Computer Science 6912
Graduate Course:
Autonomous Robotics

Memorial University of Newfoundland

Winter, 2019-20

Instructor: Dr. Andrew Vardy

Office: EN-2018

E-mail: `av` followed by the 'at' symbol, then `mun.ca`

Web page: Brightspace

Lectures: Mon, Wed, Fri from 10:00 - 10:50 in EN-1051

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 1:00 – 2:00. 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. Note: The Wednesday office hour will have to be cancelled a few times throughout the semester to accommodate Departmental/Faculty meetings.

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, Nourbakhsh, and Scaramuzza)
- Probabilistic Robotics (Selected Chapters from Thrun, Burgard, and Fox)
- Navigation and Reinforcement Learning (Various Sources)
- 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, Nourbakhsh, and Scaramuzza, 2011], [Thrun, Burgard, and Fox, 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 Editio Springer, 2017.

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

Siegwart, Roland, Illah Reza Nourbakhsh, and Davide Scaramuzza. Introduction to autonomous mobi MIT press, 2011.

Thrun, Sebastian, Wolfram Burgard, and Dieter Fox. 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, although some work from the final section of the course (swarm robotics) will require the use of Javascript (in-depth Javascript knowledge is not required).

Evaluation scheme:

Assignments (5 @ 5% each)	25%
Labs (3 @ 3.333% each)	10%
Tests (2 @ 15% each)	30%
Presentation	5%
Project Demo	15%
Project Report	15%

Presentation:

Each student will prepare a presentation on 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.

Students should select two different topics of interest and for each topic submit a recent paper (2016+), plus an older paper which the recent paper builds upon. Thus, a total of four papers should be provided as PDF files to the instructor by the paper selection deadline. The instructor will consult with the student to discuss which paper is most suitable for presentation.

Project:

The project will involve implementation of one or more of the concepts developed in the presented paper. 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.

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:

Assignment 1	24 Jan.
Lab 1	28 Jan.
Assignment 2	7 Feb.
Lab 2	11 Feb.
Test 1	14 Feb.
Assignment 3	28 Feb.
Assignment 4	13 Mar.
Lab 3	17 Mar.
Test 2	20 Mar.
Assignment 5	27 Mar.
Project Interim Demo	31 Mar.
Project Final Demo	7 April
Project Report Due	10 April

Presentations will be scheduled during the Tuesday afternoon lab slot in March 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:

Each assignment will consist of two parts. Part A will involve pen-and-paper calculations, problem solving exercises and potentially small programming exercises. Part B will be a more substantial programming exercise. The weighting of marks between Parts A and B may differ from one assignment to the next.

Programming tasks (in parts A and B) will require the use of Python. Part of the last assignment will require the use of Javascript, but in-depth knowledge of the language is not required.

Both parts of assignment 1 must be completed individually. For assignments 2-5 part B 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). Part A for all assignments must be completed individually.

For all assignments, part A is to be completed on paper and submitted at the beginning of class (at 10:00). Part B will be due on the same day but will be submitted through Brightspace.

Labs:

Three lab sessions are planned. Students will work in pairs to implement problems studied in class on real-world robots. It is anticipated that the first lab session will

involve some manual assembly and setup tasks. Labs 2 and 3 will involve programming the robots to execute various tasks.

Other Info.

- Note that there **will** be an assignment due during the last two weeks of term. For students in 6912, the project final demo will also occur 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. No reconsideration of term marks will be made after the final exam.
- 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.