CSCI 699: Robot Learning

Units: 4.0
Fall 2024 Fridays 1:00-4:20PM

Location: TBD
Website: https://liralab.usc.edu/csci699/

Instructor: Erdem Biyik
Office: TBD
Office Hours: Wednesdays 11:30am – 12:30pm
Contact Info: biyik@usc.edu

Course Description

Robot learning is an interdisciplinary field at the intersection of robotics, machine learning, cognitive science, and control theory, aiming to create intelligent and adaptable robotic systems capable of learning from their environment and experience. With rapid advances in artificial intelligence and computing power, as well as the possibility of having larger datasets, robot learning has the potential to revolutionize a wide range of applications, from manufacturing and healthcare to transportation and personal assistance. However, developing learning algorithms for real-world robotic systems poses unique challenges due to the complexities of the physical world, safety concerns, and the need for efficient and robust learning methods.

This course provides a comprehensive introduction to the fundamentals of robot learning, covering topics such as reinforcement learning, computer vision, meta-learning, sim-to-real transfer, and multi-agent learning. Students will explore cutting-edge techniques in imitation learning, inverse reinforcement learning, representation learning, and safe and robust learning, while also discussing the real-world applications and challenges of robot learning. The course is designed to be accessible to MS and PhD students in robotics, control theory, machine learning, artificial intelligence, optimization, and related fields; with an emphasis on both theoretical foundations and practical applications.

In addition to lectures, the course features a series of student-led presentations on recent research papers and a course project, allowing students to gain hands-on experience with the latest advances in robot learning and explore emerging research topics. Through a combination of lectures, homework assignments, presentations, and project work, students will develop a deep understanding of robot learning techniques and their potential to transform the way we interact with and utilize robots in our everyday lives.

Learning Objectives

1. Equip students with the fundamentals of and the state-of-the-art techniques in robot learning.
2. Provide students with an overview of the challenges and solutions in real-world robot learning applications.
3. Introduce students to the importance of safety, robustness, and data-efficiency in the development and deployment of learning algorithms for robotic systems.
4. Provide students with an opportunity to engage in hands-on learning and research through presentations of recent research papers, fostering a deeper understanding of robot learning techniques and their practical applications.
5. Encourage students to explore and contribute to new research directions in robot learning, with an emphasis on addressing real-world challenges and advancing the field of robotics.
6. Foster collaboration and interdisciplinary thinking among students with diverse backgrounds, e.g., in robotics, control theory, machine learning, and related fields; promoting the development of innovative solutions to complex robot learning problems.

Recommended Preparation

Familiarity with fundamental concepts in machine learning at the level of CSCI 467: Introduction to Machine Learning. Familiarity with fundamental concepts in robotics at the level of CSCI 445L: Introduction to Robotics.

Course Notes

Grading Type: Letter.
Syllabus, homework, and other class information will be posted on Brightspace.

Technological Proficiency and Hardware/Software Required

Students will be assumed to be proficient in at least one programming language (preferably Python).

Required Readings and Supplementary Materials

There will be no required textbook. The lectures will be based on seminal robot learning papers. The student presentations will be based on recent papers on active areas of research.

Description and Assessment of Assignments

- ***Homework:*** Students will be assigned three homework sets that consist of both report questions and programming questions (in Python). Report questions will require students to work on problems related to past lectures with pen and paper. Programming questions will require students to implement some of the methods covered in the lectures, occasionally with further improvements, and experiment them on simulated robot environments and/or machine learning tasks.
- ***Class Presentation:*** Students will present research papers from literature. Presentations will be followed by open discussions. Students will be graded based on their presentations.
- ***Course Project:*** In addition, students will be required to work on a course project in groups of 2-3. The projects must have both robotics and machine learning components. They can be, for example, application-dependent improvements over an existing robot learning method, a novel robot learning related application of an existing technique, or a completely new method that may have potential benefits. Students will write a project proposal, present their findings in an oral presentation, write a conference paper-style project report, and write an anonymous peer review for the project report of another group. There will be one project milestone along the way to guide progress. Instructor and teaching assistant(s) will provide feedback on the project milestone.

Grading Breakdown

Assessment Tool (assignments)	**% of Grade**
Homework	45
Class Presentation	15
Course Project	40
TOTAL	100

Assignment Submission Policy

Homework reports and codes will be submitted online. Students will have a total of 8 free late days that may be used for the homework assignments; a maximum of 4 late days will be allowed on a given assignment. Late days are only for homework assignments, and cannot be used for the class presentation or deadlines related to the course project.

Attendance

Attendance to the lectures is expected.

Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the USC Student Handbook. All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

Course Schedule

	Topics/Daily Activities	Deliverables
Week 1	Basics of robotics Fundamentals of machine learning	
Week 2	Basics of computer vision for robotics Representation learning	Homework #1 is out
Week 3	Class presentations (Representation learning) Reinforcement learning	
Week 4	Class presentations (Reinforcement learning) Reinforcement learning	Deadline: Homework #1
Week 5	Class presentations (Reinforcement learning) Imitation learning	Homework #2 is out
Week 6	Class presentations (Imitation learning) Learning from human feedback	
Week 7	Class presentations (Learning from human feedback)	Deadline: Homework #2 Deadline: Project proposal
Week 8	Fall Recess: No Lecture	Homework #3 is out
Week 9	Sim-to-real transfer Class presentations (Sim-to-real transfer)	
Week 10	Meta-learning Class presentations (Meta-learning)	Deadline: Homework #3
Week 11	Class presentations (Safe and robust learning) Multi-agent learning	Deadline: Project milestone
Week 12	Veterans Day: No Lecture	
Week 13	Class presentations (Multi-agent learning, Robot learning using natural language)	
Week 14	Thanksgiving Break: No Lecture	
Week 15	Project presentations Conclusions	Deadline: Final project report
FINAL		Peer reviews *(Due on the university-scheduled date of the final exam)*

Statement on Academic Conduct and Support Systems

Academic Integrity:
The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, comprises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Students and Disability Accommodations:
USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

988 Suicide and Crisis Lifeline - 988 for both calls and text messages – 24/7 on call
The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services

(though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL) – 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - (213) 740-5086
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

The Office of Student Accessibility Services (OSAS) - (213) 740-0776
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

USC Campus Support and Intervention - (213) 740-0411
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity, Equity and Inclusion - (213) 740-2101
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call
Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Occupational Therapy Faculty Practice - (323) 442-2850 or otfp@med.usc.edu
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.