EE P 545 A Au 23: The Self Driving Car: Introduction To AI For Mobile Robots

Instructor:

- Markus Grotz

TAs: # Alphabetical Order

- Jack Lowry
- Paresh Chaudhary
- Sanjar Normuradov

Lecture (**In-Person**), **ECE 125**:

- Tuesday, 6:00 pm - 9:50 pm

Lab Access, **ECE 165/159:**

Any time, **except**

- Thursday 10:30 am - 12:20 pm
- Friday 2:30 pm - 4:20 pm

TA Office Hours (In-Person), ECE 165:

- Monday, 1:00 pm - 3:00 pm
- Tuesday, 1:00 pm - 3:00 pm

Overview:

The course delves into essential components of contemporary self-driving vehicle technology, utilizing team-based tasks and hands-on application of leading-edge techniques on 1/10th scale MuSHR. rally cars.
Broadly, it addresses the subsequent subjects pertaining to:

- ROS Essentials: Nodes, Packages, Services, Workspaces
- Car Kinematics: Ackermann Steering Geometry
- Control: PID (Proportional Integral Derivative), MPC (Model Predictive Control), LQR (Linear Quadratic Control)

- Computer Vision: Pinhole & Depth Cameras, Intrinsic/Extrinsic Matrices Calibration, Triangulation/Reconstruction
- Probability: Multivariate Gaussian, Bayes & Kalman Filters
- Localization: Particle Filter (Velocity Motion Models, Beam-based Sensor Models)
- Planning: Djkstra, A*, RRT, Laplace
- Machine Learning: Linear Regression, Introduction to Neural Networks and PyTorch
- Deep & Reinforcement Learnings: CNNs, Autoencoders, Transformers, Q-learning

Objectives: By the end of this course, students should be able

- Master key mobile robot abstractions like localization, planning, and control, recognizing their role in autonomous vehicles.
- Implement these algorithms on a real robot platform, while evaluating their practical and theoretical merits
- Employ tools like Python and ROS for real-world and simulated applications.

Prerequisites:

- Knowledge of basic probability is required
- Experience with Python is recommended
- # Proficiency in coding in a procedural language (e.g. C, C++, Python, Java, etc) is required

Grading:

- **Assignments**: 70%
- **Final Project:** 30%

- If you submit edits/improvements to course materials, this will count toward participation (bonus up to 5% for participation)

Assignments:

- **Getting Started:** Introduction to ROS, and the robot
- **Control:** PID and MPC
- **Localization:** Particle Filter with Velocity-based Motion Model and Beam-based Sensor Model
- **Planning:** Navigation in a known map, integrated with Localization for closed-loop Control

Final Project:
A real car race that epitomizes all the methods and algorithms from the assignments in localization, planning, and control. Guaranteed enjoyment!

Textbooks (Optional):

- Probabilistic Robotics, *Sebastian Thrun, Wolfram Burgard and Dieter Fox*
- Reading Notes (provided as the course progresses)

Questions and Discussion:
We encourage you to use the discussion board on our Canvas page. If you have class/lab related questions, check the discussion board first to see if the question has already been asked and answered. Post your questions on the discussion board if you can't find feasible answers. And you are more than welcome to help your classmate if you know the answers to questions from other students!

Resources:

[VMware Workstation]
[Course VM images]
[ROS Tutorials]
[Python Tutorials]
[Code Editor (VS Code)]

2023 Class Schedule (Subject to change)

2023 Class Schedule (Subject to change)

Week	Date	Topics	Notes and Materials	Lab	Due date
1	10/03	Introduction: Course Objectives & Logistics, Self-Driving Cars & Robotics; Car Kinematics: Ackermann Steering Geometry; ROS Essentials; MuSHR: Overview & Demo	01-introduction.pdf Actions 01-system_architectures.pdf Actions	Assignment 0: Lab trainings Assignment 1: Getting Started with ROS	Assignment 0: 10/10/2023 Assignment 1: 10/17/2023
2	10/10	Quaternions; Control Systems: PID, MPC	02-control.pdf Actions		
3	10/17	Computer Vision: Pinhole & Depth cameras, Calibration;	03-perception.pdf Actions		

4	10/24	Probability: Introduction Multivariate Gaussians, Bayes and Kalman Filters;	04-probability.pdf Actions		
5	10/31	Particle Filter Velocity-based Motion Model, Particle Filter, Beam-based Sensor Model; Path Planning, Part1: Dijsktra, A*, RRT	05-planning.pdf Actions	Assignment 3: PID and Model Predictive Control	Assignment 3: Due 11/14/2023
6	11/7	Path Planning, Part2: Laplace, and Planning Methods Comparison. RRT with car kinematics; Machine Learning, Part1: Linear Regression & Intro to Neural Netwoks	06-planning_machine_learning.pdf Actions		
7	11/14	Machine Learning, Part2: Backpropagation, Intro to PyTorch	07-machine_learning.pdf Actions 01-pytorch_intro_tensors.ipynbDownload 01-pytorch_intro_tensors.ipynb	Assignment 4: Particle Filters	Assignment 4: Due 11/21/2023

			02-pytorch_intro_polynomial.ipynbDownload 02-pytorch_intro_polynomial.ipynb 03-pytorch_intro.ipynbDownload 03-pytorch_intro.ipynb		
8	11/21	Deep learning: CNNs, Autoencoders, Transformers	08-machine_learning.pdf Actions		Assignment 5: Due 11/28/2023
9	11/28	Reinforcement learning: Q Learning; Course Overview	09-reinforcement_learning-summary.pdf Actions		Race: 12/05/2023 Report: 12/15/2023
10	12/05	Final Race			

Previous class schedules:

We have also provide the schedules for 2022, 2021 and 2020, with the lecture materials presented. Previous class schedules can be found here.

Religious accommodation policy:
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. Accommodations must be requested within the first two weeks of this course using the Religious Accommodations Request.

Academic Misconduct:
We expect you to follow the Academic Misconduct rules of the Department of Electrical and Computer Engineering, the College of Engineering, and the University of Washington. For example, solutions you submit must be your own work. You are not allowed to re-use solutions from prior years or the TA's prior solutions. Students suspected of plagiarism will be reported to the College of Engineering for investigation and possible punishment.