ME/CS 132(b): Advanced Robotics: Navigation and Vision (Introduction to Robot Navigation & Perception)

Lecturer: Prof. Joel Burdick, Gates-Thomas 245, x4139, *jwb@robotics.caltech.edu*
T.A.s: Joseph Bowkett, Yoke Peng Leong, Daniel Pastor Moreno **T.A. office hours:** TBD
Class Meeting Time: To Be Determined (at the Organizational Meeting)
Class Location: Tentatively, Gates-Thomas 115

1 Intended Scope of ME/CS 132(b)

While ME 132(a) focused primarily on the basic theory of robotic motion planning (or *navigation*) this second quarter of ME/CS 132 will increasingly focus on the processes of *sensing and perception* for robot navigation. That is, how can a robot use sensors to become aware of its environment and its own current state, and use this knowledge to solve navigation problems? From the navigation point of view, the robot's perception system provides the data needed by a sensor-based planning algorithm to execute its plan. Because sensors provide noisy data, and often have a limited view of the world (leading to uncertainty in the robot's knowledge of its environment), the course will have an increasing focus on simple stochastic methods for handling sensor noise and uncertainty, as well as its impact on robot navigation.

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

- introduce basic robot sensing modalities for navigation: laser scanners (or LIDARS), RGB-D cameras, monocular cameras, and stereo cameras.
- Review odometry (wheel odometry, laser scan matching) and inertial navigation.
- Review the Kalman and Extended Kalman Filters for processing sensory data.
- Introduce *Simultaneous Localization and Mapping* (SLAM).
- Enable students (via laboratories) to implement sensor-based planning algorithms on a mobile or aerial 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 and perception.
- Enable students to read the research literature in this area.

2 Course Mechanics and Grading

There will be no traditional homeworks in ME/CS 132(b). All of the work will consist of hands-on laboratories where students will attempt to implment the lecture material on robot hardware. Unlike last quarter, this quarter will involve a *significant* final project.

- **Labs:** 50% (3-4 labs)
- **Final Exam or Project:** 50%.

The final project schedule in ME/CS 132(b) is intended to allow students sufficient time to tackle a realistic problem that integrates the course material on actual hardware, or possibly in a sophisticated simulation. The projects may be tackled by individuals, or teams. While students may choose their own topic, there will be a few "sponsored" projects with defined goals.

All of the labs and the final project will require programming. There is no preferred programming language for the course. Though a minimal amount of knowledge of the C++ programming language should be expected.

Course Web Site: We will use the same web site for ME/CS 132(b):

$$http://robotics.caltech.edu/wiki/index.php/ME\_CS\_132\_2017$$

Like last quarter, this web site will contain copies of lab assignments, class handouts (all the ones that are available in electronic form), and links to information that will be useful for final projects. Important information about the class, such as changes in due dates, homework errata, etc. can be found in the "Announcements" section. You should visit this site if you miss class.

References

The following *optional* text covers some of the same material as the LaValle book, but is strong on sensor-based motion planning algorithms.

- **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.

We will also use material from:

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

However, this book is optional, as we will use only a small portion of the book.

Tentative Syllabus of ME/CS 132(a)

The course lectures and content will roughly follow this tentative outline:

- Wheel odometry, scan matching odometry, and inertial navigation
- Review of Kalman Filters and Extended Kalman Filters.
- SLAM
- Probabilistic Motion Planning.

The course lectures will span the first 5-6 weeks of the quarter, with the last 4-5 weeks devoted to the final project. Teams or individuals will be expected to give short presentations on the status of their projects.