Course Syllabus

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Course Instructor: Joshua R Smith

Guest lecturer: Golnaz Habibi

Teaching Assistant team: Boling Yang, Benjamin Evans, Forum Suthar
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Lectures: ECE 045, Monday 6pm - 9:50pm

Lab: ECE 159

Office Hours:

Saturday 1pm-3pm: Ben Evans (ECE 159); 11am - 2pm Forum Suthar (ECE 159)

Sunday 1pm-3pm: Boling Yang (ECE 159); 11am - 2pm Forum Suthar (ECE 159)

Monday(5pm - 6pm), Thursday (5pm - 7pm): Forum Suthar (ECE 159)

Tuesday 9AM-10AM: Joshua Smith (CSE 582)

Golnaz Habibi: By appointment

Course Overview: In this course, we will cover topics related to state estimation (particle filters, motion models, sensor models etc), planning/control (search based planners, lattice based planners, trajectory following techniques etc), and perception and learning (object detection, learning from demonstrations etc.).

Each of the 4 assignments will involve student teams implementing the algorithms learned in lecture on 1/10th sized rally cars. Concepts from all of the assignments will culminate into a partially open-ended final project with a final demo on the rally cars. The course will involve programming in a Linux and Python environment along with ROS for interfacing to the robot.

Course Goals: By the end of this course, students will:
1. Become comfortable with tools such as ROS and Python for operating a real robot platform
2. Understand algorithms from state estimation, planning/control, perception, and learning, as well as how each of these areas contributes to the development of autonomous vehicles
3. Implement these algorithms on a real robot platform
4. Analyze both the theoretical and practical strengths and weaknesses of these algorithms

Prerequisites:
1. Proficiency in coding in a procedural language (e.g. C, C++, Python, Java, etc) is required
2. Knowledge of basic probability is required
3. Experience with Python is recommended

Grading (Tentative): 60% Assignments, 35% Final Project, 5% Class Participation

Lecture Schedule:
• Week 1: Course Logistics. Introduction to Python and ROS
• Week 2: ROS Cont'd. Introduction to Control
• Week 3: PID Control. Model Predictive Control. LQR Control
• Week 4: Bayesian State Estimation. Motion and Sensor Models
• Week 5: Particle Filters for Localization
• Week 6: Introduction to Planning and Search
• Week 7: Planning on Roadmaps. Lazy Search

• Week 8: Model Learning. Introduction to Neural Networks
• Week 9: Introduction to PyTorch. Model Predictive Path Integral Control
• Week 10: Introduction to Deep Reinforcement Learning

Assignments: The course will consist of the following five assignments:
1. Getting Started: Introduction to Python, Numpy, ROS, and the robot

2. Methods for Local Control: Path following / Move to object using images

3. State Estimation: Localization with a particle filter

4. Planning: Navigation in a known map, integration with state-estimation for closed-loop control

5. Learning: Learning robot controls from demonstrations

In addition, a partially open-ended final project will combine concepts from all of these assignments in order to autonomously navigate a track as quickly as possible.

Textbook: There is no required textbook for this course, however the following references are recommended:

Week	Date	Lecture Topic	Lecture notes and material	To read	Lab	Lab due
1	9/30/2019	Introduction; Robotics; Coordinate frames; Car Kinematics; Car HW; Intro to ROS; ROS & car demo	1a-Week1-Intro-sml.pdf 1b-Week1-Intro to ROS.pdf	mushr-paper.pdf Lynch-Park-p10-15.pdf Lynch-Park-p441-442.pdf 13.1.2.1 A simple car.pdf Lynch-Park-p448-453.pdf Ackermann steering geometry.pdf	Lab 0 :Intro to ROS	10/14/2019
2	10/7/2019	Control Systems PID, Pole Placement, LQR, MPC	2a-Week2-Control-Pt1-v3.pdf	Stanley: The Robot that Won the DARPA Grand Challenge Steve Brunton's Inverted Pendulum Simulation		
3	10/14/2019	Control pt 2; Intro to Bayesian Filtering (Probability Pt 1)	Week3-Control-pt2-state-est-pt1.pdf	Probabilistic Robotics text Amazon (https://www.amazon.com/Probabilistic-Robotics-INTELLIGENT-ROBOTICS-AUTONOMOUS/dp/0262201623/) Draft (https://docs.ufpr.br/~danielsantos/ProbabilisticRobotics.pdf)	Lab 1: Control Lab 0 Due	10/28/2019
4	10/21/2019	Particle Filters, Sensor Models, Re-	Week4-Prob-pt2.pdf	Probabilistic Robotics text		

		Sampling (Probability Pt 2)				
5	10/28/2019	Sensor Models & Motion models for particle filtering	Week5-Prob-pt3.pdf	Probabilistic Robotics text	Lab 2:State estimation Lab 1 Due	11/18/2019
6	11/4/2019	Guest lecture: Ryan Calo on Law and Robotics; Revisiting Resampling. Intro to Motion Planning & Heuristic Search (Dijkstra & A*)	Week6-Prob-PlanningPt1.pdf	Calo-law-and-driverless cars.pdf		
Veteran's Day (11/11/2019): No classes Lab3: Planning						
7	11/18/2019	Planning pt 2 (Laplace & RRT)	Week7-Plan-pt2-v2.pdf	Lav98c.pdf LaplacePlanning.pdf kuffner_icra2000.pdf	Lab3 Due	
8	11/25/2019	Linear Regression, Gradient Descent, Multi-Layer Perceptrons, Intro to Deep Learning	Week8-ML-pt1.pdf Week8_DL-pt1.pdf	strang-learning.pdf		
9	12/2/2019	Learning Pt 2	Week9-ML-pt2.pdf Week9_DL-pt2.pdf			

10	12/9/2019	Final Project			Final Project Demo	
10	12/12/2019	Final Project			Final Project Report Due	

Washington state law requires that UW develop a policy for accommodation of student absences or significant hardship due to reasons of faith or conscience, or for organized religious activities. The UW's policy, including more information about how to request an accommodation, is available at **Religious Accommodations Policy (https://registrar.washington.edu/staffandfaculty/religious-accommodations-policy/)** (https://registrar.washington.edu/staffandfaculty/religious-accommodations-policy/) . Accommodations must be requested within the first two weeks of this course using the **Religious Accommodations Request form (https://registrar.washington.edu/students/religious-accommodations-request/)** (https://registrar.washington.edu/students/religious-accommodations-request/) .

Course Summary:

Date	Details	
Mon Oct 14, 2019	**Assignment 0: Getting Started** (https://canvas.uw.edu/courses/1319731/assignments/5031057)	due by 5:59pm
Mon Oct 28, 2019	**Assignment 1: PID and Model Predictive Control** (https://canvas.uw.edu/courses/1319731/assignments/5049728)	due by 11:59pm
Mon Nov 11, 2019	**Assignment 2: Localization with Particle Filters** (https://canvas.uw.edu/courses/1319731/assignments/5064762)	due by 5:59pm
Mon Nov 25, 2019	**Assignment 3: A* Path Planning** (https://canvas.uw.edu/courses/1319731/assignments/5080598)	due by 5:59pm
Thu Dec 12, 2019	**Final Project** (https://canvas.uw.edu/courses/1319731/assignments/5096314)	due by 11:59pm
	Assignment 0 EC: Provide feedback (https://canvas.uw.edu/courses/1319731/assignments/5055321)	