MECE-E4603 Applied Robotics: Algorithms and Software

Course Designator: MECE
Course Prefix: E
Course Number: 4603
Course Semester: x
Title: Applied Robotics: Algorithms and Software
Lecture Hours: standard (13/14 lectures)
Lab Hours: 0 **Points:** 3
Instructor: Matei Ciocarlie
Prerequisites: Fundamental programming skills (e.g. COMS W1002 or COMS W1004 or COMS W1005 or ENGI E1006 or equivalent).

Corequisites: none

Program Restrictions: none

Textbook: none

Evaluation: Applied projects (70%), quizzes (30%)

Bulletin Description: The science and systems aspects of Robotics taught from an applied perspective, focusing on algorithms and software tools. Spatial reasoning; tools for manipulating and visualizing spatial relationships. Analysis of robotic manipulators; numerical methods for kinematic analysis. Motion planning, search-based and stochastic approaches. Applications for force and impedance control. Grading based on a combination of exams and projects implemented using the Robot Operating System (ROS) software framework and executed on real and simulated robotic manipulators.

Notes: This course can be taken individually or simultaneously with MECE E4602 (Introduction to Robotics). This course can also be used to satisfy the requirements of the Robotics and Control concentration of the Mechanical Engineering Master of Science program.

Rationale: The Robotics industry is booming, with new application domains ranging from logistics and e-commerce to the hospitality industry and even the home, and unprecedented investment from both start-ups and major technology companies such as Amazon or Google. This course teaches the combined science and systems aspects needed for a roboticist to hit the ground running in this new ecosystem. It presents the core aspects of mobility and manipulation using modern tools such in both software (the Robot Operating System) and hardware (the Baxter robotic manipulator). While theoretical concepts are presented as needed, the focus is on learning the practical application of these concepts in assignments executed on real robots.

Syllabus:

9/5	Introduction
9/7	Introduction to ROS
	Assignment 0 (ungraded) released: basics of ROS
9/1 2	Transforms I
9/1 4	Transforms II
	Assignment 1: Transform Manipulation and Visualization in ROS
9/1 9	Kinematic Chains / Forward Kinematics
9/2 1	Analytic Inverse Kinematics
	Assignment 2: FK and Robot Visualization
9/2 6	Differential Kinematics
9/2 8	Linear Algebra Refresher I (matrices and vector spaces, linear systems)
10/ 3	Linear Algebra Refresher II (Singular Value Decomposition)
	Redundant Robots
10/ 5	Cartesian Control I
10/ 10	Cartesian Control II
	Numerical Inverse Kinematics
10/ 12	Assignment 3: Cartesian Control and Numerical IK

	Midterm review
10/ 17	Midterm quiz
10/ 19	CTV Robotics Symposium
10/ 24	Motion Planning I
10/ 26	Motion Planning II
10/ 31	Motion Planning III
11/ 2	Trajectory Execution
	Force Generation on Robot Arms
11/ 9	Assignment 4: Motion Planning
11/ 14	Mobile Robot Kinematics
	State Estimation I
11/ 16	State Estimation II, Probabilistic Reasoning
11/ 21	State Estimation III, the Kalman Filter
11/ 28	State Estimation IV, Extended Kalman Filter, Particle Filters
11/ 30	Final review
	Assignment 5: State Estimation
12/ 5	Final quiz
12/ 7	Recap and Conclusions