Computer Science 6912
Graduate Course:
Autonomous Robotics

Memorial University of Newfoundland

Spring, 2018

Instructor: Dr. Andrew Vardy

Office: EN-2018

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

Web page: `www.cs.mun.ca/~av/courses/4766-current`

Lectures: Mon, Wed, Fri from 12:00 - 12:50 in EN-1052

Labs: Wednesdays from 9:00 - 11:50 in EN-1049. The lab slot will be used for technology demonstrations and for students to demonstrate their assignments to the instructor and/or TA. The lab slot will not be used every week.

Instructor Office Hours: 3:00 - 4:00 on Tuesdays and Thursdays. You can also email to arrange an appointment outside of office hours.

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:

- Introduction: Major paradigms in robotics
- Mobility: Methods of locomotion; kinematics; motion control; coordinate transforms
- Perception: Sensor technologies; stereo vision; feature extraction
- Localization and Navigation: Belief representation; Bayes filter; Markov localization; particle filter; Kalman filter; simultaneous localization and mapping (SLAM)
- Motion Planning: Obstacle avoidance; path planning
- Biologically-Inspired Robotics: Swarm robotics

Textbook: There is no required textbook, but the following texts may prove useful to supplement the material presented in class. Note that the *Handbook of Robotics* and Siegwart et al.'s *Introduction to Autonomous Mobile Robots* are available electronically from the university library:

- Siciliano, B., Khatib, O. (2016) *Handbook of Robotics.* Second Edition, Springer.
- Siegwart, R., Nourbakhsh, I.R. Scaramuzza, D. (2011) *Introduction to Autonomous Mobile Robots.* Second Edition, MIT Press.
- Thrun, S., Burgard, W., Fox, D. (2005) *Probabilistic Robotics.* MIT Press.

References:

- Choset, H., Lynch, K., Hutchinson, S., Kantor, G., Burgard, W., Kavraki, L.E., and Thrun, S. (2005) *Principles of Robot Motion.* MIT Press
- Dudek, G., Jenkin, M. (2010) *Computational Principles of Mobile Robotics.* Cambridge University Press.
- Trucco, V., Verri. A. (1998) *Introductory Techniques for 3-D Computer Vision.* Prentice Hall.

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 ROS (Robot Operating System) and the Python programming language. ROS will be introduced through completion of the assignments. It is expected that students will be able to develop sufficient knowledge of Python on their own.

Evaluation scheme:

Assignments (5 @ 6%)	30%
Hardware Component	5%
Presentation	5%
Project	12.5%
Mid-term Exam	12.5%
Final Exam	35%

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 (2015+), 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.

Schedule:

Assignment 1 (Individual)	23 May
Assignment 2 (Individual/Group)	30 May
Assignment 3 (Individual/Group)	13 June
Mid-term Exam	15 June
Paper selection	22 June
Assignment 4 (Individual/Group)	4 July
Assignment 5 (Individual/Group)	18 July
Presentations	June / July (Dates TBD)
Project interim demo	1 August
Project final demo	8 August (Tentative)

Note: The schedule for significant events (assignments, labs, mid-term exams, ...) will be posted online. This schedule is subject to change. Any such change will be announced in class.

Assignments:

The first assignment is to be completed individually. Remaining assignments can be completed individually or in groups of two. If completed in a group of two, the expectation is that the outcome of the assignment will go somewhat beyond bare-bones functionality and include some level of experimentation and analysis (e.g. studying the impact of varying parameters).

The assignments will consist of small analysis/programming projects. Depending upon the nature of each assignment, some written work may be required in addition to a programming component. The programs written will usually serve as controllers for simulated robots. We will make extensive use of ROS (Robot Operating System) and Python for the assignments.

Evaluation of both individual and group assignments will take place during the lab slot and will involve a demonstration component.

Hardware Component:

A small number (4-5) robots will be available for assignments 2-5 (not assignments 1 or 6). These robots will be assigned to a subset of student groups so that all students get at least one opportunity to use the robots and earn the hardware component mark. To receive the hardware component mark, students must demonstrate the transfer of working code from simulation (as required by each of these assignments) onto the physical robots. They must also complete a small report (2-3 pages) explaining what aspects had to be changed in order to get the program to work well on the robot. This report should also document experiments conducted to illustrate the performance of the underlying algorithm (e.g. by varying parameters or trying variations on the algorithm).

Other Info.

- Note that there **will** be an assignment due during the last two weeks of term.
- Late assignments 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 that I am aware of the problem as soon as possible—preferably within 2 weeks of receiving the mark and certainly before the final exam. *No reconsideration of term marks will be made after the final exam.*
- Cases of academic offences will be dealt with in accordance with the 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 Regulations or consult the Instructor, if you need clarification as to what constitutes an academic offence.