DEPARTMENT OF MATHEMATICAL AND COMPUTATIONAL SCIENCES
UNIVERSITY OF TORONTO MISSISSAUGA

CSC477H5F LEC0101
Introduction to Mobile Robotics
Course Outline - Fall 2019

Class Location & Time	Thu, 05:00 PM - 07:00 PM DH 4001
Instructor	Florian Shkurti
Office Location	DH3066
Office Hours	Thu, 4-5pm
E-mail Address	florian.shkurti@utoronto.ca
Course Web Site	http://www.cs.toronto.edu/~florian/courses/csc477_fall19/
Teaching Assistant	Nan Liang
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Course Description

An introduction to mobile robotic systems from a computational, as opposed to an electromechanical, perspective. Definitional problems in robotics and their solutions both in practice and by the research community. Topics include algorithms, probabilistic reasoning and modeling, optimization, inference mechanisms, and behavior strategies. [24L, 12P]

Prerequisite: CSC209H5; CSC338H5; CSC373H5; MAT244H5; STA256H5 Recommended Preparation: CSC375H5; CSC384H5; CSC411H5; MAT224H5/MAT240H5 (SCI)
Distribution Requirement: SCI

Students who lack a pre/co-requisite can be removed at any time unless they have received an explicit waiver from the department. The waiver form can be downloaded from here.

Detailed Course Description

This course provides an introduction to robotic systems from a computational perspective. A robot is regarded as an intelligent computer that can use sensors and act on the world. We will consider the definitional problems for robots and look at how they are being solved in practice and by the research community. The emphasis is on algorithms, inference mechanisms and behavior strategies, as opposed to electromechanical systems design. The course will broadly cover the following areas:

• Kinematics and Dynamics: How can we model robotic systems using approximate physical models that enable us to make predictions about how they move in response to given commands?

• Feedback Control and Planning: How can we compute the state-(in)dependent commands that are required to bring a robotic system from its current state to a desired state?

• Mapping: How should we represent 3D maps? How can we weigh noisy measurements from sensors as well as the robot's known pose to build a map of the environment?

• State Estimation: The state of the robot is not always directly measurable. How can we determine the relative weighs of multiple sensor measurements in order to form an estimate of the state?

• The Geometry of Computer Vision: How can we model inputs from an RGB camera? How can we triangulate points seen from two cameras. How can we estimate the camera's position (and therefore the robot's) while it is moving in the environment?

Learning Outcomes

This course aims to help students improve their probabilistic modeling skills and instill the idea that a robot that explicitly accounts for its uncertainty works better than a robot that does not. By the end of the course students will learn to be comfortable with high-dimensional probabilistic modelling, least squares optimization, as well as rigorous translation of robotics problems into optimization problems, as currently used in robotics research. Students will also get practical experience with state of the art robot middleware and simulators (e.g. ROS and Gazebo).

Textbooks and Other Materials

There is no required textbook for this course. Slides will be provided that will cover the material needed for the class. The following are optional, but recommended textbooks:

• Sebastian Thrun, Dieter Fox, Wolfram Burgard, Probabilistic Robotics.

• Steve Lavalle, Planning Algorithms.

• Gregory Dudek, Michael Jenkin, Computational Principles of Mobile Robotics, 2nd edition

• Peter Corke, Robotics, Vision, and Control

• Tim Barfoot, State Estimation for Robotics

• Simo Sarkka, Bayesian Filtering and Smoothing

Assessment and Deadlines

Type	Description	Due Date	Weight
Assignment	Feedback control	2019-10-02	15%
Assignment	Planning	2019-10-23	15%
Assignment	Filtering, smoothing, least squares	2019-11-15	15%
Assignment	Robot vision	2019-12-04	15%
Quiz	In class, 5 of them		10%
Final Exam		TBA	30%
		Total	100%

More Details for Assessment and Deadlines

There will be 7 in-class quizzes throughout the semester. When computing your quiz grade we will take the best 5 out of 7.

Penalties for Lateness

Each student will have 2 grace days throughout the semester for late assignment submissions. Late submissions that exceed those grace days will lose 33% of their value for every late day beyond the allotted grace days. Late submissions that exceed three days of delay after the grace days have been used will unfortunately not be accepted

Procedures and Rules

Missed Term Work

To request special consideration, bring supporting documentation to the instructor in person during office hours at least one week in advance.

In case of illness, bring a U of T medical certificate to the instructor within one week of the missed work. The certificate must specify the exact period during which you were unable to carry out your academic work.

Missed Final Exam

Students who cannot write a final examination due to illness or other serious causes must file anonline petition **within 72 hours of the missed examination**. Original supporting documentation must also be submitted to the Office of the Registrar **within 72 hours of the missed exam**. Late petitions will **NOT** be considered. If illness is cited as the reason for a deferred exam request, a U of T Verification of Student Illness or Injury Form must show that you were **examined and diagnosed at the time of illness and on the date of the exam, or by the day after at the latest**. Students must also record their absence on ACORN on the day of the missed exam or by the day after at the latest. Upon approval of a deferred exam request, a non-refundable fee of $70 is required for each examination approved.

Academic Integrity

Honesty and fairness are fundamental to the University of Toronto's mission. Plagiarism is a form of academic fraud and is treated very seriously. The work that you submit must be your own and cannot contain anyone elses work or ideas without proper attribution. You are expected to read the handout How not to plagiarize (http://www.writing.utoronto.ca/advice/using-sources/how-not-to-plagiarize) and to be familiar with the Code of behaviour on academic matters, which is linked from the UTM calendar under the link Codes and policies.

Final Exam Information

Duration:	3 hours
Aids Permitted:	1 page(s) of double-sided Letter (8-1/2 x 11) sheet

Additional Information

Tentative Course Outline By Week:

1. Introduction, Sensors and Actuators

2. Kinematics, Dynamics

3. PID Control, Artificial Potential Fields

4. Linear Quadratic Regulator

5. Planning

6. Mapping

7. Reading Week

8. Least Squares, Graph-Based Simultaneous Localization and Mapping

9. Bayes and Kalman Filter

10. Extended Kalman Filter

11. Particle Filter

12. Camera Optics and 3D Geometry

13. Visual Odometry and Simultaneous Localization and Mapping

Last Date to drop course from Academic Record and GPA is November 7, 2019.