UCL Université catholique de Louvain

LMECA2732

2013-2014

INTRODUCTION TO ROBOTICS

5.0 credits	30.0 h + 30.0 h	2q

Teacher(s) :	Ronsse Renaud ;
Language :	Anglais
Place of the course	Louvain-la-Neuve
Inline resources:	iCampus (> http://icampus.uclouvain.be/claroline/course/index.php?cid=MECA2732) is used for: Managing/answering the small on-line evaluations related to each mandatory reading. 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.
Prerequisites :	-- LELEC2811 (Instrumentation and sensors) -- LINMA1510 (Linear Control (optional) -- LMECA2755 (Industrial automation)
Main themes :	Robotics is a field requiring the integration of multiple expertises. Robot design requires indeed integrating a mechanical structure, one or several actuators, one or several sensrs, 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. From more than one decade, 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.
Aims :	LMECA2732 implements an integration of different concepts covered in other courses (basic geometry, industrial automation, linear control, instrumentation and sensors, etc') in the field of industrial and mobile robotics. This course opens the perspectives to the broad field of robotics, giving access to more advanced courses and/or Master thesis. -- 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 a. Disciplinary Learning Outcomes At the end of this course, students will be able to: 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. Describe and explain the working principle of typical robot sensors. Have a critical opinion regarding ethical questions related to robotics, both in industry and service robots. 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. Transversal Learning Outcomes At the end of this course, students will be able to: Quickly read a book chapter or a scientific paper and answer basic questions (multiple choices) about it. Write down a lab report in a concise and efficient way (max. 1 page), possibly including multimedia material (video'). *The contribution of this Teaching Unit to the development and command of the skills and learning outcomes of the programme(s) can be accessed at the end of this sheet, in the section entitled "Programmes/courses offering this Teaching Unit".*
Evaluation methods :	The final mark is obtained as following : 10% is awarded based on the small questionnaires (MCQ) related to the mandatory readings, to read before each lecture. There is a mandatory reading and MCQ for all lectures but 3: the introduction (S1), the course on ethics and the concluding (Q& mp;A) lecture (S14). A bonus is offered such that each student can skip one questionnaire (or two questions) without losing chance to get the maximum score. A problem-based learning project in mobile robotics has to be completed by groups of 4-5 students, to apply the theoretical concepts to a concrete example. The mark obtained in this project will count for 30% of the final mark. One lab in humanoid robotics counts for 10% of the final mark. Finally, the final written exam counts for 50% of the mark. It lasts for about 4 hours, containing both theoretical questions, and exercises, similar to those covered during the lectures and in the PBL problem. No reference is allowed during this exam.
Teaching methods :	Process organization The course follows a straight path, starting with trajectory planning, the derivation of models, and ending with lectures on control. The lectures specific to mobile robots are given early enough to be useful for the integrated project in mechatronics (LMECA2845). One course on robot ethics given by a colleague from ESP (Prof. Mark Hunyadi) is organized around S10. More open lectures on service robots, etc' are given at the end of the course. In sum, the course covers the following chapters: Introduction Recap of LMECA2755: kinematic modeling, and independent joint control Trajectory planning Mobile robot planning and navigation Mobile robot kinematics and control Mobile robot localization Robot sensors Dynamics Robot control Force and impedance control Ethics in robotics Humanoid robotics Parallel robots (optional) Q& mp;A and conceptual map On top of that, one lab is organized on humanoid robotics with the "NAO" robot (http://www.aldebaran-robotics.com). This lab is completed by groups of 2 students. A small report (one page max.) is asked. 10% of the final mark is given on the basis of the lab completion.
Content :	Introduction: robotics history; technico-econominal motivations; robot classification. Change of coordinates and associated problems: geometrical, kinematic, and dynamic models (direct/inverse); homogenous transformations; singularities. Parallel robots, mobile robots, humanoid robots, medical robots: specificities, associated components (actuators/sensors) and controllers. Concepts introduced during the course will be illustrated with two laboratories: -- One giving the students a chance to steer and program a real industrial robot. -- One giving the students a chance to steer and program a small humanoid robot.
Bibliography :	Media The two main references for the course are the books -- "Robot Modeling and Control" (http://eu.wiley.com/WileyCDA/WileyTitle/productCd-EHEP000518.html) by Mark W. Spong et al. -- Introduction to Autonomous Mobile Robots (http://www.mobilerobots.ethz.ch/) by Roland Siegwart 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 (the "bible" of robotics, http://www.springerlink.com/content/978-3-540-23957-4) by Bruno Siciliano and Oussama Khatib (Eds.). This book is available on-line (from the UCL network).

Other infos :	The lecture on ethics in robotics (S10) is given by Mark Hunyadi (http://www.uclouvain.be/260169.html), in French.
Cycle and year of study :	> Master [120] in Electro-mechanical Engineering > Master [120] in Mathematical Engineering > Master [120] in Mechanical Engineering
Faculty or entity in charge:	MECA