R7010E Robotics

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1 Course Objectives

At the completion of this course, students will be able to:

1. Experience the magic world of Robotics
2. Develop a broad understanding of fundamental principles in Robotics
3. Develop an understanding in Position and Orientation in Robotics
4. Develop an understanding of path planning for Robotics
5. Understand the fundamental principles of Ground Robotics
6. Experiment with real life ground robots (Unmanned Ground Vehicles - UGVs)
7. Understand the fundamental principles of Aerial Robotics
8. Experiment with real life Unmanned Aerial Vehicles (UAVs)
9. Understand fundamental concepts of Robotic Vision
10. Combine theory with practice
11. Develop the capacity to design, simulate and implement basic robotic applications
12. Understand the fundamental principles of Robotic Manipulators

2 Course Description

The R7010E course is aiming to give a full introduction in the magnificent word of robots, a word where the machines should plan and execute tasks without any human intervention. Of course the field of Robotics is vast and cannot be covered only by one course and in a limited time. However, the R7010E course is amining to present the fundamental concepts in the area of robotics, concepts that could form the basis for all the future directions in robotics.

The term Robotics spans in a great variety from ground robots, to bio-inspired robots, to flying, underground, marine robotics and humanoids. However, all these machines are characterized by specific demands from a theoretical and technological perspective, demands that require answers to the following fundamental questions in Robotics:

- *Where am I?*
- *What is the surrounding environment?*
- *Where should I go - what to do there?*
- *How I go from A to B point?*
- *How I perform a task autonomously?*

Through the course, answers to the these questions will be chased, while the overall course has been designed with a specific aim to give the opportunity to the students to experiment will all the theoretical materials presented in the lectures. Thus the course is accompanied by specific labs and extended demonstration of fundamental concepts in robotics. These labs will utilize the following robotic platforms:

- *Turtle Bot 3*
- *Crazyflie 2*

while during the experimentations there will be a utilization of a Motion Capture system based on VICON and the corresponding flying arena of the Robotics Team at LTU. The lab assignments will be performed in Matlab and in higher levels of programming, while extensive use of the Robotics Toolbox from Peter Corke will be take place. The toolbox can be located here:

http://petercorke.com/wordpress/toolboxes/robotics-toolbox

3 Course Practicalities

The students should have a solid background in the following areas:

- *Automatic Control*
PID control, State space, Kalman filter, extended Kalman filter, probability theory
- *Programming Skills*
Matlab
- *Curiosity on experimenting*
Extended experimentation in multiple small project oriented labs

Passing the Course Succesful completion and demonstration of all the lab assigments. This course will not involve a written examination.

Credits: 7.5

Primary Textbook A: *Robotics, Vision and Control*, 2nd Edition
Author(s): Peter Corke **ISBN:** 978-3-642-20143-1

Secondary Textbook B: *Robotics, Control, Sensing, Vision and Intelligence*,
Authors: K.S. FU, R.C. Gonzalez and C.S.G. Lee **ISBN:0-07-100421-1**

4 Structure of Lectures

Order	Lecture Name	Learning Outcomes
1-2	Representing Position and Oriantation	Positioning and orientation in Robotics
3	Time and Motion	Define paths and trajectories for Robots
4	Intro to Mobile Robotics	Model, simulate, control a mobile Robot
5	Intro to Aerial Robotics	Model, simulate, control a UAV
6	Programming with Robots	Robotic Programming with Matlab, ROS and LabView
7-8	Robot Navigation	Navigation algorithms for Robotics
9-10	Localization and Mapping	Mapping and localization for Robotics
11	Sensor and Perception	How to sense the environment
12	Robotic Vision	Fundamental concepts on Robotic Vision
13-14	Robotic Manipulators (depending on time)	Forward and Inverse Kinematics of Manipulators

Specific theory that will be covered in the course is the following from the book "Robotics, Vision and Control":

Chapters	Sub-Sections	Not Addressed
1. Introduction	all	
2. Representing Position and Oriantation	2.1, 2.2, 2.4, 2.5	2.1.2.3, 2.2.2.3, 2.3
3. Time and Motion	3.1, 3.2, 3.3	3.1.4, 3.4(different approach)
4. Mobile Robot Vehicles	4.1, 4.2	4.3
5. Navigation	5.1, 5.2	
6. Localization	6.1, 6.2, 6.3, 6.4, 6.6, 6.8	6.5, 6.7

5 Structure of Labs

Lab ID	Lab Name	Learning Outcomes
1	Time and Motion	Defining Trajectories for robots in multiple scenarios
2	Mobile Robotics	Experimenting with mobile Robots
3	Aerial Robotics	Experimenting with UAVs
3	2D SLAM	Integrate multiple components for 2D SLAM

For all the previous Labs a short report on the solved tasks will be required. The report should contain the code and the corresponding results. When the lab involves a final demonstration, the demonstration itself will be the needed report.