# ECE 464 Medical Robotics and Computer-Integrated Intervention

**Winter 2020 - January 06 to April 08**

Class time: Tuesday, Thursday 9:30-10:50 Location: NRE 2 127

**Instructor:**

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Donadeo Innovation Cntr for Engineering 13-360
Office Hours: Tuesday & Thursdays 11:00-12:00

**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.

**TA Information:**

Lab Instructor: Ali Torabi (ali.torabi@ualberta.ca)
TA: Javad Khodaei-Mehr (khodaeim@ualberta.ca)

**Lab Sections:**

| Section | Day | Time | Location |
|---|---|---|---|
| LAB H41 | Thursday | 14:00 - 16:50 | ETLC E4012 |
| LAB H42 | Thursday | 14:00 - 16:50 | ETLC E4012 |
| LAB H51 | Friday | 14:00 - 16:50 | ETLC E4012 |

**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 | Due/Scheduled | Weight |
|---|---|---|
| Assignments | Varies | 10% |
| Laboratories | Varies | 15% |
| Midterm exam | Feb 27, 2020 | 25% |
| Final exam | Scheduled by Registrar Office | 50% |

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 Dean's Office where the appropriate sticker will be affixed to the calculator.

**Text and References (Recommended):**

MAIN:

• J. J. Craig, Introduction to Robotics: Mechanics and Control, Prentice Hall, 3rd edition, 2004, ISBN 0201543613.

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 NOVINT FALCON, TRAJECTORY CONTROL, AND WORKSPACE FRAME | See lab's eClass |
| Lab 2: REMOTE CENTRE OF MOTION CREATION | See lab's eClass |
| Lab 3: REMOTE ACTIVITY | See lab's eClass |
| Lab 4: REMOTE ACTIVITY | See lab's 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

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.

**From the Office of the Dean, Faculty of Engineering**

**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 Office of the Student Ombuds 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 Office of the Student Ombuds 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"**, updated July 1, 2018

**"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."

***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 use a figure, table or graph from someone else's work without appropriate citation.*
*d) 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.*
*e) 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.*
*f) **No** assignment, lab report or project submission from one student should show strong similarity in written style or calculation layout to another student.*
*g) It is **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.*
*h) A momentary lapse in judgment **is not** an excuse.*

**"30.3.2 Inappropriate Academic Behaviour**

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 themself as another or have or attempt to have themself 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."

***Plagiarism can also be cheating (two counts in one)***

*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, and hence may also be subject to a charge of cheating.*

**"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."

**"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." **Comment: *This includes use of laptops, phones and working on assignments distracting others***

**"30.3.4(6) Violations of Safety or Dignity**

30.3.4(6)a No Student shall have sexual or physical contact with another person without that person's consent.
30.3.4(6)b No Student shall physically abuse another person, threaten any other person with physical abuse or cause any other person to fear physical abuse.
30.3.4(6)c No Student shall create a condition which endangers or potentially endangers or threatens the health, safety or wellbeing of other persons.

30.3.4(6)d No Student shall harass another person. Harassment is defined in the Discrimination, Harassment and Duty to Accommodate Policy in UAPPOL, and includes Harassment, Bullying, Sexual Harassment and Racial Harassment.
30.3.4(6)e No Student shall use words which threaten violence or physical abuse to any group or individual whether or not the group or individual thus threatened knows of such threatening words and whether or not the words are employed with a demonstration, rally or picketing."

**"30.3.6 Other Offences**

"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..." **Comment: *This includes falsely claiming ill health to defer examinations or gain extensions***

**"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."

**Association of Professional Engineers & Geoscientists of Alberta - APEGA CODE OF ETHICS**

1. Professional engineers and geoscientists shall, in their areas of practice, hold paramount the health, safety and welfare of the public and have regard for the environment.
2. Professional engineers and geoscientists shall undertake only work that they are competent to perform by virtue of their training and experience.
3. Professional engineers and geoscientists shall conduct themselves with **integrity, honesty**, fairness and objectivity in their professional activities.
4. Professional engineers and geoscientists shall comply with applicable statutes, regulations and bylaws in their professional practices.
5. Professional engineers and geoscientists shall **uphold and enhance the honour, dignity and reputation of their professions** and thus the ability of the professions to serve the public interest.

**Unauthorized use of devices & resources**

On-line resources such as **"Course-Hero"** are considered inappropriate resources that **students should avoid accessing**. Such resources are the subject of concern by the Office of the Dean and University Legal Counsel, as content has previously been identified as unauthorized use of Faculty of Engineering Professors' intellectual property, including notes & solutions. To use such resources is both **Cheating** and **Plagiarism**.

Students identified to have used **unauthorized devices**; such as **smart phones, watches and glasses**; to access E-class or communicate with others via email or social media during an **examination** have received **Cheating** sanctions which can include the loss of the full exam grade value as a minimum, up to a suspension or expulsion from University recommendation.

In many instances, cheating in examinations occurred when students were using washrooms, although some students access resources in exams in front of invigilators. Students need to be aware that the Office of the Dean uses all available technology and services to **monitor use of unauthorized devices and resources**, including IP logs specific to device traffic during examination periods. Instructors are encouraged to monitor E-class logs and 'electronic material sharing' sites during exam periods.

**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, and 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 and only retrieved once the examination is completed.
4. Any student in possession of an unauthorized electronic device, regardless of perceived 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.
6. Calculators with storage capability other than approved programmable calculators are prohibited in examinations.

**General rule for unauthorized devices in examinations**

**Students should refrain from bringing any unauthorized electronic device into an examination room**. At the very least **no unauthorized device should be on your person** during an examination, but should be secured in your backpack or bag out of reach for the duration of the examination.

**Study and assignment tips for students**

1. Study in groups, but only to discuss concepts and principles, **NOT** to complete assignments.
2. Perform assignment calculations and written solutions on your own – you are only competing with yourself.
3. Take advantage of using the TA scheduled office time to ask additional questions – if in doubt ask.
4. If colleagues are getting higher grades in assignments, labs, exams, remember you are not competing with other students only with yourself.
5. 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?

# 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.alberta.campuslabs.ca/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