



CSCI 699: Deep Learning for Robotic Manipulation

Units: 4.0

Fall 2024 Thursdays 3:30-6:50PM

Location: DMC 203

Instructor: Daniel Seita

Office: TBD

Office Hours: TBD

Contact Info: seita@usc.edu

Important Note: For a more complete overview of the course, please refer to the class website:

<https://sites.google.com/usc.edu/cs699-fa23-manipulation/>

Course Description

This special topics class and seminar will cover state of the art advances in robot manipulation. This is about robots interacting with and affecting their environment, and could refer to things such as grasping, pushing, picking-and-placing, tossing, and many other actions. Aided in part by the rise of deep learning and subsequent advances in robot perception, the research area of robot manipulation has experienced tremendous growth in recent years. Nonetheless, despite this progress, real-world manipulation remains fundamentally hard. In this course, we will review and understand robot manipulation with a focus on using learning-based techniques. We will explore how to get such systems to work more reliably in unstructured real world settings.

For Fall 2023, we are particularly excited about the theme of "multimodality" where we emphasize policies that can handle multiple types of inputs or perform multiple types of actions. For example, this would include robot manipulation based on language and images as input. Many of the topics we cover will also have overlap with dexterous manipulation and deformable object manipulation.

In this class, students will read, review, and present research papers. Most research papers will be recent and have cutting-edge results, but we will have a mix of older papers to understand how the field has evolved over the years. Students will also work on a substantial final project.

Intended audience: this class is aimed at PhD students who are studying relevant topics. However, undergraduates and master's students can enroll with permission of the instructor. If interested, please talk to the instructor at the beginning of the semester.

Learning Objectives and Outcomes

- A better understanding of robot learning, and specifically robot learning for manipulation.
- Gain experience reading, understanding, analyzing, and debating papers from premier robotics venues.
 - Main conferences: CoRL, RSS, ICRA, IROS, RSS.
 - Main journals: RA-L, T-RO, IJRR, Autonomous Robots (AURO), Science Robotics.
- Understand, implement, and experiment with state-of-the-art algorithms for the final project.
- Improve academic writing and presentation skills.

Recommended Preparation

Knowledge at the level of CSCI 467: Introduction to Machine Learning and CSCI 545: Introduction to Robotics is recommended but not required.

Students are strongly recommended to be familiar with the fundamentals of robotics (especially manipulation) and machine learning. This class will consist largely of reading and discussing papers, which requires some degree of technical maturity. At the bottom of the class website, we provide links to reference materials you can consult if desired.

Course Notes

The class is largely based on reading, reviewing, and presenting research papers, as well as a substantial final project. The standard week will involve reading 2-6 academic research papers in robot manipulation.

Technological Proficiency and Hardware/Software Required

Ability to understand research papers in robotics and machine learning and to translate algorithms to code (usually using Python and PyTorch) as needed.

Required Readings and Supplementary Materials

There is no required textbook and most readings will consist of recent academic research papers freely available online (usually on arXiv). All the required reading will be made available on the class website.

Description and Assessment of Assignments

The class will include the following components:

- Class Presentations. Students will sign up to present research papers.
- Paper Reviews. Each week, students will be asked to submit reviews for papers.
- Final Project. Students will work on a substantial final project.

Grading Breakdown

The final course grade will be based on:

- 1/3: Class Presentations.
- 1/3: Paper Reviews.
- 1/3: Final Project.

In addition, since this is a seminar-style class, students will be expected to attend class, unless they have notified the instructor in advance.

Depending on the number of students in class, we may adjust the relative grading portion of the class presentations versus paper reviews.

We will compute the # of points earned divided by the # of points “possible” (not counting extra credit) for each of the 3 components separately first. Then we combine them according to the weighing scheme for the final numerical grade.

Assignment Rubrics

See the course website for more information which contains a detailed grading breakdown for the three components.

Assignment Submission Policy

Homework will be submitted online with details provided by the instructor as the deadline gets closer. The instructor will provide a standard template which students will fill out.

Grading Timeline

You should expect to get grades for all submissions within 1 week of the deadline.

Additional Policies

Attendance is required unless you have notified the instructor in advance (e.g., due to conference travel).

There are no late days for the class.

We will drop the lowest paper review grade. In addition, there are opportunities for extra credit by doing additional paper reviews and/or class presentations.

Course Schedule: A Weekly Breakdown

	Topics/Daily Activities	Readings and Homework	Deliverable/ Due Dates
Week 1	Course introduction, review of deep learning and robotics, examples of robot manipulation research	None for this week beyond consulting necessary reference material to catch up or review as needed.	Signing up for paper presentation dates.
Week 2	Grasping	6 relevant research papers	Paper presentation (if student is presenting this week), 2 paper reviews (everyone).
Week 3	Manipulation benchmarks	3 relevant research papers (due to Labor Day)	Paper presentation (if student is presenting this week), 2 paper reviews (everyone).
Week 4	Deformable object manipulation (quasi-static and dynamic).	6 relevant research papers	Paper presentation (if student is presenting this week), 2 paper reviews (everyone).
Week 5	Articulated object manipulation; keypoints in manipulation	6 relevant research papers	Paper presentation (if student is presenting this week), 2 paper reviews (everyone).
Week 6	Manipulation with tools; graph neural networks and manipulation	6 relevant research papers	Paper presentation (if student is presenting this week), 2 paper reviews (everyone). Final project proposal.
Week 7	Tactile manipulation; vision-tactile manipulation	6 relevant research papers	Paper presentation (if student is presenting this week), 2 paper reviews (everyone).
Week 8	Dexterous manipulation	6 relevant research papers	Paper presentation (if student is presenting this week), 2 paper reviews (everyone).
Week 9	Long-horizon reasoning; combining learning and planning	6 relevant research papers	Paper presentation (if student is presenting this week), 2 paper reviews (everyone).
Week 10	Action space representation; NeRF and robotics.	6 relevant research papers	Paper presentation (if student is presenting this week), 2 paper reviews (everyone). Final project mid-term update.
Week 11	Manipulation over SE(3); learning from point clouds	6 relevant research papers	Paper presentation (if student is presenting this week), 2 paper reviews (everyone).
Week 12	Diffusion models; interactive language	6 relevant research papers	Paper presentation (if student is presenting this week), 2 paper reviews (everyone).
Week 13	Language and transformers for multi-task manipulation	6 relevant research papers	Paper presentation (if student is presenting this week), 2 paper reviews (everyone).
Week 14	“Foundational” manipulation policies	3 relevant research papers (due to Thanksgiving)	Paper presentation (if student is presenting this week), 2 paper reviews (everyone).
Week 15	Summary of topics covered thus far, guest lectures (TBA), final project presentations	Final project	Final project presentation.
FINAL	Final project written report	Final project	Final project written report due on the university-scheduled date of the final exam.

[Please see the detailed course schedule here](#) (accessible on the website) which basically restates the above schedule, except it provides links to the papers we will be discussing each week.

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.