ME 328: Medical Robotics
Syllabus (as of January 6, 2019)
Winter Quarter 2019

Course Times/Locations:

Lectures: Mondays and Wednesdays 9:30-10:20 am, Bldg. 300, Room 300
Seminars: Fridays 9:30-10:20 am, Bldg. 320, Room 105
Lab: Bldg. 550, Room 108
(The lab will not be open when other classes are using it; schedule will be distributed)

Note: Lecture and seminar lecture attendance is a required. If you wish to take the seminar *only*, sign up for CS/ME 571: Surgical Robotics Seminar. CS/ME 571 and ME 328 cannot be taken concurrently.

Instructors:

Primary instructor: Allison Okamura
Office: Bldg. 550, Room 107
Email: aokamura@stanford.edu, but post questions to piazza
Office hours: held in/around Bldg. 550, Room 107; other times by appointment (times posted on piazza)

Co-Instructor for Seminars (ME/CS 571): Federico Barbagli

Course Assistants:

Lisa Yamada	Cole Simpson	
lyamada@stanford.edu	cssimps@stanford.edu	…but post questions to piazza

Office hours: held in/around Bldg. 550, Room 108; other times by appt. (times posted on piazza)

Course Text:

There is no textbook for this course. Readings will be distributed via the course website.

Course Website:

Assignments, solutions, and latest syllabus: http://me328.stanford.edu
Grades: http://canvas.stanford.edu
Announcements, Q&A: https://piazza.com/configure-classes/fall2018/me328

Prerequisites:

You should have a basic understanding of dynamic systems such as that covered in EE 102 or ME 161. You should also be familiar with and have access to MATLAB, since some of the assignments will require working with this software. (Student versions are available at the Stanford Bookstore.) In addition, you will be better prepared for this course if you:

- Have taken an introductory controls class like ENGR 105: Feedback Control Design
- Have taken CS 223A/ME 320: Introduction to Robotics
- Have experience with programming in C or C++
- Are comfortable with linear systems
- Don't pass out when presented with images of medical procedures

If you have any questions about whether or not you have the appropriate background for this class, please talk with Allison. Enrollment will be limited at the discretion of the instructor.

Course Description:

Study of the design and control of robots for medical applications. Focus is on robotics in surgery and interventional radiology, with introduction to other healthcare robots. Delivery is through instructor lectures and weekly guest speakers. Coursework includes homework and laboratory assignments, an exam, and a research-oriented project. Directed toward graduate students and advanced undergraduates in engineering and computer science; no medical background required. Prerequisites: dynamic systems and MATLAB programming. Suggested experience with C/C++ programming, feedback control design, and linear systems. Cannot be taken concurrently with CS 571.

Course Objectives:

By the end of this class, you will:

1. Identify and describe different types of medical robots and their potential applications
2. Know basic concepts in kinematics, dynamics, and control relevant to medical robotics
3. Develop the analytical and experimental skills necessary to design and implement robotic assistance for both minimally invasive surgery and image-guided interventions
4. Be familiar with the state of the art in applied medical robotics and medical robotics research
5. Understand the various roles that robotics can play in healthcare
6. Create a compelling proposal for a new medical robot technology

Course Policies:

1. Lectures and seminars are an integral part of this class. Attendance and participation is required.
2. Homework assignments are posted on the course webpage on Wednesdays (sometimes updated on Fridays so I can create questions related to a Friday guest speaker) and due by 4:00 pm the following Wednesday. Assignments can be handed in during class on Wednesdays or deposited in the box outside the door of Allison's office (Bldg. 550, Room 107). Assignments must be stapled securely together. Occasionally you will be asked to submit code in electronic format; instructions will be provided.
3. All assignment grades will count toward the student's course grade. Assignments will be docked 50% if turned in within 24 hours of the due date/time. No credit will be given for assignments turned in after this time. No extensions are given without prior notice and approved rationale (emergency). Any appeals of assignment scores must be resolved within one week of the return of the graded assignment.
4. The best way to contact instructors and receive student input about assignment problems and class concepts outside of office hours is through the forum provided at piazza. Navigate to piazza.com, create an account, and add ME 328 to your list of courses. There you can post a new question, search through previous posts, answer other student's posts, and receive instructor feedback. This site allows the entire teaching team to know what questions students have, and we can provide answers in a centralized location. Please use this resource.
5. Discussion of course concepts and approaches to completing assignments are encouraged, but each student must submit their own work. Programs should not be shared. The Stanford Honor Code applies to this course.
6. Students who may need an academic accommodation based on the impact of a disability must initiate the request with the Office of Accessible Education (OAE). Professional staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an Accommodation Letter for faculty dated in the current quarter in which the request is being made. Students should contact the instructor and the OAE in the first week of classes since timely notice is needed to coordinate accommodations. The OAE is located at 563 Salvatierra Walk; phone: 723-1066; web site http://studentaffairs.stanford.edu/oae.

Assignments and Grading:

Your grade in this course will be determined by your performance on homework assignments and a project, as well as class participation. The breakdown of grading is as follows:

Assignments:	50%	Weekly analysis, simulation, and lab work (for the first ~half of the quarter)
Project:	40%	Propose and acquire preliminary data for a new medical robot
Class Participation:	10%	All students are expected to actively engage in lectures and discussions.

Final grades will be assigned based on the percentages above; class participation will be used to make decisions when grades are close to cutoff points. There are no exams.

Lecture Topics (not necessarily in this order)

Introductory topics
Introduction to medical robotics (applications and paradigms)
Basic kinematics concepts (forward, inverse, remote center of motion)
Basic control concepts (impedance, admittance)
Surgery for engineers
Interventional radiology for engineers

Minimally Invasive Surgery (MIS)
Human-machine interfaces
Teleoperation
Cooperative manipulation
Port placement for MIS
Robot design concepts
Video images in MIS
Augmented reality
Minimally invasive surgery training

Image-Guided Interventions
Medical imaging modalities (e.g., MRI, US, X-ray, CT)
Robot compatibility with medical imagers
Image segmentation and modeling
Tracking devices
Frames and transformations
Surgical navigation
Calibration
Rigid and non-rigid registration
Radiosurgery

Current topics in medical robotics (as time permits)
Existing clinical applications, controversies, and outcomes:
- Cardiac, abdominal, and urologic procedures with teleoperated robots
- Orthopaedic surgery with cooperative robots
- Prostate interventions with manual "robots"
- Robotic catheters for heart electrophysiology

Research topics: Mobile robots in the body, Instrument-tissue interaction modeling, Autonomous robotic surgery
Other types of healthcare robots: Physically assistive robotics, Socially assistive robotics, Rehabilitation robotics

Tentative Tour(s): (as scheduling permits)
Intuitive Surgical, Inc. (makers of the da Vinci Surgical System, in Sunnyvale, CA)

Project:
The project is to write and present a proposal for a new medical robot or medical robotics technology. Students in small teams will collect preliminary data and develop design/simulations to support the proposal. This project is designed to give students experience with the initiation of a new project in the field of medical robotics. This will develop skills such as: describing motivation and significance, performing a literature review, developing supporting evidence, data presentation, and oral presentation. More details will be provided when the project is assigned.