Course guide
270130 - ROB - Robotics

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, Spanish

LECTURER

Coordinating lecturer: ANTONIO BENITO MARTÍNEZ VELASCO

Others:

Primer quadrimestre:
CECILIO ANGULO BAHON - 11, 12
ANTONIO BENITO MARTÍNEZ VELASCO - 11, 12
MARC ROIG SEBÉ - 11, 12

Segon quadrimestre:
ANTONIO BENITO MARTÍNEZ VELASCO - 11, 12
MARC ROIG SEBÉ - 11, 12

PRIOR SKILLS

Mathematics Area

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

Physics Area

* Know the basic concepts and laws of electricity, magnetism and electromagnetism (Coulomb's law, Ohm's law, electric and magnetic field, electric charge, magnetic dipole, electric potential, potential difference, electric voltage, current, resistance and electrical conductance, and their units in the MKS system
* Know the most significant features of the physical behavior of semiconductor devices: the PN junction, the bipolar transistor and the MOS transistor.

Programming and Data Structure Area

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

Computer Architecture and Technology Area

* Know at a functional level the different logic gates.
* Know how to analyze and implement simple combinational and sequential logic systems.
* Know how to minimize and synthesize logical functions.
* Know the basic structure of a computer.
* Know the input / output subsystem and computer interrupts.
* Know that it is an operating system and its functions.
* Know the concept of process, concurrence, and communication and synchronization between processes.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

CCO1.1. To evaluate the computational complexity of a problem, know the algorithmic strategies which can solve it and recommend, develop and implement the solution which guarantees the best performance according to the established requirements.

CCO1.3. To define, evaluate and select platforms to develop and produce hardware and software for developing computer applications and services of different complexities.

CCO2.1. To demonstrate knowledge about the fundamentals, paradigms and the own techniques of intelligent systems, and analyse, design and build computer systems, services and applications which use these techniques in any applicable field.

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.

CCO3.1. To implement critical code following criteria like execution time, efficiency and security.

CCO3.2. To program taking into account the hardware architecture, using assembly language as well as high-level programming languages.

CEC2.1. To analyse, evaluate, select and configure hardware platforms for the development and execution of computer applications and services.

CES1.2. To solve integration problems in function of the strategies, standards and available technologies

CES1.8. To develop, mantain and evaluate control and real-time systems.

CES2.1. To define and manage the requirements of a software system.

CES2.2. To design adequate solutions in one or more application domains, using software engineering methods which integrate ethical, social, legal and economical aspects.

CT1.1A. To demonstrate knowledge and comprehension about the fundamentals of computer usage and programming, about operating systems, databases and, in general, about computer programs applicable to the engineering.

CT1.1B. To demonstrate knowledge and comprehension about the fundamentals of computer usage and programming. Knowledge about the structure, operation and interconnection of computer systems, and about the fundamentals of its programming.

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.

CT1.2B. 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 understand and dominate the physical and technological fundamentals of computer science: electromagnetism, waves, circuit theory, electronics and photonics and its application to solve engineering problems.

CT1.2C. To use properly theories, procedures and tools in the professional development of the informatics engineering in all its fields (specification, design, implementation, deployment and products evaluation) demonstrating the comprehension of the adopted compromises in the design decisions.

CT2.1. To demonstrate knowledge and capacity to apply the principles, methodologies and life cycles of software engineering.

CT2.5. To design and evaluate person-computer interfaces which guarantee the accessibility and usability of computer systems, services and applications.

CT3.5. To identify the use possibilities and benefits which can be derived from an application in the different business software typologies and existent ICT services.

CT3.6. To demonstrate knowledge about the ethical dimension of the company: in general, the social and corporative responsibility and, concretely, the civil and professional responsibilities of the informatics engineer.

CT4.1. To identify the most adequate algorithmic solutions to solve medium difficulty problems.

CT4.2. To reason about the correction and efficiency of an algorithmic solution.

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.

CT5.3. To design, write, test, refine, document and maintain code in an high level programming language to solve programming problems applying algorithmic schemas and using data structures.

CT5.4. To design the programs¿ architecture using techniques of object orientation, modularization and specification and implementation of abstract data types.

CT5.5. To use the tools of a software development environment to create and develop applications.

CT5.6. To demonstrate knowledge and capacity to apply the fundamental principles and basic techniques of parallel, concurrent, distributed and real-time programming.

CT8.1. To identify current and emerging technologies and evaluate if they are applicable, to satisfy the users needs.

Generical:
G5. TEAMWORK: to be capable to work as a team member, being just one more member or performing management tasks, with the finality of contributing to develop projects in a pragmatic way and with responsibility sense; to assume compromises taking into account the available resources.
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.
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

TEACHING METHODOLOGY

Throughout the course there are a series of activities that must lead the student to achieve the objectives of the subject. In a simplified way the activities can be: exposition and debate of the basic concepts of the asignatura, resolution of problems, application of the concepts in the construction of models, his simulation and back improvement and / or the development of applications for systems robots .

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 robot systems.

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

LEARNING OBJECTIVES OF THE SUBJECT

1.Know the elements that make up a robot system, the different alternatives, and how they work.
2.Know the evolution, current state and trends of robotics.
3.Know the different forms of programming of the robots and their characteristics.
4.Know and be able to differentiate the different levels of planning and control of the robot's movement.
5.Know the techniques that allow to define, calculate and generate suitable trajectories for robots, and their algorithmic implementation.
6.Know the sensors and perception systems for interaction with the environment for the most common applications
7.Know the problems and strategies of guided and autonomous vehicle navigation
8.Know how planning techniques are used in the field of robotics
9.Know the sensory requirements of mobile robots
10.Know the requirements of the most common applications of robotics and know how to discriminate which tasks are likely to be robotized.
11.Be able to identify the requirements of a task that needs to be robotized
12.Know how to program and use robots to solve the proposed task
13.Know how to integrate the information provided by the sensors in the robot program
14.Know how to choose the types of sensors needed for each application
15.Know the factors that affect the reliability of a robot and how to minimize its effect
16.Know the aspects related to the security of robotic systems
17.Know the methodology of the development of a robotization project
18.Design of robotization projects for a specific task

STUDY LOAD

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

Kinematics of manipulating robots

Description:
Geometric transformations. DH parameters. Direct kinematics. Reverse Kinematics. Differential kinematics.

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. Industrial robot programming environments and languages.

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 the mobile robot

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

Applications of robotics

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

Development of a robotization project

Description:
Requirements. Design. Ethical and social implications. Reliability and security.

ACTIVITIES

Development Topic 1

Description:
Actively participate in face-to-face sessions. Autonomous study of the proposed materials. Search for information regarding robotics, robot systems and their applications.

Specific objectives:
1, 2

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.
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

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

Theme 2 development

Description:
Actively participate in the face-to-face session. Independent study of the proposed materials. Resolution of the proposed problems.

Specific objectives:
1, 2

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.
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

Full-or-part-time: 11h
Theory classes: 4h
Laboratory classes: 2h
Self study: 5h

Theme 3 development

Description:
Actively participate in the face-to-face session. Independent study of the proposed materials. Resolution of the proposed problems.

Specific objectives:
4, 5

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

Development Theme 4

Description:
Actively participate in the face-to-face session. Independent study of the proposed materials. Resolution of the proposed problems.

Specific objectives:
4, 5

Full-or-part-time: 13h
Theory classes: 3h
Laboratory classes: 4h
Self study: 6h

Development Topic 5

Description:
Actively participate in the face-to-face session. Independent study of the proposed materials. Resolution of the proposed problems.

Specific objectives:
3, 4, 5, 12, 13

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.
G5. TEAMWORK: to be capable to work as a team member, being just one more member or performing management tasks, with the finality of contributing to develop projects in a pragmatic way and with responsibility sense; to assume compromises taking into account the available resources.
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: 17h
Theory classes: 3h
Laboratory classes: 6h
Self study: 8h

Development Theme 6

Description:
Actively participate in the face-to-face session. Independent study of the proposed materials. Resolution of the proposed problems.

Specific objectives:
1, 3, 4, 5, 9

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.
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

Full-or-part-time: 12h
Theory classes: 4h
Laboratory classes: 2h
Self study: 6h

Development Theme 7

Description:
Actively participate in the face-to-face session. Independent study of the proposed materials. Resolution of the proposed problems.

Specific objectives:
6, 9, 13, 14

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.
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Full-or-part-time: 12h
Theory classes: 2h
Laboratory classes: 4h
Self study: 6h

Development Theme 8

Description:
Actively participate in the face-to-face session. Independent study of the proposed materials. Resolution of the proposed problems.

Specific objectives:
3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.
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Full-or-part-time: 13h
Theory classes: 3h
Laboratory classes: 4h
Self study: 6h

Development Theme 9

Description:
Actively participate in face-to-face sessions. Independent study of the proposed materials. Resolution of the proposed problems

Specific objectives:
6, 7, 8, 9, 12, 13

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.
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Full-or-part-time: 10h
Theory classes: 2h
Laboratory classes: 4h
Self study: 4h

Development Theme 10

Description:
Actively participate in face-to-face sessions. Independent study of the proposed materials. Resolution of the proposed problems.

Specific objectives:
10, 11, 12, 15, 16

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.
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Full-or-part-time: 3h
Theory classes: 1h
Self study: 2h

Development Theme 11

Description:
Actively participate in face-to-face sessions. Independent study of the proposed materials. Resolution of the proposed problems

Specific objectives:
6, 10, 11, 12, 13, 14, 15, 16, 17, 18

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.
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Full-or-part-time: 8h
Theory classes: 2h
Laboratory classes: 2h
Self study: 4h

Resolution of exercises (between 3 and 6) evaluable carried out as personal work

Description:
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Specific objectives:
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.
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Full-or-part-time: 20h
Self study: 20h

Final exam are replaced by short projects developed during the laboratory sessions.

Specific objectives:
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.
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Full-or-part-time: 13h
Self study: 13h

GRADING SYSTEM

The evaluation of the subject is done from:

1.- Mini projects to be developed during the laboratory sessions.
a) Mini project related to Robot arms (MPBR)
b) Mini projects related to Mobile Robot (MPRM)
2.- Taskes (Todos) that the student will have to do to proposal of the professor.
3.- Attitude of the student in front of the asignatura.

NF = 0.1 x Attitude + 0.3 x Todo + 0.3 x MPBR + 0.3 MPRM

BIBLIOGRAPHY

Basic:
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- Siegwart, R.; Nourbakhsh, I.R.; Scaramuzza, D. Introduction to autonomous mobile robots. 2nd ed. MIT Press, 2011. ISBN 9780262295321.
- Siegwart, Roland; Nourbakhsh, Illah R.; Scaramuzza, Davide. Introduction to autonomous mobile robots. 2nd ed. Cambridge: MIT Press, 2011. ISBN 9780262015356.
- Siciliano, B.; Khatib, O. Springer handbook of robotics. Springer, 2016. ISBN 978331932552.
- Barrientos, A. [et al.]. Fundamentos de robótica. 2a ed. Madrid: McGraw-Hill, 2007. ISBN 9788448156367.
- Murphy, R.R. Introduction to AI robotics. 2nd ed. Cambridge, Massachusetts ; London, England: MIT Press, 2019. ISBN 9780262348157.

RESOURCES

Hyperlink:
- http://www.roboticsonline.com/- http://www.ifr.org- http://www.euron.org