ECE276C Robot Manipulation and Control Project

Spring 2024

Description

The overall motivation for this project is to incentivize augmentation or alternative methods to problems in robot manipulation, control and motion planning.

Projects must fundamentally solve a problem in the space primarily of **robot manipulation.** This means the output of the techniques implemented should be a control action. The project must consist of two components:

1. **Baseline method**. Most likely you will choose a method that could be improved or augmented in some way. The method should have been one covered in class.
2. **Alternative or improvement**. The method should be compared against the baseline to demonstrate its usefulness in certain scenarios. Suggestions:
   - Accounting for state uncertainty
   - Learning residual errors for compensatory control signals (adaptive control)
   - New motion planning strategies
   - Incorporating machine learning to some aspect of the control or planning problem

Before starting on your project, you will submit your proposal on Canvas for the teaching staff to review. Answer these questions:

- What are you trying to do?
- What is your baseline and how is it lacking?
- What is your alternative/improvement and why do you think it will work?
- How will you simulate the problem (what simulator, what robot – preference to pybullet and an imported robot model, like Panda).

Deliverables

Video: A project video with a voice-over of between 2- to 3-minute length will describe the project and present the results. These will be shared with the class. In the video, describe with visuals and math/algorithms:

- The baseline method.
- The augmented method.
- The comparison results.

Grading is done completely subjectively by the teaching staff and will consider the quality and content of the presentation.

Paper Report

Each group will submit a report in the IEEE conference format, which you can download templates online (in Word or Latex). The report will be 4 pages in length, and have the following sections: Introduction and Background, Methods (both baseline and new method), Results, Discussion/Conclusions, and References. Figures are required and should be included where needed. When in doubt as to how the papers should look, please take a look at what is published in IEEE's International Conference of Robotics and Automation (ICRA) as a guidelines.

With your paper, please submit a ZIP file of all your work (code, videos, etc.).

Grading Criteria: Completed all sections. Completeness of methods. Some encouraging Validation. Thoughtful Discussions. Overall Clarity and use of clear figures. Code base.

Logistics: Project group sizes may be between 1-3 persons. Expectations and grading will be scaled accordingly to account.

Deadline: Dec 11th 11:59pm. **There is no extension available.**

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Project Examples and Ideas

Adaptive Control / Statics

- Manipulator is used to pick lift objects in force control mode without knowing the weight of the object.
- Manipulator washes windows without breaking the window (by regulating forces in one direction).

Visual Servoing

- Eye-in-hand manipulator aligns itself to a 3D object such that a prescribed motion can be used for downstream grasping.
- Eye-in-hand manipulator follows the nearest object to it.

Single Arm Motion Planning

- Given several locations on an object held in space, a robot touches each location without colliding with the object or the fixture it is mounted to (i.e., simulated spot welding)
- Find the sequences of plans that reduces the overall time to finish the sequence.

Robot Manipulator on a Moving Base

- Solve the motion planning task for moving objects from a table to a shelf if it is beyond the arm reach of the robot.

Robot with two manipulators

- Solve the motion planning problem where the robot is holding a box that must stay upright.

Robot with safety awareness

- Robot manipulator uses force control to estimate the weight of objects, determining which one to push over.
- Robot manipulator uses impedance control

Robot with time-optimal trajectory control

- Given a manipulator with a known trajectory for an object being tossed at it, generate a time-optimal trajectory that “catches” the object
- Given a sword strike, find the optimal movement of a robot manipulator holding a shield to block the strike

Sim-to-Real

- Given imperfect kinematics, …
- Given noisy sensor readings (e.g., joint angles) …

Remember that you must have a baseline method covered in class to compare against.