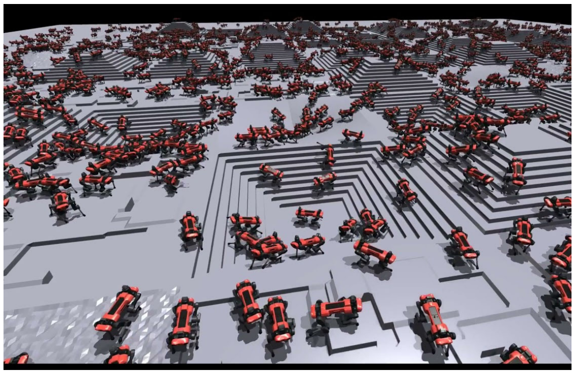
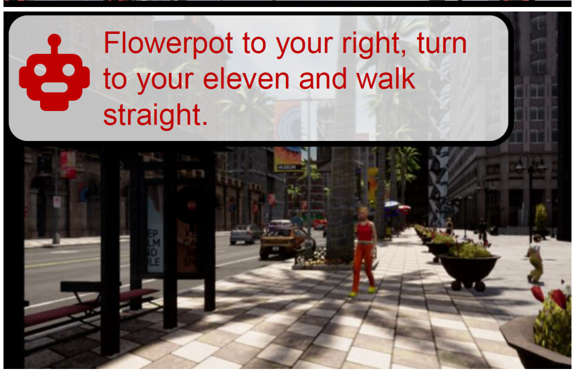
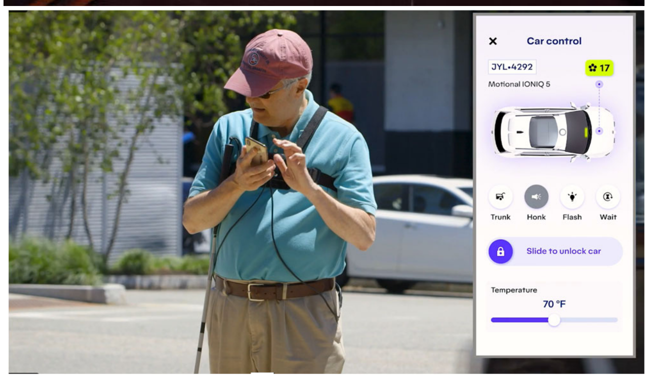
EC 500: Robot Learning and Vision for Navigation







Course Info:
Mon/Wed 4:30-6:15PM, CGS 123

Teaching Assistant:
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Office Hours: Wed 6:15-7:15PM
Blackboard: https://learn.bu.edu

Course Description

``We must perceive in order to move, but we must also move in order to perceive''

- Gibson (1979)

How can we design robotic systems that robustly operate in complex, dynamic, and uncertain real-world environments? Towards this overarching goal, this class will discuss recent developments in machine learning and perception for robotics. Specifically, we will study advanced concepts in perception, decision-making, and interaction algorithms in order to provide theoretical and experimental frameworks for understanding current limitations in state-of-the-art approaches for robot learning. Topics will include sensorimotor paradigms for perception and action, robot reinforcement learning, imitation learning, inverse reinforcement learning, exploration, hierarchial learning, model-based approaches, and human-machine interaction. We will particularly focus on one of society's most important and urgent problems, navigation, to analyze and address key challenges in state-of-the-art techniques.

Learning Objective

We will cover advanced techniques in computer vision and robot learning for real-world systems. At the end of this course, you will gain an understanding of fundamental paradigms and challenges in learning-based, state-of-the-art autonomous systems:

- How to formulate learning algorithms for general robotics and sensori-motor navigation
- Explore challenges in perception-based control pipelines
- Affordance-based and goal-directed representation of semantic scene, motion, and geometry
- Limitations (and complementarity) of reinforcement, inverse reinforcement, and imitation learning approaches
- Policy optimization (e.g., model-based vs. model-free) and sample efficiency analysis
- Multi-modal algorithms for multi-sensor (camera, LIDAR and radar perception) and multi-task learning
- Human-in-the-loop and social learning
- Reading and presenting recent research papers
- Participation in a competition to put these ideas to the test (for awards and fame)

Grading

Homework (30%): Homework will require coding in Python and PyTorch. GPU-cluster access will be provided and are highly recommended. Familiarity with Python will be assumed. Prior experience with PyTorch or Tensorflow is not required but is a plus.

Presentations and Participation (20%): Each student will get the opportunity to present. You will be graded based on your level of insight into the material, clarity and depthof presentation, how well you relate the paper to other papers and lecture material, as well as a lead discussion.

Final Project (50%): Each student is required to on a final research project. The project requires a 2-page proposal including the relevant literature survey, a proposal presentation, a milestone review, a 6-10 page-long final report, and a final presentation/demo. Projects are expected to be research level, uncovering new knowledge, and could be done either in simulation or on a real platform.

Tentative Schedule

Date	Topic	Notes	
1/23	Introduction: Why Navigation?	HW0: Due 1/25	
1/25	Deep Imitation Learning		
1/30	Deep Imitation Learning	HW1: Due in 2 weeks	
2/1	Affordances and Direct Perception		
2/6	Dynamics and Localization		
2/8	Semantic Scene Understanding		
2/13	Semantic Scene Understanding	HW2: Due in 2 weeks	
2/15	Object Detection and Tracking		

2/21	Object Detection and Tracking	Project Proposal Reports Due	
2/22	Markov Decision Process	HW3: Due in 2 weeks	
2/27	Q-Learning and SARSA		
3/1	Double Q-Learning and Deep RL for Robotics	Competition Presentations	
3/6	Spring Recess		
3/8	Spring Recess		
3/13	TRPO, DDPG, PPO	Project Proposal Revision Due	
3/15	LfD/Inverse Reinforcement Learning		
3/20	LfD/Inverse Reinforcement Learning		
3/22	Human-in-the-Loop Learning		
3/27	Human-in-the-Loop Learning		
3/29	Midterm Project Updates		
4/3	Model-based RL		
4/5	Model-based RL		
4/10	Sim2Real		
4/12	Bio-Inspired and Evolutionary Techniques		
4/17	Patriot’s Day		
4/19	Incorporating Language		
4/24	Partial Observability		
4/26	Human-Robot Interaction		
5/1	Ethics and Social Implications		
5/3	Research Presentations		
5/10	Research Paper Submission		