Carnegie Mellon University

Individual Lab Report #5

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Table of Content

1 Individual Process

The Coborg platform is a wearable robotic arm that can help people hold the target objects overhead. My work in the Coborg project mainly focused on the Vision Subsystem design and implementation. From the last progress review, I have completed the development process of the vision system by localizing the hand position and publishing the averaged 3D goal position to the desired topic. To validate the system performance, I set up the testing environment and did a self-check on the system by doing a set of test cases. In the last week, I also collaborated with teammates on the SVD test plan setup and integration of the vision and motion planning systems as well.

1.1 Validation of Vision System

From the last progress review, I have already completed the vision system development process, including generating the YOLO 2D bounding box, generating the YOLO 3D bounding box, taking the average of 3D bounding boxes to extract a single goal position. To evaluate the system performance, I set up the testing environment, which is shown in Figure 1.

1.1.1 Setup Testing Environment and Testing Scenarios

The testing environment consists of a D435i camera and a testing board which is shown in the figure below. The board is put on a chair, which is easier to move around and measure the ground truth depth (x-axis of the camera). The ground truth of the y-axis and z-axis is also marked on the board so that I can put my hands on the board and check the accuracy. When I started the tests, I made the center of my hands align with the ground truth marker. By starting the system, I read one single output from the terminal and compared it with the ground truth.

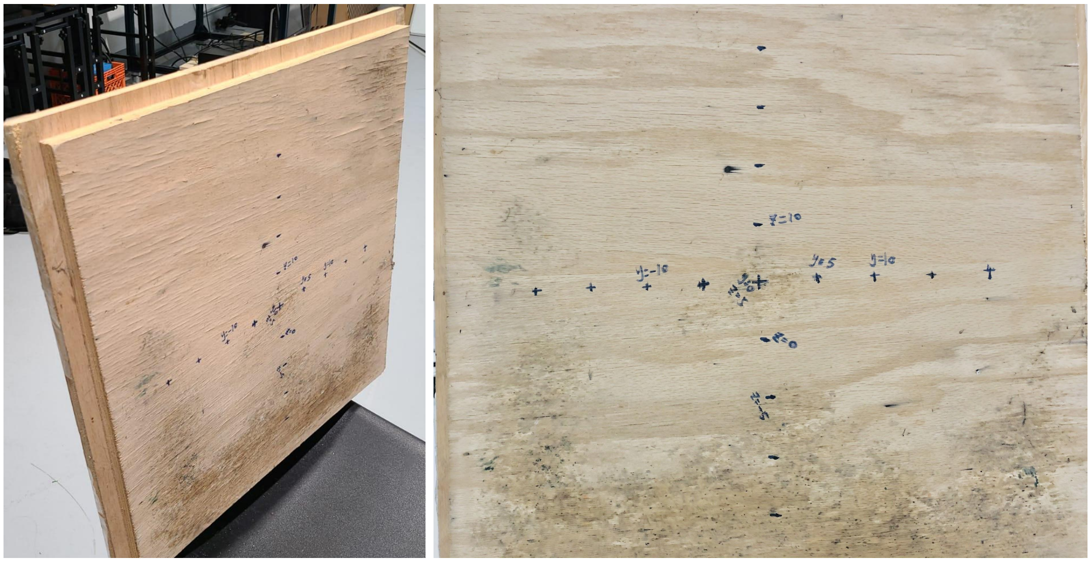

Figure 1. Test board with coordinates markers

In the last progress review report, I mentioned the two scenarios for calculating the average goal position. One is the single-hand use case, and the other is the multiple hands use case. To validate the performance, I also designed two scenarios corresponding to these two use cases. For each of these two cases, I also designed three sets of tests corresponding to three-axis values (x, y, z). Therefore, there are six sets of tests in total. Figure 2 shows an example of results from one of the six sets of tests.

GT_x (m) (one hand)	pred_x	pred_y	pred_z	Error x (m)	
0.2	None too close	~0	~ -0.05	-	
0.25	0.2517			0.0017	
0.3	0.3047			0.0047	
0.35	0.349			0.001	
0.4	0.3892			0.0108	
0.45	0.4411			0.0089	
0.5	0.4935			0.0065	
0.55	0.5471			0.0029	
0.6	0.5754			0.0246	
0.65	0.6279			0.0221	
0.7	0.6907			0.0093	
0.8	0.7855			0.0145	
0.9	0.8847			0.0153	
1	0.9907			0.0093	Error in cm
average error rate				0.01012307692	1.012307692

Figure 2. Test results on ‘x’ value in ‘one hand’ scenario

1.1.2 Validation Results

The overall error rate is summarized in Table 1. The average error rate is around 0.00699 (in meters). There might be some measurement errors, such as the ground truth measurement errors and the hand location errors. However, these measurement errors will not affect the resulted average error rate much. It still fulfills the requirements for the vision system (within 6 inches of errors). More accurate measurements will be done in the spring validation demonstration by using a laser pointer to set up the testing environment.

Avg. error rate(m)	x error rate	y error rate	z error rate
one hand	0.0101	0.0103	0.0043
two hands	0.0054	0.0019	0.0075

Table 1. The summary of testing results

2 Challenges

The main challenges I faced from the last progress review are the testing case design and testing environment setup for the spring validation demonstration. From the self-check testings, I found that the ground truth is hard to be set up accurately. Any small setup error on the ground truth will affect the final accuracy of the system. For the SVD, the ground truths are supposed to be as accurate as possible. Therefore, I worked closely with Jonathan on the ground truth setup for the vision system last week to ensure the final performance measurement.

3 Teamwork

Team Member	**Teamwork Progress**
Feng Xiang	- Worked on the impedance control and SVD test plan setup with Jonathan - The integration of the vision and motion planning system with me
Jonathan Lord-Fonda	-Worked with Feng on the impedance control and set up the SVD testing environment (collaborators: vision: me, motion: Feng, voice: Gerry)
Gerry D’Ascoli	- Finished power distribution PCB with Husam - Ensure the voice system SVD environment with Jonathan
Husam Wadi	- Project management work - Worked with Gerry on the PCB

Table 2. Teamwork for Coborg

4 Plans

For the next two weeks, I will mainly focus on the Spring Validation Demonstration preparation and the rehearsal of it. I will work with Jonathan to go through the whole process of SVD, especially for the vision subsystem demonstration. I will also need to check the functional and performance requirements on the vision system and do the final tune on the system performance before the SVD.