Carnegie Mellon University

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MRSD Project II

Individual Lab Report 08
Team C: COBORG

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Sponsor:
Biorobotics Lab

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1 Individual Progress

My efforts for this progress view focused on the goal stabilization and object avoidance functionality. For goal stabilization, I worked with Jason to finalize the initial build of the resolved rate implementation and prepared a test procedure for it. For object avoidance, I tested the integrated object avoidance with the Move-it path planning and, with Jason's assistance, filmed the test for a demonstration of the system.

The goal stabilization system reached its initial build after reaching the point where it compiles without areas but before testing. This system employs resolved rate as a "smart push" function once the arm has used Move-it path planning and object avoidance to navigate close to the goal position. This smart push is a closed loop system that converges on the goal position using the arm's Jacobian matrix to calculate the direction of linear velocity of the end effector. By tying the algorithm to the RealSense T265 visual SLAM functionality, this also allows the arm to stabilize at the goal pose by intelligently reacting to any motion of the Coborg backpack on the user. This creates a closed loop controller of the end effector that consistently adjusts it to remain in the same position in space. Unfortunately, this is prone to errors stemming from inaccuracies in the actual arm configuration compared to the model URDF and from drift in the visual slam from the T265. The next step is to test this algorithm using a pre-set goal position and forced motion of the T265 camera.

The object avoidance system was implemented, tested, and demonstrated for this progress review. In testing, the parameters were tuned again to reduce the subsampling even more in favor of faster processing, to determine the needed range of object recognition based on our used case, and to ensure that obstacle voxels aren't generated around the Coborg arm itself (i.e. the Coborg doesn't view itself as an obstacle to avoid). Luckily, the testing went well on the first try as shown in Figure 1 where the Coborg successfully path planned around my arm despite my arm being directly in the shortest path to the goal. The system did have inaccuracies in the demo due to uncalibrated motor angles on the physical arm leading to differences between the URDF model and the actual arm. This will be discussed further in the Challenges section. Overall, the demo showed successful implementation of active object avoidance.

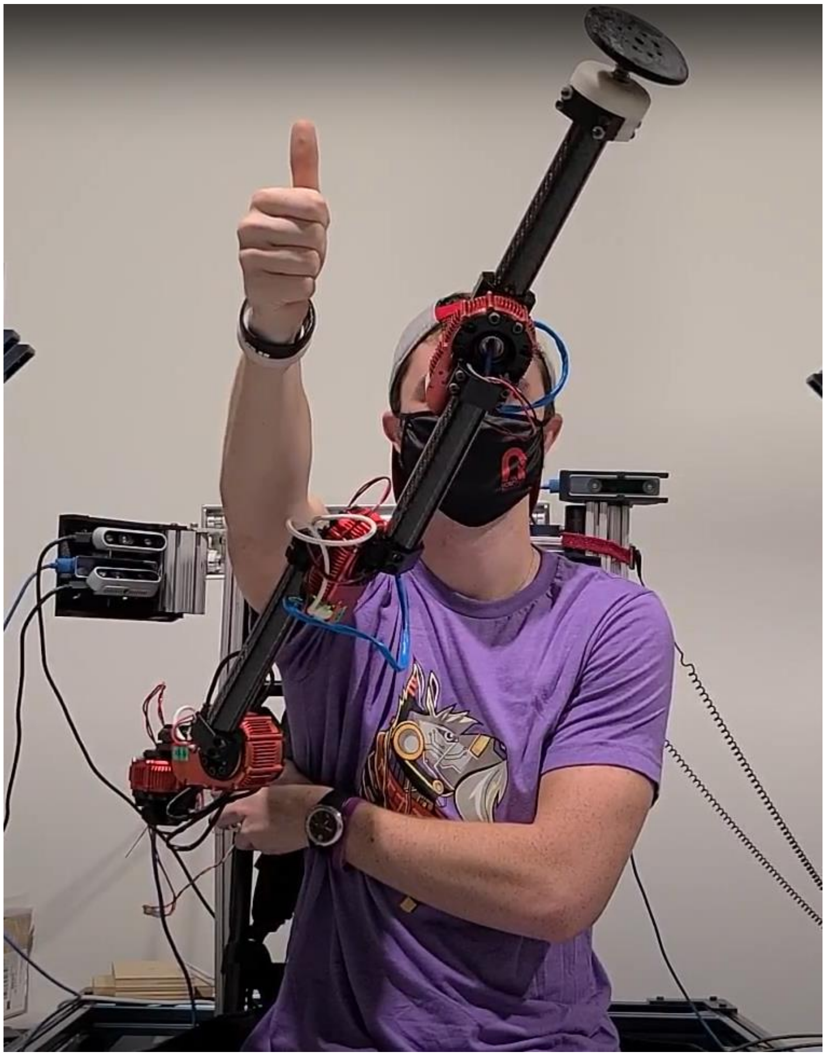

Figure 1. Active Arm Avoidance Demo

2 Challenges

Both major developments that I took on for this progress review faced challenges. The resolved rate couldn't be tested during initial building because both the hardware and the vision system were in development and non-functional at the time. The object avoidance demo exposed some problems with the system performance stemming from inaccurate motor angles on the arm that differed from the model URDF. The correct angles for the motors on the Coborg arm are shown in Figure 2. Due to this inaccuracy, the arm was not in the position that Move-it expected it to be in space. This led to some accidental collisions with my arm and also caused the object detection function to detect the arm itself as an obstacle to avoid. After the progress review, the arm was tuned to better match the URDF and these issues have since been resolved.

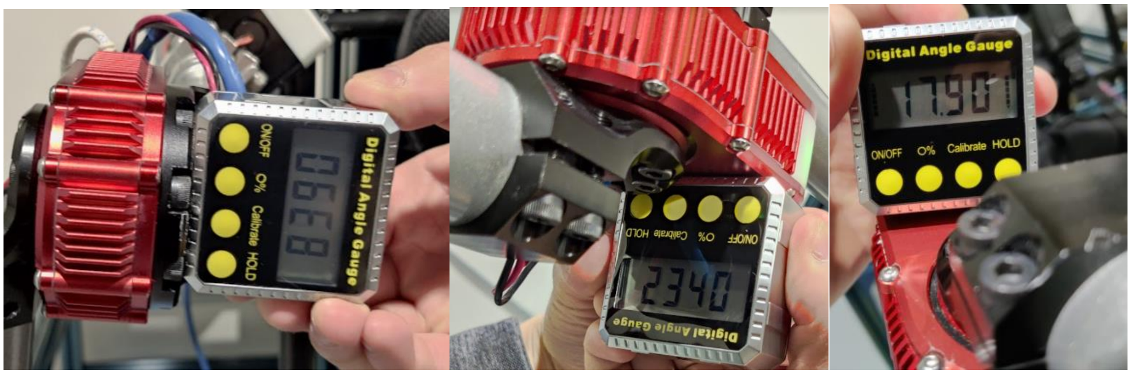

Figure 2. Ideal Motor Angles of Coborg Arm (in order from base to end effector, base motor not shown because its ideal angle is 0)

3 Teamwork

For this progress review, Jason Xiang worked on the vision upgrade with Yuqing to measure and implement new positions of the Intel Realsense cameras; worked on goal stabilization code with me to implement the resolved rate algorithm; worked with me on the obstacle avoidance functionality; and calibrated the robot URDF model. He faced challenges with manually programming transforms and with tweaking the URDF, so he decided we need to create a more automated method to modify the URDF robot model. He plans to finalize testing of goal stabilization code with me; finalize the vision upgrade implementation with Yuqing; test hand detection with two cameras across different edge cases; and complete calibration of the URDF robot model with the new incoming hardware.

Jonathan Lord-Fonda spent time since the last progress review setting up a smart manipulation branch on the Coborg GitHub while dealing with many merging issues; debugging the smart manipulation code; and discussing various project aspects with the Coborg team. For future progress reviews, he will finalize and integrate smart manipulation; test and tune the smart manipulation values; and begin revalidation efforts with the new hardware setup.

Yuqing executed on the vision upgrade plan; ran a simple demo with yolo running on both cameras to test this plan; and measured the vision transforms with Jason. She faced challenges measuring the transforms accurately with inaccurate hand tools and figuring out solutions for problems arising due to the user's shoulder blocking some view of the cameras in the new vision system. She plans to finish and test edge cases in the code for the new vision plan; integrate and test the vision system while wearing the Coborg (as opposed to the previous tests where it has been mounted to the rack); and run integration testing with the actuated manipulation system.

Husam has focused heavily on the hardware upgrade by cutting and assembling the new carbon fiber arm; working on the SOLIDWORKS model of the Coborg to transfer it to a URDF; tracking down updates on procurement of our long lead time items; and working on a Dynamixel setup for parallel, non-critical goals for the Coborg. He has been challenged in the hardware upgrade due to the unpredicted long lead times which so far has put him 15 days behind schedule. He plans to assemble the new hardware structure when the parts arrive and when he finishes the fourth iteration of the 3D printed parts. He also plans to continue to work on the SOLIDWORKS model to transfer it to the needed URDF format.

4 Plans

The follow-up efforts after this progress review include testing resolved rate and helping with the hardware upgrade. We're planning to test resolved rate goal stabilization using a pre-set goal position and forced motion of the T265 camera. I am anticipating several hours of debugging transform logic and ROS message coordination as this build wasn't able to be unit tested due to the lack of functional hardware. To aid in the resolution of this hardware issue, I will also be helping Husam with the hardware upgrade. I will be tuning the arm to better match the URDF parameters to improve accuracy in object avoidance, object detection, and goal stabilization. I will also be designing, creating, and running cables for both electrical power and control/sensor signals through the new hardware to allow for full independent mobility of the Coborg.