UCLouvain

lelme2732

2023

Robot modelling and control

5.00 credits	30.0 h + 30.0 h	Q2

Teacher(s)	Docquier Nicolas (compensates Ronsse Renaud) ;Ronsse Renaud ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	Students are expected to master the following skills: basic knowledge in description and analysis of mechanisms, and linear control, as they are covered within the courses LMECA1210 and LINMA1510.
Main themes	Robotics is a field requiring the integration of multiple fields of expertise. Robot design requires indeed integrating a mechanical structure, one or several actuators, one or several sensors, and a controller governing the robot behavior. This controller has also to be implemented by using the dedicated IT tools. Historical robotics applications were mostly developed for the industry, in the late 70s. The goal of industrial robotics is automatization of fabrication processes, targeting the increase of productivity. Later on, robotics further penetrated other application fields, characterized by unpredictable environments (while an industrial operation zone is usually unchanging and predictable). Therefore, these robots have to adapt their behavior in response to changes in the interactions with the environment. Such applications are: • Mobile robots (wheeled and legged robots), evolving on unknown and potentially irregular terrains. • Surgical robots, assisting the surgeon to reach difficult body regions, to perform very accurate gestures (out of standard human capacities), etc. • Rehabilitation robots, assisting patients with motor deficits to recover part of their autonomy. • Companion robots, providing various services like load transport, guide in a museum, etc. to one or several persons. The goal of this course is to provide a global vision of robotics challenges to Master students, both in classical applications (industrial robotics) and in more avant-gardist applications.
Learning outcomes	**At the end of this learning unit, the student is able to :** In consideration of the reference table AA of the program "Masters degree in Electromechanical Engineering", this course contributes to the development, to the acquisition and to the evaluation of the following experiences of learning: • AA1.1, AA1.2, AA1.3 • AA2.4 • AA3.1, AA3.3 • AA4.2, AA4.3, AA4.4 • AA5.2, AA5.5 • AA6.1, AA6.2 LMECA2732 integrates different technical concepts beging necessary for modeling and control of industrial and mobile robots. This course opens the perspectives to the broad field of robotics, giving access to more advanced courses and/or Master thesis. a. <u>Disciplinary Learning Outcomes</u> At the end of this course, students will be able to: 1 • Integrate and synthetize concepts and knowledge acquired in other courses to the field of robotics. Example: designing a typical linear controller for a simple robot whose kinematic and dynamic models have to be derived, and choosing the sensors to implement this controller. • Derive a geometrical, kinematic, and dynamic model (both forward and inverse) of a simple industrial or mobile robot, and establish some features related to these models (e.g. singularities). • Propose a trajectory planning method, and some classical control design approaches, taking these models into account. • Implement fundamental concepts like localization and trajectory planning to the particular field of mobile robotics. • Program a mobile robot controller implementing these concepts, using state-of-the-art robotic software. • Describe and explain the working principle of typical robot sensors. • Raise some fundamental ethical questions related to robotics, both in industry and service applications. • Describe the specific features of different robot morphologies (e.g. serial industrial robots, parallel robots, mobile robots, service robots), and make links between them. b. <u>Transversal Learning Outcomes</u> At the end of this course, students will be able to:

	• Quickly answer basic questions related to and/or applying some concepts covered during the lecture. • Write down a project report in a concise and efficient way, possibly including multimedia material (video).
Evaluation methods	In this course, students are evaluated by : • a continuous assessment in the form of a "problem-based learning" project in mobile robotics carried out during the semester, in groups of 4-6 students. • a continuous assessment in the form of small online quizzes offered at the end of some lectures, on a topic covered during the lecture itself. • an individual written exam, conducted in session, which includes both theoretical questions and exercises, similar to those done during the year and in the project. No references are allowed during the exam. To constitute the final grade, the weighting given to the continuous assessment is: • 40% for the mobile robotics project and 10% for the online quizzes if the individual written exam grade is strictly above 6/20. • 0% if the mark of the individual written exam is less than or equal to 6/20. The grade for continuous assessment is individualized according to the student's involvement in the group during the term (attendance at tutoring sessions, etc.). The work for which the continuous assessment mark is awarded cannot be repeated in the second session; the continuous assessment mark acquired in the first session is retained in the event of a second session. The use of generative AI software such as chatGPT is authorized for assistance in writing the documents requested as part of this project. However, it must be clearly and completely indicated in the document(s) concerned.
Teaching methods	The course follows a straight path, starting with trajectory planning, the derivation of models, and ending with lectures on control and programming. The lectures specific to mobile robots are given early enough to be useful for the integrated project in mechatronics (LELME2002). One course on robot ethics given by an invited teacher is organized around S10. More open lectures on service robots, etc. are given at the end of the course. A technical visit and/or presentations by external speakers will be included in the programme if practical arrangements allow. On top of that, a project about mobile robotics is organized. This project is completed by groups of 4-6 students.
Content	The course covers the following chapters: • Introduction • Mobile robot kinematics • Mobile robot planning and control • Mobile robot localization • Real-time programming of (mobile) robots • Robot-specific operating systems • Kinematic modeling and trajectory planning of industrial robots • Robot sensors • Dynamics • Robot control • Force and impedance control • Ethics in robotics • Humanoid robotics • Q&A and conceptual map
Inline resources	Moodle (http://moodle.uclouvain.be/course/view.php?id=5143) is used for: • Managing/answering the small on-line questionnaires provided at the end of some lectures. • Broadcasting general information related to the course. • Providing all lecture slides and necessary references. • Managing a forum discussing/answering the questions asked by the students
Bibliography	The two main references for the course are the books: • "Introduction to Autonomous Mobile Robots" (http://www.mobilerobots.ethz.ch/) by Roland Siegwart et al.; • "Robot Modeling and Control" (https://www.wiley.com/en-us/Robot+Modeling+and+Control%2C+2nd+Edition-p-9781119524045) by Mark W. Spong et al. Several samples of these two books are available at the library (BST). Chapters from other books are provided as complementary material for some specific lectures. The main reference for complementary materials is: • "Springer Handbook of Robotics", 2nd edition (the 'bible' of robotics, http://www.springer.com/us/book/9783319325507) by Bruno Siciliano and Oussama Khatib (Eds.). This book is available on-line (from the UCL network).
Other infos	Basic skills in C programming are recommended for this course

Faculty or entity in charge	ELME

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Biomedical Engineering	GBIO2M	5		
Master [120] in Mechanical Engineering	MECA2M	5		
Master [120] in Electro-mechanical Engineering	ELME2M	5		
Master [120] in Mathematical Engineering	MAP2M	5		