ECE 464 Medical Robotics and Computer-Integrated Intervention

Winter 2022 - January 05 to April 08

Class time: Tuesday, Thursday 9:30-10:50 Location: MEC 4-3

Instructor:

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Donadeo Innovation Cntr for Engineering 13-360
Office Hours: Tuesday & Thursdays 11:00-11:45

Course Description:

*3.8 (fi 8) (either term, 3-0-3/2) Basic concepts of computer-integrated intervention. Surgical CAD/CAM, assist and simulation systems. Actuators and imagers. Medical robot design, control and optimization. Surgeon-robot interface technology. Haptic feedback in surgical simulation and teleoperation. Virtual fixtures. Time delay compensation in telesurgery. Cooperative manipulation control. Overview of existing systems for robot-assisted intervention and for virtual-reality surgical simulation.

Prerequisites: ECE 360 or ECE 462 or E E 357 or E E 462 or consent of the Department. Credit may be obtained in only one of ECE 464 or E E 464.

Course synchronous and asynchronous content delivery schedule:

TA Information:

Lab Instructor: Javad Khodaei-Mehr (khodaeim@ualberta.ca)
TA: Mehrnoosh Afshar (mehrnoosh.afshar@ualberta.ca)
Marker: Abed Soleymani (zsoleymani@ualberta.ca)

Lab Sections:

Section	Day	Time	Location
LAB H41	Thursday	14:00 - 16:50	ETLC E3010
LAB H42	Thursday	14:00 - 16:50	ETLC E3010
LAB H51	Friday	14:00 - 16:50	ETLC E3010

Course Objectives & General Content:

This is a technical elective course on medical robotics for senior undergraduate students majoring in electrical and computer engineering. The objective of the course is to introduce the students to basics and paradigms of computer-integrated intervention, main topics in robotics (including kinematics, dynamics, control), applications of the principles of robotics in medical systems, and control for haptic teleoperation of

medical robots. The course will also overview the existing medical robotic systems and applications.

Learning Outcomes:

By the end of this course, students should be able to:

1. Calculate the spatial transformations in a given robotic system.
2. Calculate the forward kinematics and Jacobian of a given robot and solve its inverse kinematics
3. Design a Remote Center of Motion (RCM) for a minimally invasive surgery (MIS) robot
4. Calculate the dynamics of a given robot
5. Plan spatial trajectories for a given robot
6. Design linear and nonlinear position controllers for a given robot
7. Design force controllers for a given robot
8. Analyze the stability of a given telerobotic (teleoperation) system
9. Design a controller for a given telerobotic (teleoperation) system.

Marking Scheme:

Activity	(A)Synchronous	Due/Scheduled	Weight
Assignments		Varies	15%
Laboratories		Varies	15%
Midterm exam		March 1, 2022	25%
Final exam		Scheduled by Registrar Office	45%

The Faculty recommended grade point average for a 400 level course is 3.1. Instructors have the leeway to deviate from this average and can assign grades based on their own scheme. All grades are approved by the department chair (or delegate). The office of the Dean has final oversight on all grades.

Term Work

All term work solutions will be posted no later than the last day of classes. All term work will be returned to students by the final day of classes, with the exception of major term work due in the last week of classes. The latter will be returned by the day of the final examination or the last day of the examination period if there is no final examination in the course as per university policy; instructors will make accommodations to return these term work. It is the responsibility of the student to pick up all their term work at the specified time and place. Any unreturned term work, shall be retained and then shredded six months after the deadline for reappraisal and grade appeals. Final examinations will be kept for one year as required by university guidelines and the Government of Alberta's Freedom of Information and Protection of Privacy Act.

Calculator Policy

Only approved non-programmable calculators are permitted in examinations. Any calculator taken into an examination must have a sticker identifying it as an acceptable non-programmable calculator (gold sticker). Students can purchase calculators at the University Bookstore with the stickers already affixed. Calculators purchased elsewhere can be brought to the Student Services where the appropriate sticker will be affixed to the calculator.

Text and References (Recommended):

MAIN:

• J. J. Craig, Introduction to Robotics: Mechanics and Control, Pearson, 4th edition, 2018.

ADDITIONAL:

• M. Tavakoli, R.V. Patel, M. Moallem, A. Aziminejad, Haptics for Teleoperated Surgical Robotic Systems, World Scientific, 2008, ISBN 978-981-281-315-2.
Electronically Available through U of A Libraries.

• B. Siciliano, O. Khatib (Eds.), Springer Handbook of Robotics, Springer, 2008, ISBN 978-3-540-23957-4.
Electronically Available through U of A Libraries (via Springerlink).

• M. Grunwald (Ed.), Human Haptic Perception: Basics and Applications, 2008, ISBN 978-3-7643-7611-6.
Electronically Available through U of A Libraries (via Springerlink).

• M. Lin and M. Otaduy (Eds.), Haptic Rendering: Foundations, Algorithms and Applications, A K Peters, 2008, ISBN 978-156-881-332-5.

• R. H. Taylor, S. Lavallee, G. Burdea, R. Mosges (Eds.), Computer-Integrated Surgery, MIT Press, 1996, ISBN 978-0-262-20097-4.

• G. C. Burdea and P. Coiffet, Virtual reality technology (2nd Edition), Wiley, 2003, ISBN 0-471-36089-9.

Website:

eClass

Previous Examples of Evaluative Materials:

Sample exam material will be posted on eClass.

Did you know that the University of Alberta has various low-to-no-cost services to help students succeed? Visit http://www.deanofstudents.ualberta.ca/ for information about the academic, wellness, and various other support services available to U of A students. It's never too early or too late to seek help!

This is a more detailed chapter-by-chapter breakdown of the course coverage:

- Basics of medical robotics
- Paradigms of medical robotics
- Spatial descriptions and transformations
- Forward kinematics
- Inverse kinematics
- Jacobians
- Remote Center of motion creation in minimally invasive surgery (MIS) robots
- Dynamics
- Trajectory generation
- Linear control of manipulators
- Nonlinear control of manipulators
- Force control of manipulators
- Haptic teleoperation: Two port networks
- Haptic teleoperation: Stability & transparency
- Haptic teleoperation: Control architectures
- Haptic teleoperation: Delay compensation

The course and its lab will use the knowledge of and skills in mathematics, systems control, and some programming in both Matlab and C/C++ languages.

UNIVERSITY AND FACULTY POLICIES

COURSE OUTLINE POLICY

The policy about course outlines can be found in Course Requirements, Evaluation Procedures and Grading of the University Calendar, see https://calendar.ualberta.ca/

RESPECT AND PROFESSIONALISM

The Faculty of Engineering is committed to fostering and protecting an equitable, inclusive, and respectful work and study environment in line with University of Alberta policies and professional engineering industry standards. University is an opportunity for students to explore areas of interest and to potentially pursue a career in a specific field. The Faculty of Engineering prepares students to uphold industry standards to become a Professional Engineer (P. Eng). Respect, professionalism, and accountability must be upheld within the Faculty of Engineering.

Harassment and discrimination are serious issues that have a negative effect on culture and therefore the Student Code of Behaviour states that no student shall discriminate against or harass any person or group of persons. The Faculty expects an environment free of harassment, discrimination, and bullying. Please refer to the University's Discrimination, Harassment, and Duty to Accommodate Policy for definitions.

SAFETY DURING LEARNING ACTIVITIES

In all Faculty of Engineering courses, labs, seminars or other learning activities, safety is of paramount importance. In some cases, laboratory work in a program requires high standards for risk management to keep potential hazards safely under control. Anyone found to be unable to function safely, due to intoxication, harassment or discriminatory behaviour, or other reasons, in the class, lab, seminar or other learning activity may be asked to leave or be removed for their and the safety of other participants and instructors in alignment with the Student Code of Behaviour. As members, or prospective members, of the engineering profession, it is your responsibility to identify and inform the proper authorities of an unsafe work/learning environment.

AUDIO/VIDEO RECORDING

Audio or video recording, digital or otherwise, of lectures, labs, seminars or any other teaching environment by students is allowed only with the prior written consent of the instructor or as a part of an approved accommodation plan. Student or instructor content, digital or otherwise, created and/or used within the context of the course is to be used solely for personal study, and is not to be used or distributed for any other purpose without prior written consent from the content author(s).

Only those items specifically authorized by the instructor may be brought into the exam facility. The use of unauthorized personal listening, communication, recording, photographic and/or computational devices is strictly prohibited. Students should refrain from bringing any unauthorized electronic device into an examination room, including cell phones, high tech watches, high tech glasses or other such devices.

ACADEMIC INTEGRITY

Students at the University of Alberta must read and follow, in its entirety, the

Code of Student Behaviour

Failure to know the code is not an acceptable excuse for breaking the code.

The University of Alberta is committed to the highest standards of academic integrity and honesty. Students are expected to be familiar with these standards regarding academic honesty and to uphold the policies of the University in this respect. Students are particularly urged to familiarize themselves with the provisions of the Code of Student Behaviour (on the University Governance website) and avoid any behaviour which could potentially result in suspicions of cheating, plagiarism, misrepresentation of facts and/or participation in an offence. Academic dishonesty is a serious offence and can result in suspension or expulsion from the University.

Engineering students studying in the province of Alberta should also follow the

Code of Ethics

by The Association of Professional Engineers and Geoscientists of Alberta (APEGA).

The Code of Student Behaviour should not be too hard to follow. Listen to your instructor, be a good person, and do your own work, as this will lead you toward a path to success. Failure to follow the code can result in a grade of 'F' for the course, a transcript remark, suspension, and even expulsion from the university.

"Integrity is doing the right thing, even when no one is watching"
C. S. Lewis

Engineering at Alberta

NEED HELP?

There are a lot of services available to students on campus and in Edmonton, and sometimes it's hard to know where to go. While this isn't a comprehensive list, the services shown here should at least give you some ideas about where to start. If you're still not sure, check out the services just beneath this box—they'll give you the guidance you're looking for.

DON'T KNOW WHERE TO GO?

UASU Cares
uasucares.su.ualberta.ca

Office of the Student Ombuds
Call when you don't know how to solve a problem. Earlier is better.
780-492-4689

24/7 HELP

U of A Need Help Now
ualberta.ca/current-students/need-help-now

Edmonton Distress Line
780-482-4357 (HELP)

WELLNESS

ACCESS Open Minds
Appointment-based support from social workers.
Make an appointment: 780-248-2016 or accessom@ualberta.ca

ACCESS Outreach
Drop-in, single-session support and referrals.
289 CAB; M-F, 8:30am-4:30pm

Counselling and Clinical Services
Free, short-term, appointment-based counselling and psychiatric services.
Book initial consultation: in person at 2-600 SUB or call 780-492-5205
2-600 SUB; M, R, F, 8:00am-4:30pm; T,W, 8:00am-7:00pm

Interfaith Chaplains Association
Get guidance, care, and support, whether or not you identify with a particular faith.
Make an appointment: chaplain@ualberta.ca

The Landing
Offers support to students on matters of gender and sexual diversity.
0-68A SUB; M-R, 11:00am-4:00pm

Peer Support Centre
Anonymous, confidential help from trained students. Drop in, call, or make an appointment.
Help line: 780-492-4357 (HELP)
2-707 SUB; M-F, hours vary

Sexual Assault Centre
Free, anonymous, and confidential drop-in counselling.
2-705 SUB; M-F, 9:00am-5:00pm

ACADEMIC

Engineering Student Services
Drop-in, first-come, first-served advising.
2-300 Donadeo ICE; hours vary

Engineering Student Success Centre
Drop-in tutoring for first-year courses.
ECERF W2-023; M-R, 10:00am-8:00pm; F, 10:00am-3:00pm

Academic Success Centre
Many services to maximize your academic success.
1-80 SUB; M-F, 8:30am-4:30pm

Accessibility Resources
Connects students with disabilities to accommodations.
1-80 SUB; M-F, 8:30am-4:30pm

FINANCIAL

Engineering Student Services
Drop-in, first-come, first-served advising.
2-300 Donadeo ICE; hours vary

Campus Food Bank
Many food support options available.
SUB 1-81; 12:00-6:00pm

Student Connect
Offers support for many issues, including financial support.
Administration Building; hours vary

SOCIAL

Unitea
Arrange a time to socialize with a peer.
www.ualberta.ca/community-social-work/unitea

BearsDen
Find student groups, local events, and volunteer opportunities.
www.ualberta.ca/engineering/engage

WORRIED ABOUT SOMEONE?

HIAR (Helping Individuals at Risk)
If you're worried about someone because of the things they've been saying or doing, or there's a noticeable change in their behaviour (often in multiple ways), contact HIAR, who will protect your confidentiality and help decide how best to support the person.

Phone: 780-492-4372
Email: hiarua@ualberta.ca

CONFIDENTIAL SUPPORT

Office of Safe Disclosure and Human Rights
The OSDHR advises confidentially on sensitive issues you may not feel comfortable solving on your own. Contact the OSDHR if you want to get help or to make a report while keeping your privacy.

Phone: 780-248-1894
Email: osdhr@ualberta.ca

Engineering Wellness
www.uab.ca/enggwell