ENME746 – Medical Robotics

Fall 2019

Course Information

Instructor:
Professor Axel Krieger
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Office Hours: Tuesdays 1pm-130pm

Teaching Assistant:
TBD
Lab: 1177 Engineering Laboratory Building (next to Martin Hall)
Email:
Office Hours: Tuesdays noon-1pm and Wednesdays 315pm-345pm

Textbook:
Robot Modeling and Control, by Mark W. Spong, Seth Hutchinson, and M. Vidyasagar. Wiley Publishers. ISBN (10-digit): 0471649902; ISBN (13-digit): 978-0471649908, 2006.

Lectures:
Mon & Wed 2:00pm–3:15pm. EGR 0135

Problem Sets:
Problem Sets are typically assigned in lecture Wednesdays. Unless explicitly stated otherwise, Problem Sets will be due on Wednesdays of the following week at midnight. Problem Sets assigned online must be completed by midnight on Wednesday and uploaded on ELMS. Since the solutions are posted after the homework is due, no late homework can be accepted. The lowest Problem Set grade will be dropped.

Midterm Exams:
There will be one midterm exam, given approximately Wednesday, October 10.

Final Exam:
There will be one final exam, date TBD

Grades:
Your final grade will be determined by the following components:
Problem Sets 20%
Midterm Exam 25%

Final Project 25%
Final Exam 30%
TOTAL 100%

This class is cross-listed at both the Undergraduate (ENME 4XX) and Graduate (ENME 746) level. Those enrolled in the graduate section will be expected to perform the following additional assessments:

1. Solve additional parts of the problem sets beyond what those enrolled in the undergraduate section are required to solve.
2. Solve additional parts in mid-term and final exam beyond what those enrolled in the undergraduate section are required to solve.

Course Description:
The evolution of robotics in surgery is a new and exciting development. Surgical robotics brings together many disparate areas of research such as development and modeling of robotic systems, design, control, safety in medical robotics, haptics (sense of touch), ergonomics in minimally invasive procedures, and last but not the least, surgery. The primary goal of this course is to acquaint the students with the fundamentals of robot design and control and different areas of research that lead to the development of medical robotic systems. As a result, the course will cover basic robot kinematics such as forward and inverse kinematics as well as velocity and acceleration analysis. We will also cover additional topics specific to medical robotics such as medical image guidance. The course will include a project, where students will learn to develop, build, and control a medical robot.

a. Prerequisites or co-requisites: ENME 361

b. This course is an elective.

Topics:

- Review of Mathematical Preliminaries and Introduction to Medical Robotics
- Robot Forward Kinematics - Position, velocity, and acceleration analysis
- Robot Inverse Kinematics
- Manipulator Jacobian
- Introduction to Robot Dynamics
- Introduction to Medical Image Guidance
- Medical Robot Design and Control

Learning Outcomes:

This course addresses the following student outcomes:
(a) an ability to apply knowledge of mathematics, science, and engineering

(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
(l) an ability to work professionally in mechanical systems areas

Syllabus:
The following is a list of the material that will be covered. The dates and materials, however, are approximate and could be changed during the course of the semester.

Week 1	27-Aug	Introduction, Math Refresher
Week 2	3-Sep	Manipulators
Week 3	10-Sep	Rigid Body Transformations
Week 4	17-Sep	Kinematics
Week 5	24-Sep	Inverse Kinematics
Week 6	1-Oct	DH Parameters
Week 7	8-Oct	Midterm
Week 8	15-Oct	Velocity Kinematics
Week 9	22-Oct	Jacobian, Singularities
Week 10	29-Oct	Camera Models, Calibration
Week 11	5-Nov	Medical Imaging and Guidance
Week 12	12-Nov	Force Sensing and Control
Week 13	19-Nov	Final Project Start
Week 14	26-Nov	Medical Robotics Special
Week 15	3-Dec	Project Demos
Week 16	10-Dec	Finals Prep

How will I use this professionally:
Robotics and Automation is a rapidly growing market with the potential to disrupt areas of employment such as self-driving cars and trucks, manufacturing, and healthcare. This change is projected to provide a rise in employment opportunities for robotic engineers. The technical matter on robot design and control taught in this class is directly used for

solving a variety of practical engineering problems in industry and government laboratories, not just for medical robotics but also other areas of robotics. The training on group interaction during technical projects is also invaluable for later professional work.

Course Organization/Management:
This course will be managed through the Information Technology Clark School Online Internet course software (https://myelms.umd.edu).
Assistance is available through the Clark School of Engineering Information Technology via http://elms.umd.edu.

Attendance Policy:
Regular attendance at lectures is expected. Students are responsible for inquiring about and obtaining course material delivered in their absence (from course colleagues). University policy excuses the absences of students for illness (self or dependent), religious observances (http://www.president.umd.edu/policies/iii510a.html), participation in University activities at the request of University authorities, and compelling circumstances beyond the student's control. Students must submit the request in writing and supply appropriate documentation, e.g. medical documentation. Students with written, excused absences are entitled to a makeup exam (or assignments if applicable) at a time mutually convenient for the instructor and student. For more information, see UMD's policy on medically necessitated absences from class.

University wide Honor Code:
The University of Maryland, College Park has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating on exams, cheating on clicker quizzes in lecture, fabrication, facilitation, and plagiarism. Copying work done by another is considered an act of academic dishonesty and will be reported according to University policy. Please review the Code of Academic Integrity and the University's policy on academic dishonesty at http://www.jpo.umd.edu/ and http://www.shc.umd.edu
Note that no form of plagiarism will be tolerated. All work presented to the instructor is assumed to be the original work of the course participant(s). Words, diagrams, figures, or original contributions of anyone other than a student must be referenced when included in a student's work. The course instructor may use plagiarism checking software and/or request evidence of references for any submitted work. A useful website on avoiding plagiarism is found at the Purdue Online Writing Lab at
http://owl.english.purdue.edu/owl/ .