



<b>Module Title:</b>	<b>O4 - Robotics for Healthcare</b>
----------------------	-------------------------------------

<b>Coordinator:</b>	Universitat Politècnica de Catalunya, Spain	<b>Contact:</b>	Dr. Josep Fernandez <a href="mailto:josep.fernandez@upc.edu">josep.fernandez@upc.edu</a>
---------------------	---	-----------------	---

Suggested Learning and teaching hours	70 hrs
Suggested Independent study	80 hrs Learning activities Short exercises Final project
<b>Module duration (total hours)</b>	<b>150 hrs</b>

<b>Module Aims</b>
<p>This eModule aims at providing skills and knowledge on robotics and their application in healthcare.</p> <p>Problem based learning and working in multidisciplinary groups methodologies are used in order to achieve a wide and deep knowledge about the use of robot technologies in healthcare.</p> <p>The main goals of the course are the introduction to the methodological bases of robot modelling and control as well as the analysis of the medical requirements of robotics in each health area.</p>

<b>Target Group and Prerequisites</b>
<p>This module is designed for CTS students who have almost finished their Bachelor Degree or who are doing their Master Course. The students must know linear algebra, computer programming and fundamentals of mechanics.</p>

## Learning Outcomes

By the end of the training, the student should have skills and knowledge to:

- Consider the human factors as part of the inputs to the project to develop
- Analyse a problem and identify the project requirements
- Select the adequate control strategy for each robot project
- Conceive a project as a whole
- Develop project in the field of systems engineering, control and robotics for healthcare

## Module Delivery Guidance

This work is licensed under the Creative Commons Attribution 3.0 Unported License. To view a copy of this license, visit <http://creativecommons.org/licenses/by/3.0/>.

This module comprises a set of Microsoft Powerpoint (PPTX) or Open Document (ODP) presentations, all of which have teacher's guidance notes in the Notes sections of the presentations.

Some sections include exercise in a complementary document.

It is recommended to use Microsoft PowerPoint for PPTX and PPT files, and Microsoft Word for DOC or DOCX files.

It is recommended to use Open Office or Libre Office for ODP and ODT files.

A PDF version of the presentations and the exercises are also available.

## Assessment:

Chapter 2 and Chapter 6 have associated a set of exercises.

A final team project is proposed. Students, working in group, have to propose a solution to a challenge related to healthcare robotics.

## Syllabus and resources:

All theoretical and practical contents on-site are calculated in blocks of 90 minutes, e.g.

- Lectures 2,5
- Laboratory 2

means 2,5 theoretical blocks and 2 practical blocks

### Chapter 1: Foundation of robotics

- Lectures 10
- Laboratory 0

This chapter covers the foundations of robotics: Robot components. Robot's morphology, Kinematics, Dynamics and Control. Robot architecture and applications.

#### Files

- O4\_Ch1-1\_TEACHER.pptx - Introduction (8)
- O4\_Ch1-2\_TEACHER.pptx - Robot Morphology (14)
- O4\_Ch1-3\_TEACHER.pptx - Mathematical tools (38)
- O4\_Ch1-4\_TEACHER.pptx - Robot Kinematics (35)
- O4\_Ch1-5\_TEACHER.pptx - Differential Kinematics (8)
- O4\_Ch1-6\_TEACHER.pptx - Kinematic control (13)
- O4\_Ch1-7\_TEACHER.pptx - Programming and planning (7)

The PDF version of the slides are also available (STUDENT).

The PDF version of the slides with teacher notes are also available (TEACHER).

(n) Inside parentheses refers to the number of slides of each file.

### Chapter 2: Human robot interaction in medical robotics.

- Lectures 5
- Laboratory 2,5

This chapter introduces the needs and techniques about controlling a mechanical structure. The chapter includes teleoperation technique, cooperation, shared control and haptic devices.

#### Files

- O4\_Ch2-1\_TEACHER.pptx - Teleoperation (61)
- O4\_Ch2-2\_TEACHER.pptx - Co-manipulation in surgical robotics (45)
- O4\_Ch2\_LAB1\_TEACHER.zip – MATLAB exercises
- O4\_Ch2\_LAB2\_TEACHER.zip - Co-manipulation MATLAB exercise

The PDF version of the slides are also available (STUDENT).

The PDF version of the slides with teacher notes are also available (TEACHER).

(n) Inside parentheses refers to the number of slides of each file.

### Chapter 3: Assistive robotics

- Lectures 7
- Laboratory 0

The specific chapter: “Assistive robotics / Technology to help elderly and handicapped people / Robots for mobility / Robots at home” aims to introduce students on these technologies, describe their current status, implementation challenges, and their potential use and application.

#### Files

- O4\_Ch3-1\_TEACHER.pptx - Assistive robotics / Technology to help Elderly and Handicapped People (102)

The PDF version of the slides are also available (STUDENT).

The PDF version of the slides with teacher notes are also available (TEACHER).

(n) Inside parentheses refers to the number of slides of each file.

### Chapter 4: Rehabilitation robotics

- Lectures 6
- Laboratory 0

The purpose of this chapter is to present the needs in the field of rehabilitation of both motor and cognitive abilities. Different methods and systems are presented for the rehabilitation of lower and upper extremities, as well as for neurorehabilitation.

#### Files

- O4\_Ch4-1\_TEACHER.pptx - Introduction to rehabilitation robotics (14)
- O4\_Ch4-2\_TEACHER.pptx - Rehabilitation robotics. Upper limbs (32)
- O4\_Ch4-3\_TEACHER.pptx - Rehabilitation robotics. Lower limbs. Therapies (13)
- O4\_Ch4-4\_TEACHER.pptx - Rehabilitation robotics. Lower limbs. Gait balance (48)
- O4\_Ch4-5\_TEACHER.pptx - Rehabilitation robotics. Neurorehabilitation (58)

The PDF version of the slides are also available (STUDENT).

The PDF version of the slides with teacher notes are also available (TEACHER).

(n) Inside parentheses refers to the number of slides of each file.

## Chapter 5: Prosthesis

- Lectures 4
- Laboratory 0

This chapter presents artificial device that replaces a missing body part, which may be lost through trauma, disease, or a condition present at birth. After a short look through the history of prostheses, this material introduces hand prostheses, upper limbs prostheses and lower limb prostheses. Finally, some technological aids for sensory impaired people are presented.

### Files

- O4\_Ch5\_TEACHER.pptx - Prosthesis (51)

The PDF version of the slides are also available (STUDENT).

The PDF version of the slides with teacher notes are also available (TEACHER).

(n) Inside parentheses refers to the number of slides of each file.

## Chapter 6: Surgical robotics

- Lectures 7
- Laboratory 2

This chapter is an overview of the main challenges to build surgical robotics systems. The topics covers are medical imaging, coordinate transformations, registration of medical data for laparoscopic interventions and surgical robotics, in general. The material analyses the Da Vinci surgical system, as example of commercial surgical robots.

### Files

- O4\_Ch6-1\_TEACHER.ppt – 3D Visualization of Medical Images (27)
- O4\_Ch6-2\_TEACHER.ppt – Medical Image Registration: Coordinate Transformations (32)
- O4\_Ch6-3\_TEACHER.ppt – Medical Image Registration: Point-Based Methods (21)
- O4\_Ch6-4\_TEACHER.ppt – Medical Image Registration: Surface-Based Methods (20)
- O4\_Ch6-5\_TEACHER.ppt – Laparoscopic Interventions (19)
- O4\_Ch6-6\_TEACHER.ppt – The Da Vinci Surgical System (35)

Sections 2, 3 and 6 includes exercises (worksheets and solutions).

There are three videos with additional information of the Da Vinci surgical system.

The PDF version of the slides are also available (STUDENT).

The PDF version of the slides with teacher notes are also available (TEACHER).

(n) Inside parentheses refers to the number of slides of each file.

## Chapter 7: Case studies in robotics for healthcare

- Lectures 3
- Laboratory 0

In the final chapter, robots for healthcare are approached from the point of view of patients and health professionals. Eight cases are presented in different areas of health, and the implications of the proposed solutions are analysed.

### Files

- O4\_Ch7\_TEACHER.pptx - Case studies in robotics for healthcare (78)

The PDF version of the slides are also available (STUDENT).

The PDF version of the slides with teacher notes are also available (TEACHER).

(n) Inside parentheses refers to the number of slides of each file.

## Final Project: Solve a challenge

- Estimated time: 50 hours

The final project is an activity to be carried out in team, where students have to integrate different concepts presented in the module.

Students should preferably work autonomously. However, it will be useful for them to have the help of a mentor.

The document includes a short introduction to engineering design and several challenges.

### Files

- Final\_project.pptx (7)

The PDF version of the slides are also available (STUDENT).

(n) Inside parentheses refers to the number of slides of each file.

## **Suggested reading list:**

### Books

- Robotics, vision and control: Fundamental algorithms in Matlab - Corke, P.I, Springer, 2017. 2<sup>nd</sup> edition. ISBN: 978-3-319-54412-0. <http://petercorke.com/wordpress/rvc/>
- Handbook of robotics - Siciliano, B.; Khatib, O. (eds.), Springer, 2008. ISBN: 978-3-540-23957-4
- Fundamentos de robótica - Barrientos, A. [et al.], McGraw-Hill, 2007. ISBN: 9788448156367

### Journal articles & Conference papers

- Journal of Medical Robotics Research - <https://www.worldscientific.com/worldscinet/jmrr>
- The International Journal of Medical Robotics and Computer Assisted Surgery - <https://www.wiley.com/en-us/The+International+Journal+of+Medical+Robotics+and+Computer+Assisted+Surgery-p-9785JN>
- IEEE Transactions on Medical Robotics and Bionics - <https://www.ieee-ras.org/publications/t-mrb>

## **Suggested links:**

- The Place Of Robots In Healthcare - <https://medicalfuturist.com/robotics-healthcare/>
- Robotics: Changing the Future of Health Care - <https://www.cerner.com/perspectives/robotics-changing-the-future-of-health-care>