

ECE350/450-012 Introduction to Robotic Perception and Computer Vision

Dr. Y. Rosa Zheng

Instructor's Contact Information:

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Office Hours: Wed, 11:30 -13:00

Course Information:

HW platform: F1/10 Race Car

Semester: Spring 2020

Class Time: TuTh, 15:00 – 16:15

Location: 223 Packard Lab

Course Description

Course Catalog Description: Basic framework of autonomous robots; reactive and deliberative methods; perception subsystems including sensors such as sonar, Lidar, camera, or inertial measurement units (IMU); simultaneous localization and mapping (SLAM); path planning and race-line optimization; learning and vision with image classification and detection, deep learning neural networks and training algorithms, Convolutional Neural Networks (CNN).

A student-friendly description: Autonomous vehicles, industrial robots, lifelike androids, robotic helpers, and robot toys have become increasingly popular and technically advanced in recent years. To achieve an autonomous operation, a robot has to go through a series of tasks: sensing and perception, localization and mapping, exploration and learning, motion planning and navigation, etc. This course will introduce the basic framework of modern robotics such as sensing and perception, simultaneous localization and mapping (SLAM), path planning and race-line optimization; Machine Learning (ML) and Computer Vision (CV). We will build an F1/10 race car equipped with a VESC, a Lidar sensor, and an NVIDIA Jetson TX2 embedded GPU module. We will learn Robotic Operating System (ROS) and embedded GPU programming to accomplish three races: one using reactive methods, one using SLAM, and one using planning and learning. Students will work in small teams and work through 5-8 hands-on lab exercises that prepare you for the three races. Participation, teamwork and collaboration are essential for success.

Course Learning Objectives

Upon completing this course, students will be able to:

1. Understand basic frame work of modern robotics: reactive, deliberative, and interactive methods;
2. Understand basic robotic subsystems: sensing, planning, action, learning;
3. Be familiar with Robotic Operating System (ROS) and embedded GPU programming;
4. Be able to program reactive control algorithm, SLAM method, and path planning;
5. Be able to program basic machine learning algorithms and neural networks for detection and estimation.
6. Understand basic concepts of reinforcement learning.

Prerequisites

Courses: ECE108 / CSE140 / Math205 / Math 231: ECE108 Signals and Systems; CSE140 Foundations of Discrete Structures and Algorithms; Math 205 Linear methods; Math 231 Probability and Statistics.

Skills: basic math, statistics, and discrete-time linear systems; Programming and debugging in Java, Python, Matlab or C/C++; Technical writing.

Textbooks and Websites

Required textbooks: N/A

Recommended reference books:

1. Introduction to AI Robotics by Robin R. Murphy of Texas A&M University, The MIT Press, 2nd Ed. 2019. ISBN-13: 978-0262038485, ISBN-10: 026203848X.
2. Probabilistic Approaches to Robotic Perception by João Filipe Ferreira and Jorge Miranda Dias, Springer, 2018. ISSN: 978-3-319-03289-4.
3. Robotic Tactile Perception and Understanding: A Sparse Coding Method by Huaping Liu and Fuchun Sun, Springer, 2018. ISBN: 9789811061714.
4. Introduction to Autonomous Mobile Robots by R. Siegwart, I.R. Nourbakhsh, D. Scaramuzza and R. Arkin, 2nd Edition, The MIT Press, 2011, ISBN 978-0262015356.
5. Computer Vision: A Modern Approach by David A. Forsyth and Jean Ponce, Pearson, 2nd Ed, 2011. ISBN: 978-0136085928 or 013608592X.
6. Planning Algorithms, by Steven M. LaValle, Cambridge University Press, 2006.

Recommended Websites:

F1/10 website: <http://fltenth.org> by Upenn;

JetsonHacks: <http://jetsonhacks.com> blog by Jim Benson

NVIDIA: <https://www.nvidia.com>

Scikit-learn: <https://scikit-learn.org/stable/>

ROS: <http://ros.org> and Ubuntu: <http://ubuntu.com>

Policies

Expectation: When in class, please turn off all notifications on cell phones, laptop computers, and other devices that ring, buzz, or otherwise might disrupt the class.

Group work: Lab projects and their corresponding reports are to be done in groups. Each group consists of two students and shall submit only one copy of the programs and report for each project. To receive credit for a lab exercise, both members of the group must attend the classes allocated to the lab exercise. Peer evaluation (anonymous) and class observation will also be used to account for individual effort and adjustment for individual grades.

Grading Scale: Lab projects: 48%, races: 48%, attendance: 4%

Final grades are assigned as

94-100 = A

90-93.9 = A-

87-89.9 = B+	84-86.9 = B	80-83.9 = B-
77-79.9 = C+	74-76.9 = C	70-73.9 = C-
67-69.9 = D+	64-66.9 = D	60-63.9 = D-
<60 = F		

Requirements for ECE350 and ECE450 are slightly different. Some options in projects and exams are required for ECE450 but are optional for ECE350.

Attendance: You are expected to attend every lecture and lab session. You are solely responsible for anything you miss, including announcements, handouts, assignments, quizzes, programming exercises, exams, and course topics discussed in the class.

Late Papers or Missed Exams

- Late submission of project report is accepted but will be given 20% penalty per day.
- There will be two mid-term exams and one final project with demo. All exams are closed-book but you can bring a letter-sized double-sided fact sheet. Exams are to be done by each individual student. Makeup exams will not be given unless you have a very unusual excuse and instructor's permission in advance, or a documented medical/family emergency.

Logistics

Each team will develop one set of programs and write one report for each project. Each student is also required to submit a peer evaluation form for each project at Course Site. The submission time of your peer evaluation form determines your on-time or late submission.

Important Dates:

For pacing break and holidays, check: <https://ras.lehigh.edu/content/academic-calendar>. If you wish to observe religious holiday other than those on the calendar, please let the instructor know in advance.

Student Senate Statement on Academic Integrity

We, the Lehigh University Student Senate, as the standing representative body of all undergraduates, reaffirm the duty and obligation of students to meet and uphold the highest principles and values of personal, moral and ethical conduct. As partners in our educational community, both students and faculty share the responsibility for promoting and helping to ensure an environment of academic integrity. As such, each student is expected to complete all academic course work in accordance to the standards set forth by the faculty and in compliance with the University's Code of Conduct.

The work you do in this course must be your own. This means that you must be aware when you are building on someone else's ideas—including the ideas of your classmates, your professor, programs on the internet, and the authors you read—and explicitly acknowledge that you are doing so. Feel free to build on, react to, criticize, and analyze the ideas of others but, when you do, make it known whose ideas you are working with. If you ever have questions about drawing

the line between others' work and your own, ask the instructor for guidance or you may visit Lehigh Library's 'Proper Use of Information' page at <http://libraryguides.lehigh.edu/plagiarism>.

If you find that your paper has unoriginal text that is not properly cited, you should either cite the source or remove the text. If you remove or reword the unoriginal text, but retain the *idea* expressed by the source, you still must give a citation that names the source (paraphrasing without citation is not sufficient). If you do leave the uncited work in your paper, you are likely committing plagiarism. Remember, your work should build on the class discussions, reading, lectures, remarks, etc., but the paper or report you write *must* be your own work.

Other examples of cheating are

- Submitting a report for which the experiment or the write-up is not done by you.
- Allowing other teams to copy programs, results or notes.
- Stealing other student's results during projects or exams.
- Copying programs from the internet without crediting the original authors.

It is my hope and expectation that you all abide by the standards of academic integrity and that these procedures will help remind us all of the need for such standards.

The Principles of Our Equitable Community:

The Principles of Our Equitable Community: Lehigh University endorses The Principles of Our Equitable Community (www.lehigh.edu/diversity). We expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.

Accommodations for Students with Disabilities:

Accommodations for Students with Disabilities: If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, University Center C212 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.

Lehigh University Policy on Harassment and Non-Discrimination

Lehigh University upholds The Principles of Our Equitable Community and is committed to providing an educational, working, co-curricular, social, and living environment for all students, staff, faculty, trustees, contract workers, and visitors that is free from harassment and discrimination on the basis of age, color, disability, gender identity or expression, genetic information, marital or familial status, national or ethnic origin, race, religion, sex, sexual orientation, or veteran status. Such harassment or discrimination is unacceptable behavior and will not be tolerated. The University strongly encourages (and, depending upon the circumstances, may require) students, faculty, staff or visitors who experience or witness harassment or discrimination, or have information about harassment or discrimination in University programs or activities, to immediately report such conduct.

If you have questions about Lehigh's Policy on Harassment and Non-Discrimination or need to report harassment or discrimination, contact the Equal Opportunity Compliance Coordinator (Alumni Memorial Building / 610.758.3535 / eocc@lehigh.edu)