Individual Lab Report #8

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Team D (CuBi)

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Individual Progress:

During the past two weeks, I mainly worked on:

1. Implementing a failsafe mechanism for grasping.
2. Researching and proposing a plan for exploration and path planning.
3. Comparing and evaluating different approaches for mapping and localization.

I worked together with Paulo to design and implemented a failsafe mechanism for grasping. Previously, when CuBi tries to pick up objects into its tray by enclosing the finger paddles, sometimes the object may either get stuck in between two finger paddles, or prevent the fingers from closing completely, which results in an overload error of the Dynamixel motors. This is the most common case where the system will run into a failure state and not able to recover from it, unless doing a full restart. Since whenever the Dynamixel overload error happens, it will not respond to any command, which means we will lose the ability to control the joints of the manipulator.

To resolve this issue, we utilized the load feedback provided by the Dynamixel motor drivers. By monitoring a specific ROS topic published by the Dynamixel motor drivers, we are able to see the real-time load (torque) of each joint. We then plotted the data using Rqt graph, to get an idea of how the load pattern look like when the finger paddles get stuck in different scenarios.

We then figured out that at least one of the joint will have a load greater than 0.5, as a normalized value of load, when the paddles get stuck. We implemented a callback function as a watchdog to continuously monitor this in the current state machine control flow. Whenever the finger paddles get stuck, we will send a toggle command to release the object, back-off a little bit, and try to pick it up again. This failsafe mechanism works well and significantly improves the robustness of the current system.

I also spent some time doing research and literature reviews in order to design a strategy for exploration and planning. With the current system status and requirements, we are going to have a base map of the room with major large obstacles presented, prior to each operation. The idea is that CuBi will operate in

a known environment, such as a classroom in a daycare center, so we can pre-map the environment. However, there may be small variances in the details, for example, furnitures may be placed slightly differently, or there may be additional small obstacles lying on the floor.

Thus, we are planning to pre-map the environment first, then perform a cellular decomposition of the map, such as the Boustrophedon cell decomposition method. Then we generate waypoints for CuBi to visit within each cell. The assumption we made here is that: given the range our object detection (~1.2m sweep in front of the robot), we will ensure that each cell is completely observed by CuBi, when the corresponding waypoint is visited. This can be done by limiting the cell within a certain size.

We then use a global planner to plan a path traversing all the waypoints in an optimized way. A* or its variants can be utilized here to achieve this. Finally, we will also have a local planner to handle all the unexpected obstacles appearing on the path. More specifically, we expect the robot to go around unexpected obstacles in between two major waypoints.

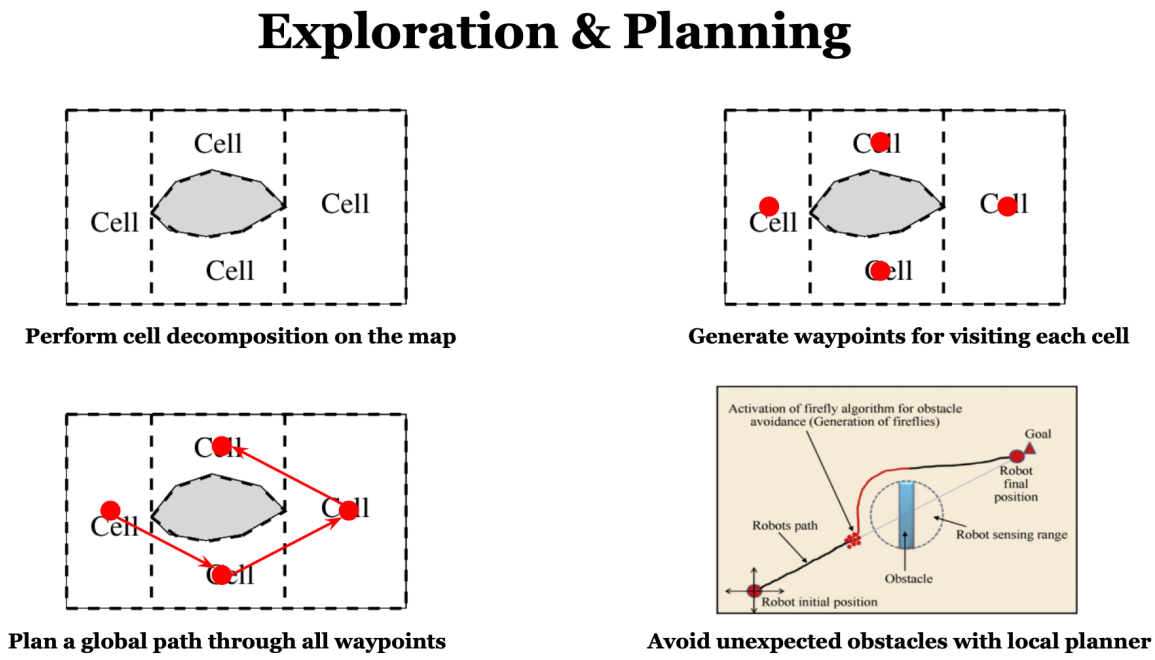

Figure 1. Strategy for Exploration and Planning

Challenges:

One of the challenges I had was to figure out a proper way to add the failsafe mechanism into the current state machine control loop, without breaking the current working states, while making sure the failsafe will work. We wrote a few unit tests for our newly written functions, and we also did full tests for the system to ensure the functionality worked as expected.

Teamwork:

As described above, I worked with Paulo to implement the failsafe mechanism for object grasping.

I also worked with Jorge to discuss about strategies and work division for exploration and planning. I helped Nithin with creating the base map and improvement of the map using LiDAR and camera information.

Future Plans:

My individual plan for the next two weeks is to start implementing and testing the exploration and planning algorithms, as well as to improve the localization module and to pipeline the mapping process.

In terms of the team, our first priority is to find a consistent testing location such that we can focus on pipelining a lot of the processes and benchmarking our system performance. The entire team will work together a lot to make sure the integration between subsystems and modules happen smoothly.