Course Description

This is an advanced graduate-level class on the theory and algorithms that enable robots to physically manipulate their world, on their own or in collaboration with people. The class will first focus on functional aspects of manipulation, such as synthesizing robust and stable grasps for dexterous hands and motion planning in these spaces, as well as learning for manipulation, such as how to predict stable grasps from demonstration and experience. Moving forward, we will discuss additional requirements that arise from performing manipulation tasks collaboratively with people: moving from purely functional aspects of motion to incorporating the human into the loop, and coordinating human and robot actions via understanding and expressing intent.

Learning Objectives

In this course, you will gain knowledge about manipulation algorithms and skills in interpreting and presenting research. By the end of this course you should be able to:

- understand and discuss the different components that make up manipulation (e.g., grasping, motion planning, configuration spaces)
- explain and compare algorithms for real-world manipulation in high-dimensional spaces
- identify different learning approaches for manipulation and discuss their pros and cons
- explain the additional challenges of human-robot interaction in manipulation
- detail the design and implementation of a user study to evaluate manipulation algorithms
- critique a research paper’s methods and analysis
- communicate scientific research to a peer audience
Grades

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student presentations</td>
<td>40%</td>
</tr>
<tr>
<td>Final project</td>
<td>40%</td>
</tr>
<tr>
<td>Quizzes</td>
<td>20%</td>
</tr>
</tbody>
</table>

**Student presentations.** Each student must present one research paper to the class, with the opportunity to do extra presentations as the schedule permits. Presentations will be 20 minutes long including a question period. (We recommend a 15 minute presentation, with 5 minutes for questions.) Students will be evaluated on:

- Demonstrating an understanding of the technical content (15%)
- Ability to present the technical approach (15%)
- Conveying significance and relevance of the work (10%)
- Conveying advantages and disadvantages (10%)
- Answering questions from the audience (10%)
- Structure of the presentation (10%)
- Use of images (figures, videos, etc.) on the slides (10%)
- Use of text that is clear and to the point (10%)
- Presentation timing (10%)

**Final project.** This class includes a final project. This should be a substantial piece of work and is expected to take between 60–80 hours over 8 weeks. Project proposals must be vetted and approved by course instructors before projects can begin. Examples of projects include an in-depth, publication-quality literature review; a user study; or the novel implementation of an algorithm. Whatever type of project is chosen, it must relate to the material from the course and it must be novel. Projects will be evaluated on:

- Proposal quality (10%)
- Demonstrated mastery of course content and novel contribution (60%)
- Presentation quality (30%)

**Quizzes.** Before each student presentation day, there will be a short (10 minute) quiz on the material from the previous lecture and the readings for the day. This quiz is intended to ensure that you are keeping pace with the material and are prepared for the day’s presentations, and is not meant to be onerous. We will drop your lowest quiz grade when calculating your final grade in the course.

**Participation.** Students will get the most out of this class if they are active and engaged. This includes asking questions and participating in discussions. There is explicit time for questions and discussion after each student presentation. We also encourage students to participate during any and all lecture sessions.
Policies

Academic Integrity

Collaboration is integral to learning, but it is important to acknowledge such collaborations. Plagiarism and cheating will not be tolerated in this course. We follow CMU’s academic integrity policy, available here: http://www.cmu.edu/policies/student-and-student-life/academic-integrity.html

Students are encouraged to discuss course material outside of class. However, any assistance you get on graded material (e.g., presentations and final projects), including assistance from classmates and CMU academic resources, should be acknowledged. Assistance is acknowledged by including an acknowledgments slide (for presentations) or section (for reports) detailing exactly who helped and in what way.

All content produced for this class must be original to the submitter. Plagiarism is a very serious offense and will be treated as such. Any sources of information should be cited correctly. Any material taken directly from the source, including figures, must be clearly quoted and attributed.

Any questions about this policy should be directed to the professors.

Inclusive Learning

We recognize that students learn in many different ways, and we strive to create a class environment where all students feel supported and encouraged to ask questions and engage in discussion.

Some students may need special accommodations due to disability. If you wish to request accommodation for a documented disability, please first contact Disability Resources (access@andrew.cmu.edu or 412-268-2013), then let your instructors know as soon as possible.

Extensions and Late Assignments

The schedule for presentations will be established within the first weeks of the course, which should provide adequate time to prepare. Rescheduling presentations or final projects can only occur in emergency situations, and must be requested as early as possible by contacting the instructors.

Expectations

These guidelines are intended to create a comfortable and productive learning environment.

You can expect us to:

- start and end class on time.
- reply to emails within 36 hours on weekdays and 48 hours on weekends.
• devise quizzes that adequately cover the material.
• grade your quizzes and send you feedback on your presentations in a timely manner.

We expect you to:

• come to class on time.
• be attentive and engaged in class.
• refrain from using laptops, cell phones, or other electronic devices during class.
• take notes and ask questions when something is unclear.
• spend an adequate amount of time on the readings each week (at least 3 hours).
• spend 60–80 hours on your final project.