



ECE 464 Medical Robotics and Computer-Integrated Intervention

Winter 2021 - January 11 to April 16

Class time: Tuesday, Thursday 9:30-10:50 Location: Zoom

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:

Lectures and labs will be delivered synchronously at the scheduled times.

Dates of labs listed later in this document correspond to the lab sections H41 and H42 (Thursdays). The lab section H51 will be held one day later (Fridays).

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	
LAB H42	Thursday	14:00 - 16:50	
LAB H51	Friday	14:00 - 16:50	

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.

Marking Scheme:

Activity	(A)Synchronous	Due/Scheduled	Weight
Assignments	Asynchronous	Varies	15%
Laboratories	Synchronous	Varies	15%
Midterm exam	Synchronous	Feb 23, 2021	25%
Final exam	Synchronous	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.

University Policies:

Policy about course outlines can be found in Course Requirements, Evaluation Procedures and Grading of the University Calendar.

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 (online at www.governance.ualberta.ca) 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.

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.

Faculty of Engineering Statement on 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, behavior, 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. 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.

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.

Lab Information:

Lab Topic	Date
Lab 1: Introduction to a 3-DOF robot simulation, forward and inverse kinematics	2021-02-11
Lab 2: Hapkit installation, sensor calibration and position control	2021-02-25
Lab 3: Haptic sensation with the Hapkit	2021-03-11
Lab 4: Dynamics and control simulation of the 3-DOF robot	2021-03-25

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.

Students **PLEASE READ**. It is **your responsibility** to be aware of and understand the implications of contravening the University of Alberta's Code of Student Behaviour.

All suspected infractions identified by Faculty, TAs, Markers and Exam Invigilators will be:

- 1) Investigated by the responsible Faculty member delivering the course including an interview with the student.
 - a) A second Faculty member will be present at the time of the interview.
 - b) The student is entitled to an advisor sourced from the Student Ombudservice during such an interview.
- 2) If the outcome of (1) warrants, then it will be referred to the Office of the Dean for investigation and possible disciplinary sanction.
 - a) The student will be invited to meet with the Associate Dean, Dr. Joseph for an interview.
 - b) The student is entitled to an advisor sourced from the Student Ombudservice during such an interview.
 - c) The Associate Dean will decide on a sanction weighing the evidence "**on the balance of probabilities**".
- 3) The student has the right to appeal any sanction imposed through the University Appeals Board.

The following is selected content from the Code of Student Behaviour that students should be particularly aware of, ref:

"CODE OF STUDENT BEHAVIOUR", Last updated Feb 3, 2014

"30.3.2 Inappropriate Academic Behaviour

30.3.2(1) Plagiarism

No Student shall submit the words, ideas, images or data of another person as the Student's own in any academic writing, essay, thesis, project, assignment, presentation or poster in a course or program of study.

30.3.2(2) Cheating

30.3.2(2) a No Student shall in the course of an examination or other similar activity, obtain **or attempt to obtain** information from another Student or other unauthorized source, give or attempt to give information to another Student, or use, attempt to use or possess for the purposes of use any unauthorized material.

30.3.2(2) b No Student shall represent or attempt to represent him or herself as another or have or attempt to have himself or herself represented by another in the taking of an examination, preparation of a paper or other similar activity. See also misrepresentation in 30.3.6(4).

30.3.2(2) c No Student shall represent another's substantial editorial or compositional assistance on an assignment as the Student's own work.

30.3.2(2) d No Student shall submit in any course or program of study, without the written approval of the course Instructor, all or a substantial portion of any academic writing, essay, thesis, research report, project, assignment, presentation or poster for which credit has previously been obtained by the Student or which has been or is being submitted by the Student in another course or program of study in the University or elsewhere.

30.3.2(2) e No Student shall submit in any course or program of study any academic writing, essay, thesis, report, project, assignment, presentation or poster containing a statement of fact known by the Student to be false or a reference to a source the Student knows to contain fabricated claims (unless

acknowledged by the Student), or a fabricated reference to a source."

"30.3.4 Inappropriate Behaviour towards Individuals or Groups

30.3.4(1) Disruption

30.3.4(1) a No Student shall disrupt a Class in such a way that interferes with the normal process of the session or the learning of other Students." *This includes use of laptops, phones and working on assignments distracting others*

"30.3.5(2) Unauthorized Use of Facilities, Equipment, Materials, Services or Resources

30.3.5(2) a No Student shall use any facility, equipment, material, service or resource contrary to express instructions or without proper authority (GFC 03 Feb 2014). See 30.9 [Appendix 2 – Regulations Pertaining to Special Events, the Use of University Resources and the Provision of Alcohol]."

"30.3.6 Other Offences

30.3.6(1) Alcohol Provision and Consumption

30.3.6(1) a No Student shall consume or serve alcohol on University property other than in licensed premises, at a University function with a valid permit issued by Ancillary Services or in accordance with regulations pertaining to University residences."

"30.3.6(4) Misrepresentation of Facts

No Student shall misrepresent pertinent facts to any member of the University community for the purpose of obtaining academic or other advantage."

"30.3.6(5) Participation in an Offence

No Student shall counsel or encourage or knowingly aid or assist, directly or indirectly, another person in the commission of any offence under this Code."

Students in the Faculty of Engineering should be aware of the ethics of Professional Engineers per:

"30.3.3 Inappropriate Behaviour in Professional Programs

30.3.3(1) A Student enrolled in Professional Programs is bound by and shall comply with the Professional Code of Ethics governing that profession and the practice of its discipline.

30.3.3(2) It shall be the responsibility of each student in a Professional Program to obtain, and be familiar with, the Professional Code of Ethics relevant to the discipline and all amendments thereto as may be made from time to time. (BG 12 May 2008)"

ASSOCIATION OF PROFESSIONAL ENGINEERS & GEOSCIENTISTS OF ALBERTA - APEGA Schedule CODE OF ETHICS (established pursuant to section 20(1)(k) of the Engineering and Geoscience Professions Act)

"Preamble

Professional engineers and geoscientists shall recognize that professional ethics is founded upon integrity, competence, dignity and devotion to service. This concept shall guide their conduct at all times."

"Rules of Conduct"

"3 Professional engineers and geoscientists shall conduct themselves with integrity, honesty, fairness and objectivity in their professional activities."

Unauthorized electronic devices in examinations

During previous examination periods, a number of students have been identified as having accessed eClass or other sources of information through cell phones or other unauthorized electronic devices. In many instances, this occurred when students were using washrooms, although some students accessed resources in the examination room in front of invigilators.

Of all the students investigated for such allegations, which are described as **cheating** under the Code of Student Behaviour, only one student was shown to be innocent. One student who was proved to have performed unauthorized electronic access during examinations on multiple occasions has now been expelled from the University of Alberta.

The Faculty of Engineering and the University of Alberta will not tolerate such behaviour. Any student suspected of using any unauthorized electronic device will be investigated by the course instructor and the Office of the Dean and, if found guilty, will receive a sanction.

In general, **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.**

Below are the Faculty of Engineering rules related to unauthorized electronic devices in examinations.

1. Section 23.5.1(1) Permitted References and Aids, of the University Calendar states: "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". Any violation of this is a violation of the Code of Student Behaviour.
2. On entering an examination, students must turn off all unauthorized electronic devices including but not limited to cell phones, laptops, tablets, watches with internet/storage capability, or other audio-visual devices. Invigilators should remind students to do this before the examination is started.
3. Such devices should be placed in a carrying bag or backpack, which should be placed behind or underneath the student's chair; or if the room is deemed capable, invigilators may ask all bags and backpacks be placed in a designated area within the examination room (front) and only retrieved once the examination is completed.
4. Any student in possession of an unauthorized electronic device, regardless of action, will be reported by the invigilator and/or instructor for investigation under the Code of Student Behaviour. All such reports will be referred to the Office of the Dean.
5. Students requiring a washroom break must present their ONEcard to the invigilator prior to leaving the examination room. Invigilators will be responsible for noting such students' names and exact time of departure and return.

Plagiarism and cheating

Plagiarism and cheating under the University of Alberta Code of Student Behaviour are defined in sections 30.3.2(1) and 30.3.2(2) as stated above.

Cheating can take many forms, such that it is possible to cheat without plagiarizing. However plagiarizing within the context of assignments, papers, lab reports, tests and examinations is also an attempt to take academic advantage over others in the same class; such that a better grade may be achieved. Taking academic advantage over others is hence also cheating. If you find yourself being suspected of plagiarism then it is likely that the Faculty of Engineering will also investigate you on the count of cheating simultaneously.

Dispelling some of the myths that lead to plagiarism

- a) It is **not OK** to use someone else's words or work without appropriate citation and referencing but claim that you are 'honouring them' by using their words.
- b) It is **not OK** to put references at the end of a piece of work but not cite the reference at the end of the specific section of paraphrased text or vice-versa.
- c) It is **not OK** to put a verbatim quote in quotation marks or italics and not to cite the reference at the end of the quote, or vice-versa.
- d) It **is OK** for you to work with a person or group on an assignment, lab report or project as long as your solution or submission for grading was worked and written independently of the person or group.
- e) **No** assignment, lab report or project submission from one student will show strong similarity in written style or calculation layout to that of another student.
- f) It is hence **not OK** to work with someone else on an assignment or lab report or paper **and** submit an identical or highly similar document for grading.
- g) A momentary lapse in judgment **is not** an excuse.
- h) Providing the opportunity for another student to copy your work **also** makes you guilty of plagiarism.

Study, assignment and examination tips for students

- i. Study in groups, but only to discuss concepts and principles, NOT to complete assignments.
- ii. Read previous lecture or seminar notes over before the next lecture – this will improve understanding concepts.
- iii. Perform assignment calculations and written solutions on your own – you are only competing with yourself.
- iv. Read the course text and materials, and seek further published information when needed – use the library.
- v. Take advantage of using the TA scheduled office time to ask additional questions – if in doubt ask.
- vi. If you are confused, no question is a stupid question – seek out an opportunity to ask the TA or instructor.
- vii. If colleagues are getting higher grades in assignments, labs, exams, remember you are not competing with other students only with yourself. Do not get drawn into taking short-cuts to try and match grades with others.
- viii. If you are tempted to take a shortcut think about this: What is the value of the assignment or lab or test that I am tempted to cheat or plagiarize to get credit? Remember, when you are caught the consequences will be far greater than just simply taking a zero in the course element.

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

Office of the Student Ombuds

Call when you don't know how to solve a problem. Earlier is better.

780-492-4689

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U of A Need Help Now

HELP

Edmonton Distress Line

780-482-4357 (HELP)

WELLNESS

ACCESS Outreach

Drop-in, single-session support and referrals.

M-F, 8:30am-4:30pm

Counselling and Clinical Services

Free, short-term, appointment-based counselling and psychiatric services.

Book initial consultation: call 780-492-5205

M-F, 8:00am-4:00pm

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.

M-R, hours vary

Peer Support Centre

Anonymous, confidential help from trained students. Drop in, call, or make an appointment.

Help line: 780-492-4357 (HELP)

M-F, hours vary

Sexual Assault Centre

Free, anonymous, and confidential drop-in counselling.

M-F, 11:00am-3:00pm

ACADEMIC

Engineering Student Services

Drop-in, first-come, first-served advising.

Email: enggadvising@ualberta.ca

Engineering Student Success Centre

Drop-in tutoring for first-year courses.

Academic Success Centre

Many services to maximize your academic success.

M-F, 8:30am-4:30pm

Accessibility Resources

Connects students with disabilities to accommodations.

M-F, 8:30am-4:30pm

FINANCIAL

Engineering Student Services

Drop-in, first-come, first-served advising.

Email: enggadvising@ualberta.ca

Campus Food Bank

Many food support options available.

Student Connect

Offers support for many issues, including financial support.

Administration Building; hours vary

SOCIAL

Unitea

Arrange a time to socialize with a peer.

BearsDen

Find student groups, local events, and volunteer opportunities.

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