

CSCI-4190 Introduction to Robotic Algorithms

Spring 2004

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| Instructor: | Prof. Wes Huang | TA: | Yogi Girdhar |
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| office: | Amos Eaton 111, x8189 | office: | TBA |
| office hours: | TBA (Tu 1/13 3-4, R 1/15 2-3) | office hours: | TBA |
| classroom: | Darrin 236 | | |
| times: | Mondays and Thursdays, 10:00 - 11:50 | | |
| prerequisites: | CSCI-2300 Data Structures and Algorithms MATH-1020 Calculus II MATH-2800 Introduction to Discrete Structures | | |
| text: | none (course notes) | | |
| optional text: | Dudek and Jenkin, "Computational Principles of Mobile Robotics" | | |
| WWW: | http://www.cs.rpi.edu/courses/spring04/ira | | |
| secretary: | Shannon Bornt <bornts@cs.rpi.edu>, Amos Eaton 132 | | |

1 Course description

This course is an introduction to algorithms for robotic systems. The theme of the course is how these algorithms intelligently make use of sensory information from their environment and purposefully act upon it. Topics will include motion planning, processing sensor information, localization, mapping, and handling uncertainty. We will discuss applications in mobile robotics and in robotic manipulation. There is a laboratory component of this class in which students will implement a number of these algorithms on mobile robots.

2 Course activities

Since robotics is about developing algorithms and theory to give robots certain capabilities, the course activities span the range from algorithms and theory to implementation on robot hardware.

In general, there is something due every Monday: the three assignments are due on Mondays, the two exams are on Mondays, and the exercises are due on the other Mondays. The four lab writeups will be due on Thursdays. See the schedule for tentative due dates.

Note on programming environments: Your assignment code must compile and run on the CS department department SunOS (Solaris 9 UNIX) computers. That said, all the software libraries and support code will work under Linux (and probably other versions of UNIX). It should work under Windows as well, but you are on your own there. For the labs and the final project, however, your code will have to run under Linux because that is what using the robot requires.

2.1 Assignments

There are three assignments in this class; they will focus on implementing some general algorithm in software (only). The assignments will involve writing a program in C++, but there will also be some written component. The assignments are to be done individually; each will be approximately 2.5 weeks long. Assignments are due on Mondays.

There will be some libraries and support code you will have to use for these assignments. In particular, there will be a library for graphical display, a library for reading configuration files, and the CGAL computational geometry algorithms library. The first two are libraries we have written, and the last is available free for academic use.

2.2 Final project

You will do a final project in teams of 2–3 students. This project must combine at least two aspects from the class (e.g. mapping and localization, or motion planning and control) and must involve implementation on the robot in my lab. You will have some choice for your final project topic.

2.3 Labs

There are four labs on the tentative schedule; the labs will focus on programs that will control a mobile robot to do a specific task. My intention is for the labs to be reasonably short and self contained. There will be a 2 week period in which you must complete the lab.

The first lab will be a “supervised lab,” so you will need to arrange a lab time with the TA. For the remaining labs, you will be able to use the lab anytime, but you will have to arrange to demonstrate your results to the TA.

2.4 Exercises & reading reports

In order to reinforce material covered in class or for students to develop a better understanding of a topic, I will assign a small number of exercises on approximately a weekly basis. There will be an exercise due on every Monday that there is no assignment due or exam. These will generally be handed out the Thursday before they are due.

Some of these exercises may take the form of reading reports. These will require you to read a research paper from some robotics conference and to write a short summary and critique. Reading reports will be handed out at least a week in advance.

2.5 Exams

There are two exams: one halfway through the semester and one at the end. These will test your knowledge of and ability to apply the algorithms and theory covered in class.

3 Grading

Your grade will be determined according to the following (tentative) breakdown:

| | |
|-----|-----------------------------|
| 36% | Assignments |
| 18% | Final project |
| 10% | Labs |
| 10% | Exercises & reading reports |
| 26% | Exams |

You must “pass” at least half the assignments and labs in order to receive a passing grade for this class.

4 Resources

We will be making extensive use of the course home page and WebCT during the semester. Many (but not all) handouts will be available online through this page.

There will be a number of items placed on reserve at the library. The course home page will contain a list of these items.

The instructor and TA will hold regular office hours; you can feel free to drop in during these times. You may also make an appointment to see the instructor or TA outside of these times. We will try to keep the course web page updated with our current office hours.

5 Course policies

The following policies will be clarified as necessary during the semester and will be revised if necessary. The course home page will be updated with the current versions.

5.1 Academic honesty

I expect any assignment, lab, exercise, reading report, quiz, or final project that you turn in to be your own work (with your partner/team when appropriate) — the product of your understanding of the course material and your own efforts in completing the activity. More specifically, it is inappropriate to give or receive code for an assignment to or from anyone else. The same applies to the labs and final project except that you will of course be working with a lab partner and final project team.

The Rensselaer Handbook of Student Rights and Responsibilities defines several types of academic dishonesty, all of which are applicable to this class. Students found in violation of academic dishonesty policies may receive a failing grade for this course.

Please contact the instructor if there is any question about academic (dis)honesty.

5.2 Late work

By default, everything in this class is due at the beginning of class (10:00) on the day it is due. However, I will usually collect written work during the break (i.e., in the middle of class). Exercises will be collected at the beginning of class because we will generally go over the solutions right away.

Late work places an additional burden on the teaching staff and is unfair to those students who turn in their work on time. It also tends to delay the grading process. However, I do want to encourage students to complete work for a short period after the deadline.

Unless you make *prior* arrangements with the instructor, late work is treated as follows:

- No late exercises will be accepted.
- For all other activities, there is a two-tier system with flat late penalties. Work turned in before the first-tier deadline is assessed a 7.5% penalty. Work turned in before the second-tier deadline is assessed a 15% penalty. Late work is not accepted after the second-tier deadline. The default deadlines are:

| day due | first-tier deadline | second-tier deadline |
|----------|---------------------|----------------------|
| Monday | 5pm Tuesday | 10am Thursday |
| Thursday | 5pm Friday | 10am Monday |

Different components of an assignment or lab will generally be treated separately under this late policy.

Any late papers should be turned in to the TA's mailbox in the Amos Eaton first floor lounge.

5.3 Attendance

You are expected to attend class prepared to discuss or answer questions on previously covered material.

5.4 Excuses

If there is some good reason that you will need an extension on any assignment, exercises, etc., contact me *in advance*. If you do not contact me in advance, I will ask you to get a letter from the Dean of Students. They will verify excuses (typically illness, family emergency, etc.) and write a memo. This way I can be assured of a valid excuse without needing to know details of students' personal lives.

5.5 Grading appeals

If you disagree with the grading on an assignment, exercise, etc., I will ask you to appeal first to whoever graded it (often the TA) so that consistency over the class is maintained. Should you appeal a grade to the TA and are unsatisfied with the outcome, then see the instructor. Appeals must be made within two weeks after the work is returned.

5.6 Changes

There may be changes to the policies, deadlines, and schedule described in this syllabus. You can expect me to give you reasonable notice of any changes. All changes will be announced in class and appear on the course web page or WebCT.

6 Tentative Schedule

| Week | Date | Topic | Assign | Exercise | Labs |
|------|----------|--|--------|----------|--------|
| 1 | M Jan 12 | Introduction; Mobile robot hardware | | | |
| | R Jan 15 | Motion planning: intro, C-space | A1 out | | |
| 2 | M Jan 19 | NO CLASS — Martin Luther King, Jr. Day | | | |
| | R Jan 22 | Motion planning: cellular decompositions | | E1 due | L1 out |
| 3 | M Jan 26 | Motion planning: roadmap methods | | E2 due | |
| | R Jan 29 | Motion planning: randomized methods | | | |
| 4 | M Feb 2 | Localization: intro, least squares estimation | A1 due | | |
| | R Feb 6 | Localization: least squares estimation | A2 out | | L1 due |
| 5 | M Feb 9 | Localization: Kalman filter | | E3 due | |
| | R Feb 12 | Localization: Kalman filter | | | |
| 6 | T Feb 17 | Localization: Markov localization | | E4 due | |
| | R Feb 19 | Mapping: intro, representation | | | L2 due |
| 7 | M Feb 23 | Mapping: occupancy maps & modeling | A2 due | | |
| | R Feb 26 | Mapping: topological maps | A3 out | | |
| 8 | M Mar 1 | Exam I: | | | |
| | R Mar 4 | Mapping: feature/landmark-based maps | | | L3 due |
| | M Mar 8 | NO CLASS — spring break | | | |
| | R Mar 11 | NO CLASS — spring break | | | |
| 9 | M Mar 15 | Motion planning: nonholonomic methods | | E5 due | |
| | R Mar 18 | Motion planning: online methods | | | |
| 10 | M Mar 22 | Motion planning: online methods | A3 due | | |
| | R Mar 25 | Architectures: intro, deliberative architectures | | | L4 due |
| 11 | M Mar 29 | Architectures: reactive & hybrid architectures | | E6 due | |
| | R Apr 1 | Control: dynamics of physical systems | | | |
| 12 | M Apr 5 | Control: basic feedback control | | E7 due | |
| | R Apr 8 | Control: basic feedback control | | | |
| 13 | M Apr 12 | Manipulation | | E8 due | |
| | R Apr 15 | Manipulation | | | |
| 14 | M Apr 19 | Computer Vision | | E9 due | |
| | R Apr 22 | Computer Vision | | | |
| 15 | M Apr 26 | Exam II | | | |