UCL Université catholique de Louvain

LMECA2732

2016-2017

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:	Moodle (> > http://moodleucl.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.
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 expertises. 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.
Aims :	In consideration of the reference table AA of the program "Masters degree in Mechanical 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 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. 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 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').
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 :
--
The final evaluation is a written exam. It lasts for about 3 to 4 hours, containing both theoretical questions, and exercises, similar to those covered during the lectures. No reference is allowed during this exam. If the student obtains less than 8/20 as final exam mark, only this will count for the final evaluation.
--
Otherwise, if the student obtains at least 8/20 as final exam mark, the final evaluation is computed as following:
o The final written exam counts for 50% of the final mark.
o 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 50% of the final mark.
Finally, at the end of some lectures, a small online questionnaire will be organized, on a topic covered during the lecture. Students displaying good participation and performance to these questionnaire will receive one bonus point (+1/20) to their final mark.

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 :

The course covers the following chapters:
Introduction
Mobile robot kinematics
Mobile robot planning and control
Mobile robot localization
Recap of LMECA2755: kinematic modeling Trajectory planning, revisited
Robot sensors
Dynamics
Robot control
Force and impedance control
Ethics in robotics
Humanoid robotics
Parallel robots (optional)
Q& mp;A and conceptual map

Bibliography :

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', 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:	MECA

Programmes / formations proposant cette unité d'enseignement (UE)

Intitulé du programme	Sigle	Credits	Prerequis	Acquis d'apprentissage
Master [120] in Biomedical Engineering	GBIO2M	5	-	
Master [120] in Electro-mechanical Engineering	ELME2M	5	-	
Master [120] in Mechanical Engineering	MECA2M	5	-	
Master [120] in Mathematical Engineering	MAP2M	5	-	