ECE 495/595 — Winter 2017
Introduction to Unmanned Ground Vehicles

Instructor:

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Course Description

The purpose of this course is to provide an overview of common techniques and challenges encountered in mobile robotics. Broadly, such topics include sensor data processing, sensor fusion, environment perception and mapping, and path planning and control.

Toward this end, the student will also be exposed to the Robot Operating System (ROS) software development environment. ROS is supported by a rapidly-growing community of open-source developers, and is starting to be adopted widely in many research, industrial, and automotive applications. ROS will be used to illustrate the theoretical components of the course, as well as providing the student with a meaningful hands-on experience that will help the student learn the concepts more effectively.

Programming homework will be distributed and submitted using the Mercurial version control tool. Besides making the submission and grading of homework more efficient, the student will also gain experience using version control tools that are widely used in both industrial and open-source software development.

Course Objectives

At the end of the course, the student will be able to:

- Write C++ code to run in a ROS system.
- Derive kinematic state space models for a variety of mobile robot platforms.
- Process raw data from a variety of common sensors into a form usable for navigation.
- Control a vehicle to drive between GPS waypoints.
- Understand the concepts behind SLAM algorithms.
- Understand a variety of commonly-used path planning techniques and the strengths and weaknesses of each.
- Control a vehicle to follow a specified path without collisions.
- Perform simple color thresholding and morphological processing on digital images to detect objects of interest.
- Design and tune Extended Kalman Filters.

Evaluation

The course grade will be determined according to the following rubric:

Homework	40%
Simulation Project	20%
Final Project	40%

Projects

There will be two projects assigned during the course:

- The first project will be a simulation project that is the same for everyone, and is meant to make sure the student is comfortable with the basics of ROS before starting heavy work on the second project. Deliverables will include a written report, as well as compilable and executable code.
- The second project will be more in-depth, and each group will select a different topic. Several ideas will be provided, but the students are free to propose their own project ideas. The second project will involve an oral presentation on April 26th, as well as a written report and all the developed code.

Homework and Grading Policy

- The two project deadlines are March 19th and April 28th at midnight. Late penalties will accrue at a linear rate of 10% per 24 hours late. For example, if the simulation project is submitted at 3:00 pm on March 20th (15 hours late), a nominal grade of 95% will be adjusted to:

$$\text{adjusted grade} = 95\% - \frac{10\%}{24\,\cancel{\text{hours}}} \times 15\,\cancel{\text{hours}} = 88.75\%$$

- All homework assignments will have an attached due date. Late penalties will be implemented similarly to the projects, but at a rate of 2% per 24 hours late, with the exception of Homework #5, which is penalized at 10%. However, any homework that isn't submitted by April 28th at midnight will be marked zero.

Tentative Schedule

Week	Topic	Highlights
1/2	Introduction and software setup	
1/9	ROS, C++ and Ubuntu basics	Homework #1 due 1/11
1/16	Vehicle kinematics	
1/23	Coordinate transformations, ROS concepts	Homework #2 due 1/25
1/30	More ROS concepts	
2/6	GPS fundamentals, even more ROS concepts	Homework #3 due 2/8
2/13	GPS navigation, simulation project kickoff	Homework #4 due 2/15
2/20	**Winter Recess!**	
2/27	Sensor data recording, state space modeling	Homework #5 due 2/27
3/6	LIDAR sensors, obstacle avoidance, path planning	
3/13	LIDAR sensors, obstacle avoidance, path planning	**Project #1 due on 3/19**
3/20	Simulated robots in ROS	
3/27	Image processing and computer vision	
4/3	Map building and localization	
4/10	Kalman filter sensor fusion	Homework #6 due 4/10
4/17	Work on projects!	**Final project presentations on 4/26 7:00pm – 10:00pm** **All homework and project reports due on 4/28 at midnight**