ECE 4180 – Introduction to Robotics

Winter 2022

IMPORTANT NOTICE

Lectures and laboratories in this course will initially be conducted via remote instruction but will return to in-person instruction the week of February 28th, 2022. All students are required to be present for in-person instruction at that time. Furthermore, University policy requires all students to be fully vaccinated against COVID-19 in order to attend campus and participate in this course.

Course Objectives

This course provides fundamental concepts of robotics, including robot classification and applications, mathematics of robot modeling and kinematics, mathematics of small-scale (differential) motion, sensor and actuators, sensor interfacing, motor control, trajectory planning, path planning and robot programming. Robotics is an interdisciplinary subject involving aspects of mathematics, electrical, computer, and mechanical engineering, and applies mathematical techniques and algorithms to overcome automation problems. Both the theoretical aspect of robotics and real applications will be discussed and presented, including 6-degrees of freedom robot wrists, robot control and stability.

Course Content

The following topics will be covered:

Module I: Forward and Inverse Kinematics
- Forward kinematics for 3DoF manipulators
- Linear algebra review
- Rotation matrices
- Homogeneous transformations
- Denavit-Hartenburg notation
- Inverse kinematics for position and orientation
- Kinematic decoupling

Module II: Differential Motion
- Robot Jacobian and velocity kinematics
- Trajectory execution robot singularities and Jacobian
- Decoupling singularities
- Redundancy and Jacobian

Module III: Computer Vision
- Linear filtering
- Template detection
- Edge detection
- Interest point and keypoint detection

Module IV: Robot Control
- Torque, speed, moment of inertia
- Position control, proportional control
- Review of control systems
- First order systems
- Second order systems
- Pole placement
- Root locus
- Robot control examples

Textbook

Other Resources


Learning Outcomes

1. Understand the mechanical aspects of robots.
2. Become familiar with the principle of sensors and actuators and their usages in robotics.
3. Understanding of the mathematics of forward and inverse kinematics of robots.
4. Understand the mathematics of robot Jacobian, differential motion and redundancies.
5. Proposing, implementing, and documenting a robot design project.

Expected Competency Levels

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<thead>
<tr>
<th>Outcome</th>
<th>KB</th>
<th>PA</th>
<th>IN</th>
<th>DE</th>
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CEAB Graduate Attributes Assessed

- **KB.3** – Recalls and defines, and/or comprehends and applies information, first principles, and concept in specialized engineering science.
- **PA.3** – Analyzes and solves complex engineering problems.

Evaluation

The final course grade will be determined from a student's performance in laboratories, assignments, and on examinations. Programmable calculators are not allowed in the mid-term and final examination. Students must receive a minimum of 50% on the final examination and must complete all the laboratories in order to be eligible to receive a passing grade.

<table>
<thead>
<tr>
<th>Component</th>
<th>Value (%)</th>
<th>Method of Feedback</th>
<th>Learning Outcomes Evaluated</th>
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* Method of Feedback: F - Formative (written comments and/or oral discussion), S - summative (numerical grade)

Academic Integrity

Students are expected to conduct themselves in accordance with the highest ethical standards of the Profession of Engineering and evince academic integrity in all their pursuits and activities at the university. As such, in accordance with the General Academic Regulations on Academic Integrity, students are reminded that plagiarism or any other form of cheating in examinations, term tests, assignments, projects, or laboratory reports is subject to serious academic penalty (e.g. suspension or expulsion from the faculty or university). A student found guilty of contributing to cheating by another student is also subject to serious academic penalty.
Copyright Notice

All materials provided in this course are copyright and are provided under the fair dealing provision of the Canadian Copyright Act. This material may not be redistributed in any manner without the express written permission of the relevant copyright holder.

Requirements/Regulations

• Attendance at lectures and laboratories is essential for successful completion of this course. Students must satisfy each evaluation component in the course to receive a final grade.

• It is the responsibility of each student to contact the instructor in a timely manner if he or she is uncertain about his or her standing in the course and about his or her potential for receiving a failing grade. Students should also familiarize themselves with the University’s General Academic Regulations, as well as Section 3 of the Faculty of Engineering Academic Regulations dealing with incomplete term work, deferred examinations, attendance and withdrawal.

• No programmable devices or systems (such as calculators, PDAs, iPods, iPads, cell phones, smart watches, wireless communication or data storage devices) are allowed in examinations unless approved by the course instructor.

• Students should be aware that they have access to an extensive range of resources and support organizations. These include Academic Resources, Counselling, Advocacy and Accessibility Offices as well as documentation of key University policies e.g. Academic Integrity, Respectful Behaviour, Examinations and related matters.

Retention of Student Work

Students are advised that copies of their work submitted in completing course requirements (i.e. assignments, laboratory reports, project reports, test papers, examination papers, etc.) may be retained by the instructor and/or the department for the purpose of student assessment and grading, and to support the ongoing accreditation of each Engineering program. This material shall be handled in accordance with the University’s Intellectual Property Policy and the protection of privacy provisions of The Freedom of Information and Protection of Privacy Act (Manitoba). Students who do not wish to have their work retained must inform the Head of Department, in writing, at their earliest opportunity.