Computer Science 6778
Graduate Course:
Autonomous Robotics

Memorial University of Newfoundland

Winter, 2014

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-w14`

Lectures: Tuesdays and Thursdays from 12:30 - 1:45 in EN-1052

Labs: Thursdays from 2:00 - 5:00 in EN-1049. The lab slot will be used for technology demonstrations and for students completing group assignments to demonstrate their work. The lab slot will not be used every week.

Instructor Office Hours: 2:00 - 4:00 on Tuesdays. Feel free to drop by outside of the official office hours. If my door is fully closed then I am either absent or busy. Email for an appointment to be sure of catching me.

TA: Tamkin Avi Khan

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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

Textbook: There is no required textbook, but the following texts may prove useful to supplement the material presented in class. Note that the Siegwart et al. book is available electronically from the university library:

- 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:

Individual Assignments (3 @ 7%)	21%
Group Assignments (2 @ 7%)	14%
Presentation	5%
Project	10%
Mid-term Exam	15%
Final Exam	35%

'Terminator points' will be awarded for extra achievment on the assignments (both individual and group assignments). A maximum of 10 terminator points will be awarded for each assignment. They will be used to counter deductions from the current assignment and will be carried forward if unutilized (1 terminator point counters 1 mark out of 100 awarded for an assignment). Unutilized terminator points will be used to counter deductions on the final exam at the rate of 10 terminator points per mark out of 100. In general, terminator points counter deductions only and will not be used to raise the mark on any assignment or the final exam above 100%. The terminator point system will be administered exclusively by the instructor.

Terminator points will be awarded for going above and beyond the requirements of any assignment. However, points will be awarded only for additional work related to the main content of an assignment.

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.

Two or three possible papers should be selected by the paper selection deadline. PDF or paper copies of these papers must be provided to the instructor by this 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.

Tentative schedule:

Assignment 1 (Individual)	23 January
Assignment 2 (Group)	6 February
Paper selection	13 February
Assignment 3 (Individual)	20 February
Mid-term Exam	26 February
Paper presentations	6 March
Assignment 4 (Group)	13 March
Assignment 5 (Individual)	3 April
Project submission	Final exam date + 5 days

Note: The schedule for significant events, such as assignment deadlines and the mid-term exam, will be posted online. This schedule is subject to change. Any such change will be announced in class.

Assignments:

Three assignments will be completed individually and two will be group assignments. The purpose of the group assignments is to utilize some of the department's limited robotic hardware. In both cases, 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.

The formation of students into groups for the group assignments will be done by the instructor. Evaluation of the group assignments will take place during the lab slot and will involve a demonstration component.

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 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 11.4 of the University Regulations or consult the Instructor, if you need clarification as to what constitutes an academic offence.