Computer Science 6912
Graduate Course:
Autonomous Robotics

Memorial University of Newfoundland

Fall, 2022-23

Instructor: Dr. Andrew Vardy

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Lectures: Mon, Wed, Fri from 10:00 - 10:50 in EN-1052

Labs: Tuesdays from 2:00 - 4:50 in EN-1049. Three labs are planned, which will take up at least three 3-hour sessions. However, it is possible that more than three sessions will be required. **There will be no option to make-up for missed labs.**

For students in 6912, the lab slot will also be used for presentations and demos.

Instructor Office Hours: Mondays and Wednesdays 11:00 – 12:00. E-mail to arrange an appointment outside of office hours. You can also stop by my office and if my door is ajar, I will be happy to help you. If my door is closed I am either out of the office or very busy.

Calendar Description:

Introduction to Autonomous Robotics examines the fundamental constraints, technologies, and algorithms of autonomous robotics. The focus of this course will be on computational aspects of autonomous wheeled mobile robots. The following topics will be covered: major paradigms in robotics, methods of locomotion, kinematics, simple control systems, sensor technologies, stereo vision, feature extraction, modelling uncertainty of sensors and positional information, localization, SLAM, obstacle avoidance, and 2-D path planning.

Course Outline:

- Major Paradigms in Robotics
- Representing Position and Orientation (Ch. 2 of Corke)
- Robot Vehicles and Control (Ch. 4 of Corke)
- Perception and Sensors (Ch. 4 of Siegwart et al.)
- Probabilistic Robotics (Selected Chapters from Thrun et al.)
- Navigation and Reinforcement Learning (Selected Material from Sutton and Barto)
- Swarm Robotics (Selected Material from Hamann)

Textbook: There is no required textbook for this course.

For much of the course we will utilize material from [Corke, 2017]. Fortunately, it is available for free in electronic form from the MUN library. We will also use some material from [Siegwart et al., 2011], [Thrun et al., 2005] and [Hamann, 2018] as indicated above. [Hamann, 2018] is available in electronic form from the MUN library.

References:

Corke, Peter.
Robotics, Vision and Control: Fundamental Algorithms In MATLAB®, Second Edition. Springer, 2017.

Hamann, Heiko. Swarm Robotics: A Formal Approach. Springer, 2018.

Siegwart, Roland, et al. Introduction to autonomous mobile robots. MIT press, 2011.

Sutton, Richard S, and Andrew G Barto. Reinforcement learning: An introduction. MIT press, 2018.

Thrun, Sebastian, et al. Probabilistic robotics. MIT press, 2005.

Prerequisites:

Students should have a solid background in computer programming, algorithms, calculus, linear algebra, and statistics. Such a background may have been obtained through completion of the following courses at Memorial: COMP 2711, MATH 2000, MATH 2050, and STAT 2510. Assignments will require the use of Python.

Evaluation scheme:

Assignments (8 @ 3% each)	24%
Labs (3 @ 3.333% each)	10%
Tests (2 @ 14% each)	28%
Presentations (2 @ 6% each)	12%
Project Demo	16%
Project Report	10%

Presentations:

Each student in 6912 will give two presentations. The first will be on a foundational topic. The point here is to introduce a fundamental concept that is not covered in class. The emphasis should be on clearly presenting this concept to the class.

The second presentation will cover a modern research paper in robotics. The paper should be chosen from the proceedings of one of the main conferences in robotics:

- IEEE/RSJ International Conference on Intelligent Robots and Systems
- IEEE International Conference on Robotics and Automation

The proceedings for both of these conferences are available through IEEE Xplore, which is accessible through the university library's web site. Papers published in other respectable conference proceedings and journals may also be accepatable. The paper chosen should be reasonably self-contained so that it can be explained without having to go through all of its references. It should also present additional material beyond what is discussed in class.

Project:

It is recommended that the project focus on implementing one or more of the concepts described in the research paper presentation. The student should discuss the scope of the implementation with the instructor. It is crucial that some experimental results be demonstrated either in simulation or using physical robots.

Alternately, the project can cover another topic that is related to the student's interests or research. However, such a topic should be cleared by the instructor.

The project can be completed either individually or in groups of two. Projects completed by groups will be held to a significantly higher standard of accomplishment.

Further information on the requirements for the project demo and report will be posted on Brightspace.

Schedule:

Lab 1	13 Sept.
Assignment 1	21 Sept.
Assignment 2	28 Sept.
Test 1	3 Oct.
Lab 2	4 Oct.
Assignment 3	12 Oct.
Assignment 4	19 Oct.
Assignment 5	26 Oct.
Assignment 6	2 Nov.
Test 2	7 Nov.
Lab 3	8 Nov.
Assignment 7	16 Nov.
Assignment 8	23 Nov.
Project Interim Demo	29 Nov.
Project Final Demo	6 Dec.
Project Report Due	13 Dec.

Presentations will be scheduled during the Tuesday afternoon lab slots. The exact schedule for presentations will be published once enrollment stabilizes.

Note: The schedule for course events (assignments, labs, and tests) will be posted on Brightspace. This schedule is subject to change which will be announced in class.

Assignments:

The assignments will come in two varieties: pen-and-paper assignments involving written problem solving exercises, and programming assignments. Approximately half of the assignments will be pen-and-paper, while the rest will involve programming. Programming assignments will require the use of Python as well as the CoppeliaSim robotics simulator.

All pen-and-paper assignments **must be completed individually**. The first programming assignment must also be completed individually. Subsequent programming assignments may be completed individually or in groups of two. If completed in a group of two, the expectation is that the group will go beyond bare-bones functionality and include some level of experimentation and analysis (e.g. studying the impact of varying parameters).

Pen-and-paper assignments are to be completed on paper and submitted in-person at the beginning of class (at 10:00) on the due date. Programming assignments will be submitted electronically through Brightspace.

Labs:

Three lab sessions are planned. Students will work in pairs to implement behaviours on real-world robots.

Other Info.

- Note that there **will** be an assignment due during the last two weeks of term.
- Late assignments, labs, and missed tests will only be accepted in case of illness, childbirth, or bereavement, or by prior arrangement with the Instructor. In case of illness, you should obtain a doctor's certificate prior to the test time or due time.
- If you feel any mark was unfair or incorrectly recorded, ensure the instructor is aware of the problem as soon as possible, and within at most 2 weeks of receiving the mark.
- Cases of academic offences will be dealt with in accordance with university regulations. Academic offences includes: copying, allowing work to be copied, failing to cite sources, and presenting work done in collaboration as one's own. Please read Section 6.12.4 of the university calendar if you need clarification as to what constitutes an academic offence.