ECE 464 Medical Robotics and Computer-Integrated Intervention

Fall 2017 - September to December

Class time: Monday, Wednesday, Friday 12:00-12:50 Location: NRE 2 090

Instructor:

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Office Hours: Mondays, Wednesdays and Fridays 1:00-2:00 pm

Course Description:

*3 (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: Jay Carriere (jtcarrie@ualberta.ca)
TAs: Thomas Lehmann (lehmann@ualberta.ca), Ali Torabi (ali.torabi@ualberta.ca)

Lab Sections:

Section	Day	Time	Location
LAB D41	Thursday	14:00 - 16:50	ETLC E5002
LAB D42	Thursday	14:00 - 16:50	ETLC E5002
LAB D51	Friday	14:00 - 16:50	ETLC E5002

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		10%
Laboratories		15%
Midterm exam		25%
Final exam		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 midterm test and final exam 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.

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	2017-10-05 (& 6th)
Lab 2: REMOTE CENTRE OF MOTION CREATION	2017-10-19 (& 20th)
Lab 3: TELEOPERATION AND SOFT TISSUE PALPATION EXPERIMENTS	2017-11-02 (& 3rd)
Lab 4: PERFORMING A DRAWING TASK IN TELEOPERATION MODE	2017-11-23 (& 24th)

Students will undergo lab specific safety training as a part of this course and are expected to follow appropriate lab safety procedures at all times.

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.