Control and automation applications in biomedicine

Academic Year: (2022 / 2023) **Review date: 17/05/2022 13:08:48**

Department assigned to the subject: Systems Engineering and Automation Department

Coordinating teacher: COPACI , DORIN SABIN

Type: Electives ECTS Credits : 6.0

Year : 4 Semester : 2

OBJECTIVES

By the end of this subject, students will be able to have:

1. a coherent knowledge of their branch of engineering including some at the forefront of the branch in automation of biomedical engineering.
2. the ability to apply their knowledge and understanding of automation applications to identify, formulate and solve engineering problems using established methods in the field of biomedical engineering;
3. the ability to apply their knowledge and understanding to develop and realise designs of automation applications to meet specific requirements;
4. workshop and laboratory skills in programming biomedical engineering systems;
5. the ability to select and use appropriate equipment, tools and methods such as sensors and actuators applied to biomedical engineering;
6. the ability to combine theory and practice to solve engineering problems of automation applications applied to biomedical engineering.
7. an understanding of applicable techniques and methods in applicable in biomedical engineering applications, and of their limitations;
8. awareness of the health, safety and legal issues and responsibilities of engineering practice, the impact of engineering solutions in a societal and environmental context, and commit to professional ethics, responsibilities and norms of biomedical engineering practice.

DESCRIPTION OF CONTENTS: PROGRAMME

The program is splitted as follows:
1. Robotic surgery systems.
1.1 Introduction
1.2 Minimally Invasive Surgery.
1.3 Laparoscopic robots
1.4 Elements and console terminals teleoperación
1.5 Haptic interfaces and control aspects.
2. Prosthetics and orthotics of upper limbs.
2.1 Exoskeletons and Prosthetics for hand
2.2 Prostheses and exoskeletons for elbow and wrist
3. Prosthetics and orthotics for lower limbs.
3.1 Prosthetics and orthotics for foot and ankle AFO
3.2 Prosthetics and orthotics for knee
3.3 Prosthetics and orthotics for knee, ankle and foot KAFO
4. Exoskeletons.
4.1 Exoskeletons for lower member
4.2 Exoskeletons for upper member
5. Control strategies:
5.1 Motion Control: speed and position control.
5.2 Force Control: force control, impedance control and control of admittance.
6. Actuators and sensors used in prosthetics, orthotics and exoskeletons.
7. Computer brain interfaces.

7.1 EEG, ECOG and implantable systems.
7.2 Analysis of the response.
8. Support systems for surgery.
8.1 Robots for neurosurgery,
8.2 Robots for traumatology,
8.3 Planners operations,
8.4 Robots for rehabilitation, robotic instruments, micro-robots.

LEARNING ACTIVITIES AND METHODOLOGY

The activities carried out in the teaching of the subject are:

Lectures. Presentation of the main concepts. Discussion and clarification of doubts about the concepts. It will work on transparencies that will be given to students to facilitate learning in addition to a text or basic reference texts on the subject required.

Classes practical exercises. Sessions in which problems arise and let students into groups to raise their solutions.

Laboratories. The students (in teams of 2 or 3) they propose a practical case studies, should study and then make the simulation data and analysis. knowledge of the topics covered in lectures and practical classes in the subject will be used. a previous study will, will work in the laboratory and then a written report with the results and proposed solutions will be delivered.

Addendum COVID-19:
Due to the situation caused by COVID-19, if it were both theory classes and seminars, they would be carried out online, the practices would be attempted in the laboratories, except in the case of impossibility, in which case they would be adapted to be carried out online.

ASSESSMENT SYSTEM

% end-of-term-examination/test:	0
% of continuous assessment (assigments, laboratory, practicals…):	100

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7. an understanding of applicable techniques and methods in applicable in biomedical engineering applications, and of their limitations;
8. demonstrate awareness of the health, safety and legal issues and responsibilities of engineering practice, the impact of engineering solutions in a societal and environmental context, and commit to professional ethics, responsibilities and norms of biomedical engineering practice.

Evaluation:
The evaluation of the subject is based on the continuous evaluation model. The overall grade for the course derives from three practical works (100% of the final grade) and attendance at practices and seminars (compulsory except for just cause) and theory classes. To carry out the work, the Matalab / Simulink program is used.

The practical works consist of:
- 2 laboratory assignments (in groups of two students) where students must implement, simulate and analyze the data obtained on topics related to the techniques learned in theory class and seminars. Each group must submit a report with the results obtained. Each of these works is scored with 25% of the final grade, the two works have a total of 50% of the final grade.
    - The first work consists of the simulation of the biomechanics of the human body: implementation

% end-of-term-examination/test: 0

% of continuous assessment (assigments, laboratory, practicals…): 100

of

skeletal segments and mathematical modeling of human muscle based on the Hill model.
- The second job involves processing electromyography signals and generating references from these signals for different actuators / devices like prosthetics.

- A final project that represents 50% of the final grade. The final work is done in groups of 2 students who must do a project on one of the teachers' proposed topics, related to topics learned in theory classes and seminars. Some examples of final works are: conceptual development of exoskeletons, development of rehabilitation interfaces (video games) where different sensors are involved, etc. Each of the groups must submit a report and the program files if applicable.

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The way of evaluating remains the same.

BASIC BIBLIOGRAPHY

- Wearable Robots: Biomechatronic Exoskeletons Edited by Jose L. Pons, John Wiley and sons , 2008

ADDITIONAL BIBLIOGRAPHY

- Ernesto Carlos Martinez-Villalpando, Design and evaluation of a biomimetic agonist antagonist active knee prosthesis,, Phd Thesis MIT,, 2007.

- Samuel Kwok-Wai Au,   Powered ankle foot prosteses for theimprovement-of-amputee-walking-economy,, Phd Thesis MIT,, 2007.

- Ulrich Hoffmann, Bayesian Machine Learning Applied in a Brain-Computer Interface for Disabled Users, , Phd Thesis EPFL,, 2007.