ME/CS 132b: Advanced Robotics

Spring 2015

Lecturer: Vasu Raman, ANB 338, x1768, vasu@caltech.edu
T.A.s: TBA
T.A. office hours: TBD
Class Meeting Time: Tu/Th 1:00-2:25 p.m.
Class Location: BBB 24

Course Objectives

This second quarter of ME/CS 132 will focus on **Robot Motion Planning.** The ability of a robot to plan its motions without explicit human guidance is a basic prerequisite for robotic autonomy. A robot motion planning algorithm enables an autonomous mobile robot to determine its movements in a possibly cluttered environment so as to achieve a variety of goals while avoiding collisions.

This course will try to strike a balance between reviewing basic concepts, practical algorithms, and theorems/proofs underlying important motion planning results. We will first focus on robot motion planning, where the geometry of the robot's stationary surroundings is known in advance. We also touch on topics in motion planning in the presence of a priori unknown or poorly known geometry of the robot's surroundings.

The course includes a lab component in which students will work with a differential drive robot to implement the algorithms covered in lecture. The lab is in 12 Steele, which is on the basement floor. If you have any requests or concerns with respect to accessibility, please contact course staff before the first lab session. You may find additional helpful resources at `http://diversitycenter.caltech.edu`.

The educational goals of ME/CS 132b are to:

- introduce basic robotic motion planning problems.
- provide students with a basic review of motion planning theory and an introduction to the most widely used planning algorithms.
- introduce sufficient terminology and concepts so that interested students can independently read the robotic motion planning research literature.
- enable students (via laboratory exercises) to implement motion planning algorithms on a mobile robot, and expose them to practical issues involved in implementing a motion planner
- have students (possibly in teams) carry out a significant final project in the area of robotic motion planning.

Grading

The course-work will consist of 2 homework assignments, 2 labs (whose goal is to get students familiar with implementing planning algorithms on mobile robots in order to be prepared for the final project), and a final project.

- Homework: 20%
- Labs: 20%
- Final Project: 60%.

Prerequisites

There are no formal prerequisites for the course other than ME/CS 132a, and some of the required background material will be reviewed during the first weeks of lecture. The instructional content of ME/CS 132b is largely independent of the material in ME/CS 132a, but students are expected to be able to use the experimental lab equipment introduced in the lab at the end of ME/CS 132a, and to apply the sensor processing and mapping techniques learned in the first quarter in their final project. The greater emphasis on a final project in this quarter will require a good comfort level with computer programming in at least one of the following languages: C, C++ or Python.

Resources

- **Course Web Site:** The web site for this course can be found at: `https://www.cds.caltech.edu/~murray/wiki/index.php/ME/CS_132b,_Spring_2015`. This web site will contain copies of homework and lab assignments, homework solutions, class handouts and links to information that will be useful for the final project.
- **Piazza Site:** Students are highly encouraged to post questions and answers on the course Piazza site, which is accessed at `http://piazza.com/caltech/spring2015/mecs132b/home`. The site will be monitored on business days by the course staff. Students can expect an answer within one business day. Students are expected to communicate in a professional manner. Important information about the class, such as changes in due dates, homework errata, etc. will be announced on Piazza, as well as in the Announcements section on the website.

Collaboration Policy

Students are encouraged to discuss and collaborate with others on the homework. However, you should write your own solution to show your own understanding of the material. You should not copy other people's solution or code as part of your solution. You are allowed to consult the instructors, the TAs, and/or other students. Outside reference materials can be used except for solutions from prior years or similar courses taught at other universities. Outside materials must be cited if used. All our activities in this course will be governed by the Caltech Honor Code, which can be viewed at `https://deans.caltech.edu/HonorCode/HonorSystem`.

References

1. The following text will provide the main background for the first half of the course:

    - **Planning Algorithms** by Steven M. LaValle (Cambridge Univ. Press, New York, 2006).

    This book is strong on classical motion planning theory and algorithms. It also includes excellent reference material on information-space approaches to planning, and evasion-pursuit algorithms. While these subjects are beyond the immediate scope of this class, they are accessible to interested students. For those of you interested in motion planning, I would recommend buying this book as a reference. Fortunately, the book is available freely on line at: http://msl.cs.uiuc.edu/planning/.

2. The following optional text covers much of the same material as the LaVallle book:

    - **Principles of Robot Motion: Theory, Algorithms, and Implementations**, by Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, Bradford Books, MIT Press, 2007.

3. The following textbook, used during the first quarter, should continue to be a useful reference for this quarter's course, especially for the final project:

    - **Probabilistic Robotics**, by Sebastian Thrun, Wolfram Burgard, and Dieter Fox, MIT Press, 2005

Tentative Syllabus

The course lectures and content will roughly follow this outline:

- An overview of robot motion planning problems
- The configuration space of a rigid body
- The classical motion planning paradigms: (1) potential fields; (2) roadmaps; (3) cellular decomposition and approximate cellular decomposition
- Graph search and discrete planning algorithms
- Sampling-based planning algorithms
- Sensor-based planning in unknown environments: Bug algorithms
- Other topics inspired by the project proposals, as time permits

An updated schedule can always be found on the course website.