Carnegie Mellon University

16-681

MRSD Project I

Task 14 Progress Review 4
Team C - COBORG

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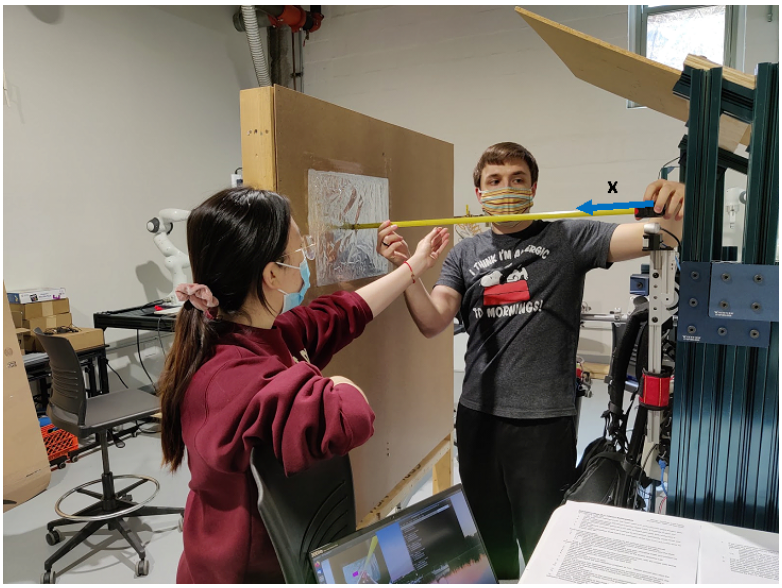
1. Individual Progress

My primary tasks for this progress review were centered on the validation testing. Alongside Husam, I set up the structure for the validation testing. I made all of the measurements and determined the locations for both the actuated manipulation and vision tests. I worked alongside each of the subsystem heads to refine the testing and executed it to ensure that we were receiving accurate results. Figure 1 demonstrates a secondary calibration I undertook to ensure that the measured values were accurate. We took a rough measure along the x-axis, checking to make sure that the depth of the camera and the depth defined by the ground truth both matched to a simple measurement made directly from the camera to the board.

Figure 1 - Vision Calibration Measurements



This figure shows the calibration confirmation of our vision validation test. Determining the ground truth measurements involved measuring from the camera to the front-left corner of the structure, from the front-left corner of the structure to the front-right corner of the board, and

then measuring from the front-right corner of the board to the target location, indicated by a little dot of permanent marker. Needless to say after all of those measurements it was important to confirm their accuracy by making a direct measurement from the camera to the target along the x-axis. This measurement matched the ground truth by a margin of 1 or 2 cm, an acceptable error considering that our validation test is to be within 6". Any error in the ground truth measurement will, overall, hinder the accuracy of the system because error sums through combination by the root mean square so these slight shifts will not allow us to unfairly pass our validation testing, as long as we test multiple locations, which we will be.

In addition to my primary tasks described above, I also developed an alternative strength test to be implemented for the validation testing. As part of our Validation Test Review we mentioned that one of our challenges was that the Coborg failed the strength test we had set out for it. In accordance with John's suggestion I picked up a piece of plywood from Home Depot that would act as a "representative panel" and Jason commanded the Coborg to hold it up overhead. It had ample strength to hold the part without assistance.

Besides preparing for the upcoming SVD, Jason and I also began working on the next steps of the robot, which include creating motion controls for the integrated system. We began implementing an impedance control program to stabilize the part while it was held in the air but ran into challenges to be described later. Unfortunately we did not have a working system at the time of the Progress Review, but we believe that it is right around the corner.

2. Challenges

The primary problem that we encountered in this cycle was that our impedance controller for the stabilization system failed. When switched from position control, maintained by the HEBI motors, to our implementation of impedance control, the robotic arm responded with seemingly indiscriminate motions and posed a danger to itself. Jason and I spent most of the day debugging it, and even though we didn't make much progress, we ruled out many possibilities. While it seems bleak to have no idea where to fix the program I am not concerned over whether it will be feasible. Impedance control for manipulators is a solved problem and I am confident that our issue lies in the specific implementation of the code rather than the theory of how to control the robot. Additionally, some of the first things we checked were theory-related (e.g. Does the Jacobian appear reasonable for the robots current configuration?).

3. Teamwork

Jason's work during this previous cycle included calibrating the robot arm to the URDF model which was vital for developing an accurate actuated manipulation test. Similarly he measured the transforms between the robot frame and camera frames. Beyond that I worked with Jason to run pre-SVD validation testing.

Gerry's work during this previous cycle included testing, validating, and soldering the Power Distribution PCB alongside Husam. Beyond that I worked with Gerry to finalize the voice subsystem validation plan for the SVD.

Yuqing's work during this previous cycle included wrapping up the vision system and validating the performance for the SVD alongside me. She also worked with Jason to integrate the vision and motion planning systems.

Husam's work during this previous cycle included working with Gerry to solder the Power Distribution PCB and test and validate the system. Additionally, Husam completed project management tasks to make sure things ran along smoothly.

4. Plans

Before the next progress review I will finalize the validation plans and run through the validation test for each subsystem from top to bottom, ensuring that we can complete each test and (ideally) meet each listed requirement within our 30 minute time limit. Additionally I will be performing statistical analysis on voice validation data generated by Gerry.

Beyond validation work I will be finishing the implementation of the impedance controller for stabilization with Jason and implementing a dynamics model of the robot to enable consistent impedance control. At a higher level in the same vein I intend to research and implement either CHOMP or Elastic Bands for the arm's more complex motion controls.