Course guide
270408 - IR - Introduction to Robotics

Last modified: 03/02/2025

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:** Catalan, Spanish

LECTURER

Coordinating lecturer: ANAÍS GARRELL ZULUETA

Others: Segon quadrimestre:
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.

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:
Robotic history, types of robots and robo-ethics

Perception

Description:
Uncertainty, sensor perception, noise position and normal distribution

Localization I

Description:
Probabilidad condicional y teorema de bayas, localización, filtro bayesiano, filtro de kalman

Localization II

Description:
Ejemplo FIltro de Kalman, filtro de kalman extendido, filtro de partículas

Mapping

Description:
Mapas, Slam, movimiento, ruedas

Forward kinematics, inverse kinematics

Description:
Calculation of direct and indirect kinematics, example of vehicles with wheels

Planning

Description:
Planning, exploring, borders, replanning, exploring vs. exploitation

Introduction to manipulator robots.

Description:
Definition of a manipulator robot. Types and components. Position and orientation of a rigid solid. Representations of orientations.

Direct kinematics of the manipulator robot.

Description:
Reference systems and coordinate systems. Joint coordinate systems. DH parameters and homogeneous transformation matrices. Direct kinematics.

Differential kinematics of the manipulator robot.

Description:
Linear and angular velocity of a rigid solid. Velocity propagation. Geometric and analytical Jacobian of a robot manipulator. Singularities of a robot.

Inverse kinematics of the manipulator robot I

Description:
Analytical inverse kinematics of simple robots. Pieper's theorem and method for analytical inverse kinematics of manipulator robots with spherical wrist. Numerical methods based on the Jacobian matrix for the inverse kinematics of a manipulator robot (pseudoinverse, transposed, etc.).

Inverse kinematics of the manipulator robot II

Description:
Numerical methods based on the Jacobian matrix for the inverse kinematics of a manipulator robot (pseudoinverse, transposed, etc.).

ACTIVITIES

Introduction

Specific objectives:
1, 2

Related competencies :
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.
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CG7. To interpret and apply current legislation, as well as specifications, regulations and standards in the field of artificial intelligence.
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Full-or-part-time: 10h
Self study: 4h
Theory classes: 4h
Laboratory classes: 2h

Mobile robots

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

Specific objectives:
2, 7

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Self study: 8h
Theory classes: 4h
Laboratory classes: 4h

Perception of the environment

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

Specific objectives:
3, 4

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

Mobile robot navigation

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

Specific objectives:
4, 7

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

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
Self study: 8h
Theory classes: 2h
Laboratory classes: 4h

Manipulator robots

Description:
Architectures and features

Specific objectives:
2, 3

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

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
Self study: 4h
Theory classes: 2h
Laboratory classes: 2h

Generation of trajectories

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

Specific objectives:
5, 7

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

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
Self study: 12h
Theory classes: 4h
Laboratory classes: 6h

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

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CG5. Work in multidisciplinary teams and projects related to artificial intelligence and robotics, interacting fluently with engineers and professionals from other disciplines.
CG7. To interpret and apply current legislation, as well as specifications, regulations and standards in the field of artificial intelligence.
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.
CG6. To identify opportunities for innovative applications of artificial intelligence and robotics in constantly evolving technological environments.
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.

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

GRADING SYSTEM

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

There will be a minimum of one evaluable exercise presented in the theoretical class with an E grade.

There will be a final practice with an NPF grade.

The final grade of the subject will be calculated as follows: NF=0'3·NP1+0.3·NP2+0'1·E+0.3·NPF

Attendance at laboratory classes is mandatory, justified non-attendance will penalize the final grade of the subject.

Solo se podrán presentar a la reevaluación esas persona que, habiéndose presentado a los exámenes parciales los hayan suspendido.La nota máxima que se podrá obtener es un 7.

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- Barrientos, Antonio. Fundamentos de robótica. 2a ed. Madrid: McGraw-Hill, cop. 2007. ISBN 9788448156367.
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