16-843: Manipulation Algorithms

Fall 2017, 12 Units

Time: Tue & Thu, 9-10:30am

Instructors:
Katharina Muelling (kmuelling@nrec.ri.cmu.edu)
Stefanos Nikolaidis (snikolai@cmu.edu)

Website: http://personalrobotics.ri.cmu.edu/16843

Please see the website for the latest schedule and information

Course Description

In this advanced graduate-level class, you will learn about the theory and algorithms that enable robots to physically manipulate their world with and around people. We will first focus on functional aspects of manipulation, such as synthesizing robust and stable grasps for dexterous hands, the geometry of manipulation configuration spaces, and motion planning in these spaces. We will discuss both analytical and machine learning approaches. We will then generalize these techniques to settings where robots manipulate objects together and in coordination with people. By the end of this class, you will be able to describe and compare algorithms for real-world manipulation, design user studies to evaluate these algorithms in robot interactions with people and communicate your ideas to a peer audience. Evaluation is based on student presentations, a final project and short weekly quizzes based on the assigned reading material.

Prerequisites

There are no official pre-requisites, although having taken "Kinematics, Dynamics, and Control" will be helpful.

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:

- identify 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 and compare different learning approaches for manipulation
- explain the additional challenges of human-robot interaction in manipulation
- analyze the design and implementation of a user study to evaluate manipulation algorithms
- critique a research paper's methods and analysis
- communicate effectively scientific research to a peer audience

Grades:

Component	Percentage
Paper Presentations	30%
Paper Reviewing	10%
Final Project	40%
Quizzes	20%

Student presentations. Each week, students will present one or two papers in class in groups of two to three students, on a rotating schedule. Presentations will be about 15 minutes long. You 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%)

We strongly encourage you to implement and include in their presentation the results of simplified versions of the algorithms presented in the papers. One day ahead of the presentation, you will send us an outline of the key points you want to emphasize in the paper, so that we make sure that all important points are addressed. After the presentation, we will have a 10 to 15-minute discussion, where the group of students that presented the paper ("Authors") will discuss its strengths and limitations, and defend the paper against the arguments proposed by a group of "Reviewers". We will expect the reviewers to have read the paper, to have positioned it with respect of the state-of-the-art and to have identified strengths and weaknesses. This will create an engaging environment and it will contribute to an understanding of the material.

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. In the beginning of the class, we will discuss your background and research interests, and we will prompty give you a list of potential projects that relate to the course material and that match your interests. Examples of projects include an in-depth, publication-quality literature review; a user study; or the novel implementation of an algorithm. You will write a project proposal, work on the project upon approval and present it at the end of the term.

We will evaluate projects on:

- Proposal quality (10%)
- Demonstrated mastery of course content and novelty of 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. The quiz will frequently connect different concepts from multiple readings and/or the material. 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 will be explicit time for questions and discussion after each student presentation. We also encourage students to participate during any and all lecture sessions.

Expectations

We can expect you to:

- come to class on time.
- be attentive and engaged in class.
- take notes and ask questions when something is not clear.
- spend an adequate amount of time on the readings each week (at least 3 hours).
- spend 60-80 hours on your final project.

Policies

Acedemic 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 have a disability and require accommodations, please contact Catherine Getchell, Director of the Office of Disability Resources at getchell@cmu.edu or 412-268-6121. If you have an accommodations letter from the Office of Disability Resources office, we encourage you to discuss your accommodations and needs with us as early in the semester as possible. We will work with you to ensure that accommodations are provided as appropriate.

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 or having make-up quizzes can only occur in emergency situations, and must be requested as early as possible by contacting the instructors.