Individual Lab Report #11

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Team D (CuBi)

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Individual Progress:

During the past two weeks, I mainly worked on the integration of all subsystems.

Most of the efforts is in modifying the state machine, adding states and the logic of switching between different states, while receiving all the information from all different subsystems, including poses of detected objects from the object detection module, next waypoint to go to from the exploration module, grasping validation status, etc.

Another large portion of the work is in improving the current control logic, including tuning gains to reduce position overshooting, tuning thresholds to improve alignment accuracy and adding intermediate states such as rotate before putting the manipulator arm down after picking up a toy to prevent crashing into the wall. Most of the time have been spent on testing the performance iteratively after changing logics and strategies.

An example of a successful pipeline is shown in Figure 1. below.

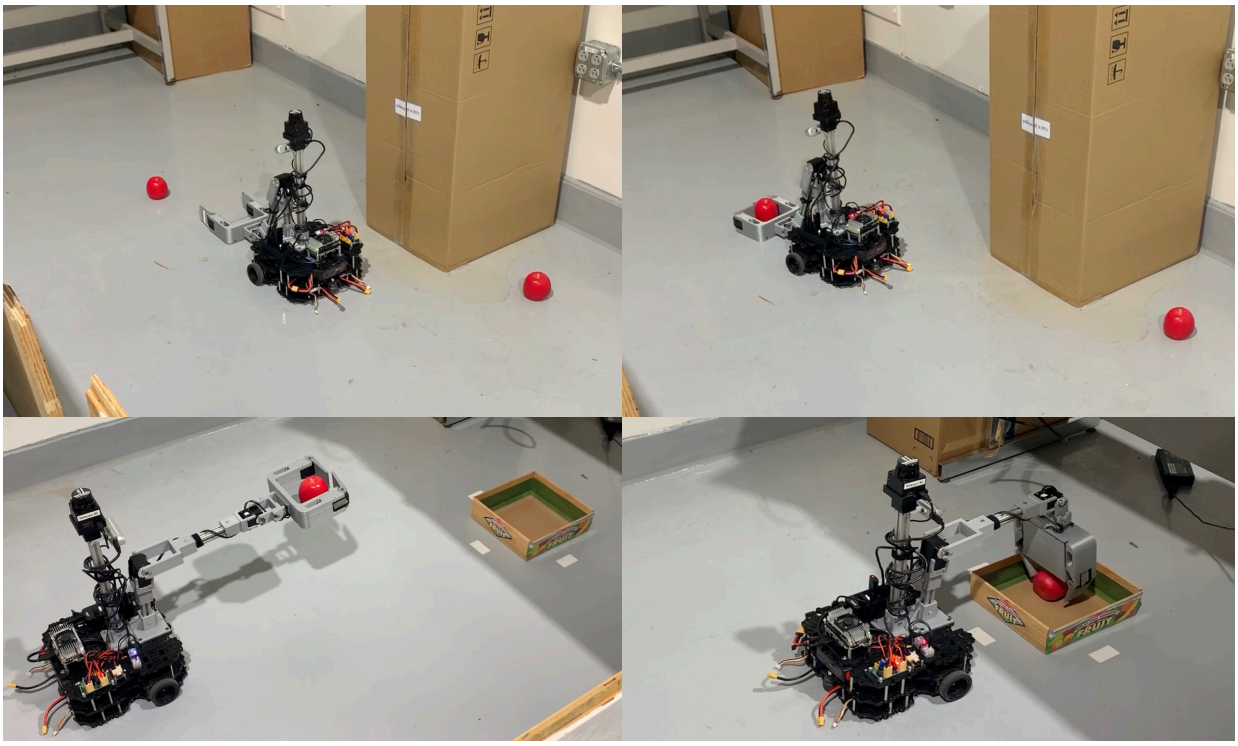

Figure 1. CuBi detected, approached, picked up a toy and dropped it into a box.

Challenges:

The major challenge for me was to modify the state machine and control logic to adapt to the exploration and object detection module. Since this is the first time we integrate the above module together, by letting CuBi explore the new test area, detecting toys, approaching them, picking them up, going back to the box and dropping them, there are tons of issues that prevents everything from working together smoothly.

For an example, with the current control logic, when we command CuBi to go to a certain point in the map, essentially it is the front side of CuBi's base that is controlled to reach that point. However, in order to pick a toy up, ideally we want the front of the tray to be at where the toy is located. One possible solution is to directly control the tray position instead, by acquiring error feedback with corresponding frames. But this solution is infeasible because when CuBi rotates, the tray is around 50cm off-centered and the movement at the point where we control is significantly large. Thus, all the fine-tuned threshold values and controller gains does not work for this new model.

I then used an alternative approach. Whenever CuBi observes an object to pick up, it will calculate and "approaching point" where we want the base of CuBi to be, in order to align the tray towards the object. The approaching point is calculated based on geometry relationship of the object's position and CuBi's position where it observes the object. Testings have proved that this method works better than the previous one, but still needs improvement in the future.

Teamwork:

We worked together most of the time during the past two weeks. Since integration of different subsystems that are implemented by different teammates can be tricky. Therefore, we performed most of the tests while working together in our testing area.

I worked with Jorge to finish integrating the exploration module into the state machine, and to resolve existing issues in the current control logic that prevent CuBi from approaching toys accurately. I worked with Laavanye on the

improvement and integration of the object detection pipeline. While running the object detection pipeline onboard with CuBi moving around in the new testing area, we observed that there are many false positive detections appearing near the boundaries, such as corners under the wooden board. We applied marginal filtering methods, as well as geo-fences to filter out these false positives, such that CuBi will not try to "pick up" the walls. I worked with Paulo to fix the broken 3D-printed bracket for the manipulator, as well as the integration of a local planning module, which is part of the exploration pipeline. I also worked with Nithin to calculate the pose of the box, where CuBi will drop the toy. We attached an AR tag to the box and placed it at a fixed location. Then we launched the localization module of CuBi, drives it to the desired location, and queried the box pose relative to the map frame from the TF tree.

While working and testing together a lot and with everyone's contribution and efforts, we have managed to resolve a lot of existing issues in the system, plus new problems that are brought up when integrating different subsystems. We will continue working together to strive to a successful fall validation demonstration.

Future Plans:

Given that there is only one week left before the FVD, the future plan is to keep working on integration of all subsystems, to carry out tests, and to improve robustness. More specifically, the highest priority issues to be resolved are: improve object alignment and pick up accuracy, improve the speed of manipulator movements and improve robustness in terms of not getting stuck and higher success rate while picking up objects.