MECH 650 Autonomous Mobile Robotics

Fall 2014-15

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Office hours: Wednesdays 8:00 to 10:00 RGB 410

Class Meetings

Monday, Wednesday 2:00 – 3:20 am, Bechtel 407

Textbook (2 references)

1. *Probabilistic robotics*, MIT Press, Thrun, Burgards, and Fox. 2005
2. *Introduction to Autonomous Mobile Robots*, 2nd Edition, MIT Press, Siegwart, Nourbakhsh, and Scaramuzza. 2011

Prerequisites

By course:
- EECE 230: Introduction to Programming
- EECE 312: Electronics and Electronic Circuits.
- MECH 435: Control Systems

By topic:
- Linear algebra,
- Probability and statistics,
- Programming skills in Matlab and/or C, C++

Other References

1. *Principles of Robot Motion*, Choset et al. 2005.
2. Optimal State Estimation, Simon, D. Wiley-Interscience, 2006.
3. *Microelectronic Circuits*, Sedra, A. and Smith, K., Oxford University Press, 2004.
4. *Sensors and Signal Conditioning*, , 2nd Ed., R. Pallàs-Areny and J. Webster, Wiley2001.
5. *Measurement Systems Application and Design*, Fifth Ed., E. O. Doebelin, McGraw-Hill, 2003.
6. *The Art of Electronics*, P. Horowitz and W. Hill, Cambridge University Press, 1989.
7. *Introduction to Engineering Experimentation*, J. Wheeler and A. R. Ganji, Prentice Hall, 1996.
8. *Interfacing Sensors to the IBM PC*, W. Tompkins and J. Websters, Prentice Hall, 1988.
9. *Handbook of Modern Sensors: Physics Design and Application*, J. Fraden, AIP, 1993.
10. *Control Sensors and Actuators*, W. deSilva, Prentice Hall, 1989.
11. *Microsensors: Principles and Application*, J. W. Gardner, Wiley, 1994.
12. *Sensors for Mobile Robots: Theory and Applications*, H. R. Everett, A K Peters, 1995.
13. *The Measurement, Instrumentation, and Sensors Handbook*, John G. Webster, (Editor), CRC Press, 1998.

Catalogue Description

This course is designed to provide engineering graduate and 4th year students with the opportunity to learn about autonomous mobile robotics. Topics include sensor modeling, vehicle state estimation, map-based localization, linear and nonlinear control, and simultaneous localization and mapping.

Student learning outcomes At the end of the course the student will:
Have the ability to develop motion and measurement models for different types of mobile platforms.
Have the ability to develop control strategies for vehicle stabilization and state estimation.
Demonstrate an understanding of the integration of different robotics libraries into autonomous systems. An example includes the Robotics Operating System (ROS).
Demonstrate knowledge of different path planning algorithms, including A* and anytime dynamic AD*.
Demonstrate knowledge of the different localization techniques using infrastructure-based and infrastructure-less paradigms. We will cover adaptive Monte Carlo localization.
Demonstrate knowledge of different Simultaneous Localization and Mapping (SLAM) techniques.
Demonstrate the ability to work in teams to develop a working mobile robot to perform a specific task.

Tentative Schedule

1. Syllabus, Introduction, Probability, Optimization, State
2. Motion Modeling
3. Controllers: Linear, Nonlinear
4. Measurement Modeling
5. Estimation: Bayes Filter, Kalman Filter
6. Estimation: Kalman Filter, Extended Kalman Filter
7. Estimation: Particle Filter
8. Mapping: Localization, Mapping
9. Mapping: SLAM
10. Planning: Graph Based, Probabilistic Methods
11. Planning: Optimal Methods
12. Case study: Adept Pioneer 3At

Grading

Students will be graded according to the following scheme.

Entry	Weight	Note
Drop Quizzes	10%	First 15 minutes
Assignments	30%	Reinforce concepts
Final	30%	Detailed later
Project	30%	Detailed later

Course Policy

Class attendance and quizzes

The class is a place for the teacher and students to interact. Therefore, I design my lectures in such a way to foster interaction. In order for the synergy to work you must participate in the lectures as much as possible. You are here to learn and I am here to teach. Feel free to voice your opinion anytime during the lectures. Bring you class lecture notes with you to class and participate during the lecture.

Quizzes will be held without notice during the first 15 minutes of class, so please come early to lectures. The frequency and timing of the quizzes vary. If you miss a quiz you will NOT be given an opportunity to make it up.

Final exam
For this course you will be required to write a final exam. I recommend you practice the assignment problems to get a flavor of typical problems in autonomous robotics.

Project and assignments
Students will work in teams to build and analyze various elements of autonomous robotics. You will be required to complete a final project, where you will have the opportunity to integrate the information you have learned throughout the course. You will be expected to write a report about your project and present your work in a PowerPoint presentation. You will receive more details on the project at a later time.

Homework assignments
One of the most effective means of learning is doing homework. Homework assignments will be handed out during the semester in conjunction with lecture topics, in-class discussions, and reading assignments. You are highly encouraged to do them because they will help you to be prepared for the final exam.

Make-up tests and late homework policy
NO MAKE UP TESTS WILL BE GIVEN. If you miss an exam for a justified cause (*e.g.*, with a doctor's report) I will change the weight of the grade accordingly to compensate for your missed exam.

Resources for the Course

Resources for the course include:

- MOODLE: Includes a forum, which acts like a <u>center of focus</u> for the course. Any concerns you might have or ideas you want the entire class to hear you can post on the forum. Furthermore, anything I want to relay to you such as assignments, solutions, and homework will be posted on Moodle.
- The text and references for the course.
- The instructor; class notes and handouts, your teammates.
- The library, the web.

Course learning outcomes

At the end of the course

1. Students will demonstrate an understanding of the different paradigms for motion modeling
2. Students will be able to perform state estimation using methods based on Baye's theory, Kalman Filters, Extended Kalman Filters, and Particle filters.
3. Students will be able to implement Simultaneous Localization and Mapping (SLAM) and enable a robot to produce a map in an autonomous fashion.
4. Students will be able to code path planning algorithms such as A* or AD*.
5. Students will be able to implement the above algorithms on a real robot or on a simulator.