MECENG C106A and MECENG 206A: Introduction to Robotics

Undergraduate and Graduate Course Syllabus

Instructor: Koushil Sreenath, Shankar Sastry

Course Description

This course is an introduction to the field of robotics. It covers the fundamentals of kinematics, dynamics, and control of robot manipulators, robotic vision, and sensing. The course deals with forward and inverse kinematics of serial chain manipulators, the manipulator Jacobian, force relations, dynamics, and control. It presents elementary principles on proximity, tactile, and force sensing, vision sensors, camera calibration, stereo construction, and motion detection. The course concludes with current applications of robotics in active perception, medical robotics, autonomous vehicles, and other areas.

Students are expected to have a background in linear algebra, calculus, and basic physics, as well as familiarity with the Python programming language. The lectures are supplemented with homeworks and experimental work in the laboratory using the Baxter robot and multiple mobile Zumy, Turtle robots. There are two midterms, but no final exam. The last month is devoted to the design and implementation of a final project, carried out in groups of ~4 students.

Required text: Richard Murray, Zexiang Li and S. Shankar Sastry: "A Mathematical Introduction to Robotic Manipulation" (first edition digitally available).

Additional lectures will cover the basics of computer vision, path planning, state estimation and control.

Grading Policy

Labs 20%: There will be a total of eight labs spaced over the start of the semester. Labs will ask you to complete a number of exercises, including derivation of equations and implementation in Python and ROS for use with cameras, the Baxter robot and other hardware.

Homework 20%: Homework assignments will reflect material covered in the lectures and discussion sections. They are posted to bCourses and must be submitted to Gradescope by the deadline. You have a total of five late days for the semester and may use up to 3 late days on any given assignment.

Exams 20%: There are two midterm exams, each worth 10% of your final grade. There is no final exam

Final Project 40%
A substantial part of the grade is based on the final group project. Groups comprise of two to four people, and can include people outside of your lab group. The choice of project topic is up to the student, but the final project must integrate sensing, planning, and actuation in some non-trivial way. They usually involve both hardware and software demonstrations (during the pandemic it has been exclusively software). It is our estimate that the projects require between 60-80 hours per person, and the projects are done in groups of 2-4, though there are occasionally solo performers. The project grade includes

1. A project proposal submission which is graded by the entire teaching staff,
2. Mid-project presentations
3. Final presentations which are graded by the entire teaching staff.
4 A project website for each project at the end of the class.

Differences between ME C106A and ME 206A
Students enrolled in MECENG 206A are required to incorporate work from a published paper into their project (ie. implement an inverse kinematic algorithm). Additionally, the final project report will be submitted as a conference-style paper (in addition to the video submission and website required by the undergraduate version). For students enrolled in MECENG 206A a satisfactory project is one that could lead to submission for publication in a leading conference on robotics, vision, AI/ML. The determination of this is left to the discretion of the instructor. Final projects which are too modest in scope, or if after submission the projects seem to not be up to graduate level expectations we have in the course of many check-ins during the semester elevated the level of complexity of the projects. There would be no other changes in the curriculum between the undergrad and grad version as in other mezzanine level courses. This policy is the same as that of, for example, CS189/289A, EE149/249A, and ME193B/292B.

Course Schedule

	Date	Lecture	Discussion	Homework	Lab
L0	8/25	Introduction / Project Ideas			
L1	8/30	Rigid Body Motion	RBM		1
L2	09/01	Rotations		HW1 - Rotations	1
L3	09/06	Homogenous Coordinates	Labor Day		2
L4	09/08	Exponential Coordinates		HW2 - Forward Kin	2
L5	09/13	Forward Kinematics	Forward Kin		3
L6	09/15	Inverse Kinematics		HW3 - Inverse Kin	3
L7	09/20	Vision	Inverse Kin		4
L8	09/22	Vision (continued)		-	4
L9	09/27	Review	Review		5
L10	09/29	Rigid Body Velocities		-	5
L11	10/4	MIDTERM I	Review		6
L12	10/6	Jacobians			6
L13	10/11	Force Wrenches	Velocities		6
L14	10/13	Contact Sensors		HW4 - Velocities	6
L15	10/18	Newtonian Dynamics	Wrenches		7
L16	10/20	Lagrange Dynamics		HW5 - Wrenches	7
L17	10/25	Feedback Control	Dynamics		8
L18	10/27	State Estimation		HW6 - Dynamics	8
L19	11/01	Parameter Identification	Review		
L20	11/3	Contact Sensors			

L21	11/8	Review	HW 5 - 9		
L22	11/10	MIDTERM II		-	
L23	11/15	Systems Testing/Lyapunov	Projects		
L24	11/17	Results Validation/Lyapunov			
L25	11/22	Special Topics/ PID on Robot			
L26	11/24	THANKSGIVING			
L27	11/29	Special Topics/Guest Lecture			
L28	12/01	Special Topics/Guest Lecture			