COURSE DESCRIPTION
ROBOTICS FOR BIOENGINEERING

SSD: AUTOMATICA (ING-INF/04)

DEGREE PROGRAMME: BIOINGEGNERIA INDUSTRIALE (P16)
ACADEMIC YEAR 2024/2025

COURSE DESCRIPTION

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GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE: NOT APPLICABLE
MODULE: NOT APPLICABLE
TEACHING LANGUAGE: INGLESE
CHANNEL: FG A-Z
YEAR OF THE DEGREE PROGRAMME: II
PERIOD IN WHICH THE COURSE IS DELIVERED: SEMESTER II
CFU: 6

REQUIRED PRELIMINARY COURSES

None.

PREREQUISITES

Basic knowledge of programming techniques; basic knowledge of closed loop control systems.

LEARNING GOALS

The course aims to provide the notions and the basics of design, implementation and control of collaborative robotic systems that physically interact with the human being, including soft and wearable systems. In addition to the use of methods for modeling and control of robotic systems consisting of rigid kinematic chains, theoretical methods will be provided for modeling and control of systems that include soft parts integrated into the structure or completely soft structures, robots capable of reconfiguring and adapting to the environment, as well as wearable robots such as prostheses and exoskeletons. Through practical applications of the knowledge acquired through the use of simulators for case studies, basic knowledge of the most common software used for

robot programming will be provided.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The student must demonstrate knowledge of collaborative robotic systems, in particular the mechanical structure and its characteristics, the typical control systems and the software used for programming. The student must demonstrate that he/she has acquired the modeling and control techniques of robotic systems characterized by soft structures that interact in close physical contact with the human being, including minimally invasive systems for surgery and wearable systems for rehabilitation.

Applying knowledge and understanding

The student must demonstrate the ability to design a control system, chosen among the classical systems studied. The student must be able to implement such a control system using simulation tools provided during the course. Furthermore, the student must demonstrate basic knowledge of typical open-source tools for rapid prototyping, electronics and 3D printing.

COURSE CONTENT/SYLLABUS

1. Introduction to soft and collaborative robotics: areas of use and state of the art; 2. Hardware solutions for a collaborative system: soft covers and variable impedance actuators; 3. Soft robots: modeling and control; 4. Continuous and snake-like robots; 5. SOFA simulator; 6. Bioinspired robots; 7. Microrobots and magnetic actuation. 8. Teleoperation: introduction and definition of the different existing schemes (unilateral and bilateral), methods of representation and control of a teleoperated system, passivity and stability, tank theory; 9. Haptic interfaces: definition and control schemes; 10. Shared and semi-autonomous control: impedance control in collaborative robots; 11. Supervised autonomy: control architectures and interfaces; 12. Learning techniques applied to shared control.

READINGS/BIBLIOGRAPHY

B. Siciliano, O. Khatib (Eds.), Springer Handbook of Robotics, 2nd Edition, Springer, Berlin, 2016, ISBN 978-3-319-32552-1.
K.M. Lynch, F.C. Park, Modern Robotics: Mechanics, Planning, and Control, Cambridge University Press, 2017, ISBN 9781107156302.
J. Rosen, B. Hannaford, R.M. Satava (Eds.), Surgical Robotics: Systems, Applications, and Visions, Springer, 2011 ISBN 9781441911261.
A. Schweikard, F. Ernst, Medical Robotics, Springer, 2015, ISBN 9783319228914.
Notes from the lectures, available to students enrolled in the course through Segrepass.

TEACHING METHODS OF THE COURSE (OR MODULE)

The teacher will use: a) lectures for about 70% of the total hours, b) classroom exercises using simulation tools for soft robots and/or robots for surgery and rehabilitation, based on SOFA, ROS, Gazebo and CoppeliaSim, c) 2/3 2-hour seminars held by doctors, robotic researchers and representatives of the medical robot industry.

EXAMINATION/EVALUATION CRITERIA

a) Exam type

- [ ] Written
- [x] Oral
- [x] Project discussion
- [x] Other : The project must be delivered to the teacher one week before the oral exam and then discussed during the oral exam through a presentation of the results obtained. The paper aims to verify the student's ability to design simple control algorithms for collaborative robotics applications in the medical field (surgical or rehabilitative), using one of the simulators, based on ROS, SOFA, Gazebo and CoppeliaSim, which were introduced and used during the course exercises. The oral exam follows the discussion of the paper and is aimed at a critical discussion of the solution(s) given by the student to the problems proposed in the simulation paper, and at verifying the acquisition of the concepts and contents introduced during the lessons.

In case of a written exam, questions refer to

- [ ] Multiple choice answers
- [x] Open answers
- [ ] Numerical exercises

b) Evaluation pattern

The project is mandatory to access the oral exam, and it contributes to 25% of the final evaluation.