Universidad Zaragoza

Academic Year/course: 2021/22

69161 - Assistive Robotics

Syllabus Information

Academic Year: 2021/22
Subject: 69161 - Assistive Robotics
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: 3.0
Year: 1
Semester: Second semester
Subject Type: Optional
Module:

1. General information

1.1. Aims of the course

The objective is to provide a student with knowledge of the latest advances in the application of robotics to healthcare and assistive robotics. The course will focus on the techniques and technologies applied in robotic exoskeletons to help the movement of human limbs using robotic prostheses and orthoses, in the generation and control of their movement, and in biosignals processing, mainly electromyographic (EMG) and electroencephalographic (EEG)signals, to adapt them for the motion control. The latest advances in Medical Robotics will be described.

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
- Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
    - Target 8.2 Achieve higher levels of economic productivity through diversification, technological modernization and innovation, including by focusing on high value-added and labor-intensive sectors
- Goal 9: Industry, innovation and infrastructure
    - 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.

1.2. Context and importance of this course in the degree

It is an optional course in the Master. In recent years there have been substantial advances in the field of applied robotics in the field of aid to movement through exoskeletons. It is multidisciplinary, since it ranges from modelling robots, generating movement, controlling the mechanism, and processing and adapting different biosignals for device self-control. A wide variety of knowledge acquired in the careers that give access to the Master and in the Master itself is used. On the one hand, the applications have a clear and growing social interest, since they are mainly aimed at people with motor disabilities or dependents in the case of exoskeletons. On the other hand, there is a clear professional interest in how these technologies help medical doctors, particularly in surgery.

The objectives of this subject are built on the learning results of the previous courses, such as Robotics, Autonomous Robots, Signals and Systems, Automatic Systems, and others related to signal processing and filtering, and those obtained in Autonomous Robots course of the Master. The previous knowledge acquired in the Master's subjects constitutes a good basis for the subject, but they are not essential to study it. This course provides the necessary bases for those who do not have such bases. Robotic manipulators along with visual and visual reconstruction of internal organs are increasingly used techniques in surgery and in assistive robotics devices.

1.3. Recommendations to take this course

Subject of the Master that provides necessary prior knowledge: Autonomous Robots.

The course develops concepts, methods and applications partially based on knowledge of Robotics, Control and Biosignal processing. Students from Bachelor's degrees in Industrial Engineering (Electronics and Automation, Industrial Technologies, Mechanics fundamentally), Telecommunication Engineering, and Computer Engineering, have been able to acquire basic technical knowledge of signal processing, system modeling, filtering, and Robotics, which together with the knowledge acquired from the aforementioned Master's course constitutes a good basis for taking this course. Those coming from other studies may need some additional training in these techniques to be able to follow the course.

2. Learning goals

2.1. Competences

Basic and General:

- 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.
- CB8 - That students are able to integrate knowledge and face the complexity of formulating judgments based on information that, being incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of their knowledge and judgments.
- 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.
- 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.

Specific:

- 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.
- 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.

2.2. Learning goals

The student, to pass this course, must demonstrate the following results:

- Is able to understand the bases and mechanisms of generation and biosignals processing, in particular EMG and EEG.
- Is able to understand and apply bioinspired models to generate control techniques from biosignals.
- Is capable of carrying out the simple design of the control system of manipulator robots, in particular of exoskeletons.

2.3. Importance of learning goals

The importance of the learning results designed for this subject lies in the ability that the student acquires to understand and know the multiple uses of robotics in the professional world and in research, in a field that is currently being developed and will undoubtedly have much development in the coming years. The student will also be able to carry out the design of robotic systems from the point of view of modelling and control, which will allow him to get involved in his professional life in projects related to the development and application of these devices.

3. Assessment (1st and 2nd call)

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

The student must demonstrate that they have achieved the expected learning outcomes through the following assessment activities:

- E1. On-site written test: Theoretical-practical questions (30%)
- E2. Practical work: Resolution of case studies (60%) and evaluation of the accomplishment of the practice and the report of results of the same. (5%)
- E3. Oral presentations and discussions: Presentation of results of exercises, case studies, papers and practices and answering questions about them. (5%)

To pass the course, the four assessment activities must be carried out. Both the E1 face-to-face written test and the E2 practical work must be passed (5 points out of 10 in each one).

There will be a global test in each of the calls established throughout the course, on the dates and times determined by the Engineering School. This global test will be evaluated with the same criteria as the tests during the course.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The methodology followed in this course is oriented towards achievement of the learning objectives. A wide range of teaching and learning tasks are implemented, such as

- Lectures. The teacher will present the course contents and practical exercises corresponding to each topic. Students will solve exercises or study cases proposed by the teacher in class, which will be evaluated.
- Laboratory Practice sessions: Students will do the practice work using the equipment and software provided. They will be evaluated based on the activity performed during the session and from a subsequent report of results.
- Case study. The students will solve individually or in group practical cases proposed by the teacher, which will be evaluated
- Research articles. The teacher will propose the reading and analysis of advanced and current articles on the subject, which will be presented by the students, and will be evaluated.
- Seminars by expert guest lecturers.

4.2. Learning tasks

The course includes the following learning tasks:

- **A01 Lectures (22 hours).** The teacher explains the main contents of the course. The contents include doing exercises or simple practical cases by the teacher and students. In each topic, the possibility of conducting seminars by external experts will be considered.
- **A03 Practice sessions (4 hours).** These sessions will be carried out with the available equipment. The student must do a preliminary study prior to conducting the practice work, develop a proposal during the session, and write a brief report on the obtained results. All these activities will be evaluated in accordance with the provisions of section Assessment tasks.
- **A05 Assignments.** The student must individually solve practical cases proposed by the teacher. If the proposed case study is complex it may be done in groups as established by the teacher. This activity will be evaluated in accordance with the section Assessment tasks.
- **A06 Tutorials.** Students can review and discuss the materials and topics presented in both theoretical and practical classes during the teacher's office hours.
- **A08 Assessment.** A set of theoretical and practical written tests, oral presentations, reports, and practice work. The details are in the section Assessment tasks.

4.3. Syllabus

The course will address the following topics:

1. Introduction to Robotics: Manipulation Robotics, Mobile robotics, Assistive Robotics, Medical robotics, robotized Exoskeletons.
2. Polyarticulated mechanism modelling. Degrees of freedom of the human limbs. Generation of movements for robotic manipulators, trajectory generation, kinematic and dynamic motion control.
3. Robotic exoskeletons. Application of robotic manipulation techniques to exoskeleton control.
4. Exoskeleton control from biosignals. Muscle activation. Bioinspired models for exoskeleton control. Miosignals processing (EMG). Exoskeleton control from electroencephalographic signals (EEG).
5. Applications of assistive robotics.

4.4. Course planning and calendar

Further information concerning the timetable, office hours, assessment dates and other details regarding this course, will be provided on the first day of class or please refer to the EINA website.

4.5. Bibliography and recommended resources

1. Introduction to robotics : mechanics and control / Craig, John J.. - 4th ed. Ed. Pearson, 2017
2. Wearable robots: biomechatronics exoskeletons / J.L. Pons. Chichester : Wiley, 2008
3. Medical robotics / edited by Vanja Bozovic. Viena : I-Tech EDucation and Publishing, 2008