

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Full-or-part-time: 2h
Theory classes: 2h

Exercise resolution

Description:
Resolution of evaluable exercises (between 3 and 6) carried out as personal work or in pairs

Specific objectives:
1, 2, 3, 4, 5, 6, 7

Related competencies :
CG5. Work in multidisciplinary teams and projects related to artificial intelligence and robotics, interacting fluently with engineers and professionals from other disciplines.
CG3. To define, evaluate and select hardware and software platforms for the development and execution of computer systems, services and applications in the field of artificial intelligence.
CG6. To identify opportunities for innovative applications of artificial intelligence and robotics in constantly evolving technological environments.
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.
CG7. To interpret and apply current legislation, as well as specifications, regulations and standards in the field of artificial intelligence.
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.
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.
CE28. To plan, ideate, deploy and direct projects, services and systems in the field of artificial intelligence, leading its implementation and continuous improvement and assessing its economic and social impact.
CE17. To develop and evaluate interactive systems and presentation of complex information and its application to solving human-computer and human-robot interaction design problems.
CE24. To ideate, design and build intelligent robotic systems to be applied in production and service environments, and that have to be capable of interacting with people. Also, to create collaborative and social intelligent robotic systems.
CE25. To ideate, design and integrate mobile robots with autonomous navigation capability, fleet formation and interaction with humans.
CT8. (ENG) Perspectiva de gènere. Conèixer i comprendre, des del propi àmbit de la titulació, les desigualtats per raó de sexe i gènere a la societat; Integrar les diferents necessitats i preferències per raó de sexe i de gènere en el disseny de solucions i resolució de problemes.
CT1. Entrepreneurship and innovation. Know and understand the organization of a company and the sciences that govern its activity; Have the ability to understand labor standards and the relationships between planning, industrial and commercial strategies, quality and profit.
CT2. Sustainability and Social Commitment. To know and understand the complexity of economic and social phenomena typical of the welfare society; Be able to relate well-being to globalization and sustainability; Achieve skills to use in a balanced and compatible way the technique, the technology, the economy and the sustainability.

Full-or-part-time: 30h
Self study: 30h

GRADING SYSTEM

The course will be evaluated continuously. There will be no final exam.

Throughout the course, a series of exercises will be requested that will help the teacher evaluate the student at the end of the course. These exercises can be both face-to-face and non-face-to-face and can consist of the presentation of the results of practices developed in the laboratory (NL), as well as the theoretical / practical solution of problems proposed by the teacher in class (NT).

The final grade of the course will be calculated as follows: NF=0'6NL+0'1NT+0.15EP+0.15EP

BIBLIOGRAPHY

Basic:

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- Siegwart, Roland; Nourbakhsh, Illah Reza; Scaramuzza, Davide. Introduction to autonomous mobile robots. 2nd ed. Cambridge: MIT Press, cop. 2011. ISBN 9780262015356.
- Barrientos, Antonio. Fundamentos de robótica. 2a ed. Madrid: McGraw-Hill, cop. 2007. ISBN 9788448156367.
- Siciliano, Bruno; Khatib, Oussama. Springer handbook of robotics. 2nd ed. Springer International Publishing, 2016. ISBN 9783319325521.
- Murphy, R.R. Introduction to AI robotics. 2nd ed. Cambridge, Massachusetts: The MIT Press, 2019. ISBN 9780262348157.