CSCI 699: 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://danielseita.github.io/cs699-fa2024.html
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 2024, we will continue the “multimodality” theme from last fall, where we study robots 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. For 2024, we will also focus on higher-DOF control, including bimanual robots, quadrupeds with arms, and humanoid manipulation.

In this class, students will read, review, and present research papers. Most research papers will be recent and have cutting-edge results. Students will also work on a substantial final project.

Intended audience: this class is aimed at PhD students who are doing research in this topic. 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 robotics venues.
  - Main conferences: CoRL, RSS, ICRA, IROS, ISRR, ISER, WAFR.
- 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.

Course Notes
The class is 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.
• Written assignments. This will include reviewing papers, scribing notes from class, etc.
• Final project. Students will work on a substantial final project, which should result in a future paper.

**Grading Breakdown**
The final course grade will be based on:

- 20%: Class presentations.
- 40%: Written assignments.
- 40%: 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 number of points earned divided by the number of points “possible” for each of the 3 components separately first. Then we combine them according to the weighing scheme for the final 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.

**Use of Generative AI in this Course**
*Generative AI is encouraged:* You are expected to use AI (e.g., ChatGPT and image generation tools) in this class. Learning to use AI is an emerging skill; this is an opportunity for you to discuss with the instructor appropriate use of these tools. Keep in mind the following:

- AI tools are permitted to help you brainstorm topics or revise work you have already written.
- If you provide minimum-effort prompts, you will get low-quality results. You will need to refine your prompts to get good outcomes. This will take work.
- Proceed with caution when using AI tools and do not assume the information provided is accurate or trustworthy if it gives you a number or fact: assume it is incorrect unless you either know the correct answer or can verify its accuracy with another source. You will be responsible for any errors or omissions provided by the tool. It works best for topics you understand.
- AI is a tool, but one that you need to acknowledge using. Please include a paragraph at the end of any assignment explaining if, how, and why you used AI and indicate/specify the prompts you used to obtain the results. Failure to do so is a violation of academic integrity policies.
- This class will have specific areas in the assignments where you must cite your usage of Generative AI.
### Course Schedule: A Weekly Breakdown (See website for more details)

<table>
<thead>
<tr>
<th>Week</th>
<th>Topics/Daily Activities</th>
<th>Readings and Homework</th>
<th>Deliverable/ Due Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Course introduction, review of deep learning and robotics, examples of robot manipulation research</td>
<td>None for this week beyond consulting necessary reference material to catch up or review as needed.</td>
<td>Signing up for paper presentation dates.</td>
</tr>
<tr>
<td>Week 2</td>
<td>Grasping</td>
<td>6 relevant research papers</td>
<td>Paper presentation (if student is presenting this week), paper reviews / scribing (all).</td>
</tr>
<tr>
<td>Week 3</td>
<td>Robot simulators, benchmarks</td>
<td>6 relevant research papers</td>
<td>Paper presentation (if student is presenting this week), paper reviews / scribing (all).</td>
</tr>
<tr>
<td>Week 4</td>
<td>Deformable object manipulation (quasi-static and dynamic).</td>
<td>6 relevant research papers</td>
<td>Paper presentation (if student is presenting this week), paper reviews / scribing (all).</td>
</tr>
<tr>
<td>Week 5</td>
<td>Articulated object manipulation; keypoints in manipulation</td>
<td>6 relevant research papers</td>
<td>Paper presentation (if student is presenting this week), paper reviews / scribing (all).</td>
</tr>
<tr>
<td>Week 6</td>
<td>Manipulation with tools; graph neural networks; dexterous manipulation.</td>
<td>6 relevant research papers</td>
<td>Paper presentation (if student is presenting this week), paper reviews / scribing (all). Final project proposal.</td>
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<tr>
<td>Week 7</td>
<td></td>
<td>No class due to Fall Recess.</td>
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<tr>
<td>Week 8</td>
<td>Tactile manipulation; vision-tactile manipulation</td>
<td>6 relevant research papers</td>
<td>Paper presentation (if student is presenting this week), paper reviews / scribing (all).</td>
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<tr>
<td>Week 9</td>
<td>Long-horizon reasoning; combining learning and planning</td>
<td>6 relevant research papers</td>
<td>Paper presentation (if student is presenting this week), paper reviews / scribing (all).</td>
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<tr>
<td>Week 10</td>
<td>Action space representation; NeRF and robotics.</td>
<td>6 relevant research papers</td>
<td>Paper presentation (if student is presenting this week), paper reviews / scribing (all). Final project mid-term update.</td>
</tr>
<tr>
<td>Week 11</td>
<td>Manipulation over SE(3); learning from point clouds</td>
<td>6 relevant research papers</td>
<td>Paper presentation (if student is presenting this week), paper reviews / scribing (all).</td>
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<tr>
<td>Week 12</td>
<td>Diffusion models; interactive language</td>
<td>6 relevant research papers</td>
<td>Paper presentation (if student is presenting this week), paper reviews / scribing (all).</td>
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<tr>
<td>Week 13</td>
<td>Foundation models for manipulation</td>
<td>6 relevant research papers</td>
<td>Paper presentation (if student is presenting this week), paper reviews / scribing (all).</td>
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<tr>
<td>Week 14</td>
<td></td>
<td>No class due to Thanksgiving.</td>
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<tr>
<td>Week 15</td>
<td>Summary of topics covered thus far, guest lectures (TBA), final project presentations</td>
<td>Final project</td>
<td>Final project presentation.</td>
</tr>
<tr>
<td>FINAL</td>
<td>Final project written report</td>
<td>Final project</td>
<td>Final project written report due on the university-scheduled date of the final exam.</td>
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A more detailed schedule will be available on the course website. It basically restates the above, except it provide slinks 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.