CS 1501

Intro to Robotics: Autonomy, AI, and Applications

Course Description

Introduces the basic principles of robotics, focusing on core topics in autonomy and artificial intelligence, as well as their applications in self-driving cars, drones, and other types of robots. Students will learn the fundamentals of the autonomy software stack and related AI algorithms that allow robots to perform complex tasks like navigating an environment and detecting pedestrians. Course website: http://rohanraval.com/cs1501

Instructors

Student Instructor: Rohan Raval

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Faculty Advisor: Nicola Bezzo

- Assistant Professor, ECE and Systems Engineering
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Prerequisites

None, although basic Computer Science coursework (at the level of CS1110) is highly recommended.

Course Structure

- Attendance (50%)
  - Lectures will be once a week, 50 mins each. I will try my best to make lectures discussion-based as much as possible to foster engagement. There may also be guest lectures.
- Readings (50%)
  - There will be a list of readings each week, from which students should pick one to write a short analysis. These readings will expand on concepts talked about in class and connect them with work being done in industry or academia.
- This course is a 1-credit P/F class.
- As with any course, you will get out of it what you put into it! The idea behind this course is to present a sampling of concepts from which you can explore more about robotics -- and in doing so, hopefully instill an interest in robotics (possibly as a profession!)

Schedule of Topics

Week 1-2: Introduction

- Types of Robots
- Core Concepts of Autonomy
  - Autonomy Stack: Perception, Planning, and Control
  - Autonomy IRL: Research and Industry Directions
- Artificial Intelligence in Robotics
  - What is AI? A (very) brief history
  - Role of Machine Learning, focusing on Perception and Prediction

Week 3-4: Mapping, Localization and Pose

- Sensors
- HD Maps and Map Building
- Pose and Localization
  - Representation of Pose, and Degrees of Freedom
- State Estimation: the Predict-Update cycle and the Kalman Filter
- Particle Filter
- SLAM (Simultaneous Localization and Mapping)
- (if time) Iterative Closest Point (ICP) Algorithm

Week 5-7: Motion Planning and Navigation

- Intro to Graphs
- Graph Search Algorithms (BFS, DFS, Grassfire, Dijkstra's, A*)
- Obstacle Avoidance
- Probabilistic Road Maps (PRM) and Rapidly-exploring Random Trees (RRT)
- Artificial Potential Fields
- Real-world Motion Planning challenges

Week 8-9: Perception and Prediction

- Basic intro to Deep Learning and Neural Networks
- Basic Computer Vision and Visual Odometry
- Common Classification Problems
  - Image Segmentation, Lane Finding, Vehicle and Pedestrian Detection
- Prediction of other actors

Week 9-10: Motion Control

- Feedback: Open vs Closed-loop
- PID Controller

Week 11-12: TBD (based on student choice)

- E.g. Safety and Ethics, Aerial Robotics, Swarm Robotics, Connected Autonomy, etc.