Universidad Zaragoza

Academic Year/course: 2021/22

69150 - Autonomous Robots

Syllabus Information

Academic Year: 2021/22
Subject: 69150 - Autonomous Robots
Faculty / School: 110 - Escuela de Ingeniería y Arquitectura
Degree: 615 - Master's in Robotics, Graphics and Computer Vision/ Robótica, Gráficos y Visión por Computador
ECTS: 6.0
Year: 1
Semester: First semester
Subject Type: Compulsory
Module:

1. General information

1.1. Aims of the course

The main objective of the course is to give an overview of the main components and algorithms that currently exist to provide autonomy to a mobile robot. To do this, objectives of two types are considered:

El principal objetivo de la asignatura es el de dar una visión general de los principales componentes y algoritmos que existen en la actualidad para dotar de autonomía a un robot móvil. Para ello, se plantean en la asignatura objetivos de dos tipos:

1. Theoretical: The aim is that the student knows and manages with ease the basic theoretical contents that support the current knowledge of autonomous robots. At the end of the course the student will be able to:
    - Know and understand basic mathematical tools for autonomous robots.
    - Design and develop systems for generating trajectories, planning of movements and navigation of robots.

2. Practical: The aim is for the student to know how to operate with ease in a realistic application domain that involves at least one robot performing tasks autonomously, applying and analyzing the practical implications of the theoretical contents. At the end of the course the student will be able to:
    - Develop programs, using existing robotic software platforms, that allow the robot to carry out different interactions with the environment through its sensors or actuators autonomously.
    - Understand aspects and problems related to the operation of autonomous robots in different real applications.

These approaches and objectives are aligned with some of the Sustainable Development Goals, SDG, of the 2030 Agenda (https://www.un.org/sustainabledevelopment/es/) and certain specific goals, in such a way that the acquisition of the Learning outcomes of the subject provides training and competence to the student to contribute to a certain extent to their achievement:

- Goal 3: Ensure healthy lives and promote well-being for all at all ages
    - Target 3.6 By 2020, halve the number of deaths and injuries caused by traffic accidents in the world
- Objective 9: Industry, innovation and infrastructure
    - Target 9.4 By 2030, modernize infrastructure and reconvert industries so that they are sustainable, using resources more efficiently and promoting the adoption of clean and environmentally sound industrial technologies and processes, and ensuring that all countries take measures in accordance with their respective capabilities.
    - Target 9.5 Increase scientific research and improve the technological capacity of industrial sectors in all countries, particularly developing countries, including by fostering innovation and significantly increasing, by 2030, the number of people working in research and development

per million inhabitants and the spending of the public and private sectors in research and development.

- Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable
    - Target 11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all and improve road safety, in particular by expanding public transport, paying special attention to the needs of people in vulnerable situations , women, children, people with disabilities and the elderly

1.2. Context and importance of this course in the degree

Within the set of courses focused on the robotic branch, this course is the first to be taken and it is compulsory for all students of the master's degree. Thus, it serves as an introduction to the basic aspects of modeling and characterizing most common robotic systems. Within the robotics block, it is also the course in which greater attention is paid to the mobility aspects associated to robotic systems, ranging from their kinematics to more general planning and navigation techniques. Understanding these concepts will make it easier for the student to understand the rest of the compulsory and optional subjects in robotics.

1.3. Recommendations to take this course

Meet the necessary requirements for admission to the master.

2. Learning goals

2.1. Competences

The student will acquire the following **basic competences:**

- CB6 ? To possess and understand knowledge that provides a basis or opportunity to be original in the development and / or application of ideas, often in a research context.
- CB7 - That students know how to apply the acquired knowledge and ability to solve problems in new or little-known settings within broader (or multidisciplinary) contexts related to their area of ??study.
- CB9 - That students know how to communicate their conclusions and the latest knowledge and reasons that support them to specialized and non-specialized audiences in a clear and unambiguous way.
- CB10 - That students possess the learning skills that allow them to continue studying in a way that will have to be largely self-directed or autonomous.

The student will acquire the following **general competences:**

- CG01 ? Acquisition of advanced and demonstrated knowledge, in a context of scientific and technological research or highly specialized, a detailed and well-founded understanding of the theoretical and practical aspects and of the working methodology in the fields of Robotics, Graphics and / or Computer Vision, allowing them to be innovative in a context of research, development and innovation.
- CG02 - Ability to apply and integrate their knowledge, their understanding, their scientific foundation and their problem-solving abilities in new and imprecisely defined environments, including multidisciplinary contexts, as highly specialized researchers and professionals.
- CG03 - Ability to evaluate and select the appropriate scientific theory and the precise methodology of their fields of study to formulate judgments based on incomplete or limited information, including, when necessary and pertinent, considerations on social or ethical responsibility linked to the solution that is proposed in each case.
- CG04 - Ability to predict and control the evolution of complex situations by developing new and innovative work methodologies adapted to the specific scientific / research, technological or professional field, generally multidisciplinary, in which their activity is carried out.
- CG05 - Ability to transmit in English, orally and in writing, in a clear and unambiguous way, to a specialized audience or not, results from scientific and technological research or the most advanced field of innovation, as well as the most relevant foundations on which they are based.

- CG06 ? To have developed sufficient autonomy to participate in research projects and scientific or technological collaborations within their subject area, in interdisciplinary contexts and, where appropriate, with a high component of knowledge transfer.
- CG07 - Ability to take responsibility for your own professional development and specialization in one or more fields of study.
- CG08 ? To possess the aptitudes, skills and method necessary to carry out multidisciplinary research and / or development work in the fields of Robotics, Graphics and / or Computer Vision.
- CG09 - Ability to use the techniques, skills and tools of Engineering necessary for solving problems of the Robotics, Graphics and / or Computer Vision fields.
- CG10 - Ability to understand, relate to the state of the art and critically evaluate scientific publications in the fields of Robotics, Graphics and / or Computer Vision.
- CG11 - Ability to manage and use bibliography, documentation, databases, software and hardware specific to the fields of Robotics, Graphics and / or Computer Vision.
- CG12 - Ability to work in a multidisciplinary group and in a multilingual environment.

The student will acquire the following **specific competences:**

- CE01 - Ability to apply mathematical and artificial intelligence methods to model, design and develop Robotics, Graphics and / or Computer Vision systems and applications.
- CE02 - Ability to design and develop new methods and algorithms applicable to autonomous systems or virtual and augmented reality.
- CE04 - Ability to conceive, design and develop software, products and systems in the field of Robotics.
- CE08 - Ability to conceive, design and develop Machine Learning systems, and apply them to Robotics, Graphics and / or Computer Vision problems.
- CE09 - Ability to autonomously carry out a work of initiation to research and / or development in the field of Robotics, Graphics, or Computer Vision, in which the skills acquired in the degree are synthesized and integrated.
- CE13 - Ability to apply high performance computer systems or numerical or computational methods to Robotics, Graphics or Computer Vision problems.

2.2. Learning goals

In order to pass this course, the student must demonstrate the following skills:

- Knowledge and understanding of basic mathematical tools for autonomous robots: spatial transformations and probabilistic robotics.
- Knowledge of the basic handling of robotic development software platforms.
- Ability to design and develop systems for generating trajectories, planning of movements and robot navigation.
- Ability to develop navigation systems that integrate information from different sensors.
- Ability to apply the concepts and systems learned to the design of 2D and 3D robot navigation systems.
- Knowledge of the problems and basic techniques used in multi-robot systems.
- Knowledge of the aspects and problems related to the operation of autonomous robots in different real applications.

2.3. Importance of learning goals

The learning results of this course enable the student to develop algorithmic solutions, rigorously formulated, that solve fundamental problems in the field of robotics. From the research perspective, the contents of the course will make the student able to formalize and propose solutions to problems of interest to the scientific community. From a more applied perspective, oriented to industry, the knowledge acquired in the course will enable the student to recognize the possibilities and limitations in the use of robots in real environments, with important implications related to the improvement in productivity and the reduction of costs.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

The student must demonstrate the achievement of the expected learning outcomes through the following assessment activities.

Theoretical Assessment (ET): One or more written or oral tests that demonstrate that the student has acquired the theoretical knowledge of the course.

Practical Assessment (PE): Deliverables of practical works (laboratories, special and research oriented) to demonstrate that the student has acquired the practical skills of the course.

Each of the two evaluations will result in a score of 0 to 10 points. The student's final grade will be calculated by weighing 40% ET and 60% EP,

Final grade = 0.4 * ET + 0.6 * EP.

To pass the course, the student must obtain a grade greater than or equal to 5 points both in the ET and the Final grade. If the ET grade is below 5 points, the course calification will be the minimum between 4 points and Final grade. Otherwise, the course calification will be Final grade.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The learning process that has been designed for this course is based on the following:

1. Master classes by the faculty.
2. Solution of theoretical problems in class and practical work.
3. The development of laboratory exercises by students and tutored by faculty members. In them they will apply, in a simulated or real environment, their theoretical knowledge, facing the limitations and constraints that are inherent in real systems. All this will result in a greater understanding, deepening and assimilation of the theoretical part of the course.
4. Personal study by students.

It must be taken into account that the course has a strong theoretical support and that additionally the student have to understand and assimilate its importance in the industry.

4.2. Learning tasks

The course consists of 6 ECTS credits that represent an estimated dedication by the student of 150 hours, divided into the following activities:

- A01 - Master class: 30 hours
- A02 - Resolution of problems and cases: 6 hours
- A03 - Laboratory sessions: 12 hours
- A04 - Special sessions: 2 hours
- A05 - Practical research or application work: 25 hours
- A06 - Personalized tutor professor-student: 5 hours
- A07 ? Individual study: 65 hours
- A08 - Assessment tests: 5 hours

4.3. Syllabus

The course is divided in 7 blocks:

1. Basic tools: spatial transformations, probabilistic robotics and robotic platforms
2. Autonomous robots: kinematics and dynamics

3. Motion planning and reactive navigation
4. Multi-sensory perception in autonomous robots
5. Métodos de decisión y aprendizaje para planificación y navegación
6. Multi-robot systems
7. Field Robotics

4.4. Course planning and calendar

The schedule of the course for class sessions and practices is set by the Center.

The other learning-related activities that can be carried out during the course will be announced in advance.

The academic calendar of the activities to be carried out in the course will be available on the Center's website. The student must be attentive to the detailed dates for the completion of practices and delivery of assignments, which will be conveniently informed both in class and through the ADD.

4.5. Bibliography and recommended resources

Introduction to autonomous mobile robots. R Siegwart, IR Nourbakhsh, D Scaramuzza
Probabilistic Robotics. S. Thrun, D. Fox and W. Burgard