Individual Lab Report #6

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Individual Progress:

During the past two weeks, I mainly worked on the preliminary configuration and validation of a 2-D lidar SLAM package, using the Hokuyo lidar on our robot as input data source.

As one of the system requirements stated, the robot should be able to scan and map the room. After discussing about this, we think that at least the information regarding the boundaries of the room and the layout of large obstacles (i.e. furnitures) should be provide by the map, since such information is essential to explore the room efficiently. We have equipped our system with an 2-D Hokuyo lidar and it should be capable of this task.

The first step before implementing and integrating the SLAM pipeline for our robot is to use some existing 2-D lidar SLAM package, configure and adapt it to our system to validate that it satisfies our requirement to some extent. Therefore, I configured our robot with the Hokuyo lidar and our existing wheel + IMU fused odometry, and collected a few rosbags in several mocked-up environments. I also set up the TF frame transformation from laser scan to the base footprint of the robot, such that all frames are consistent.

With the collected rosbags, I evaluated three popular open-source 2-D lidar SLAM packages: GMapping, Hector SLAM and Google Cartographer. Each package has its advantages and limitations. For our particular use cases consisting of indoor, small-scale environments with relatively reliable odometry data provided, Hector SLAM happens to be the best choice so far. As comparisons, GMapping requires a much slower movement, especially in-place rotations, to generate a reasonable result, where Google Cartographer is much heavier, requiring larger computational resources, and having much more dependencies on 3rd party libraries.

Below are the pictures of the testing environment, and the mapping being built. Note that after traveling for around 5 minutes in a loop, the map drifted a bit and became inconsistent. The reason might be that robot's odometry drifted, as well as loop closure failed to find the correspondence.
We will try to resolve this issue in the future.

Figure 1a. Test Environment on 4th Floor, NSH

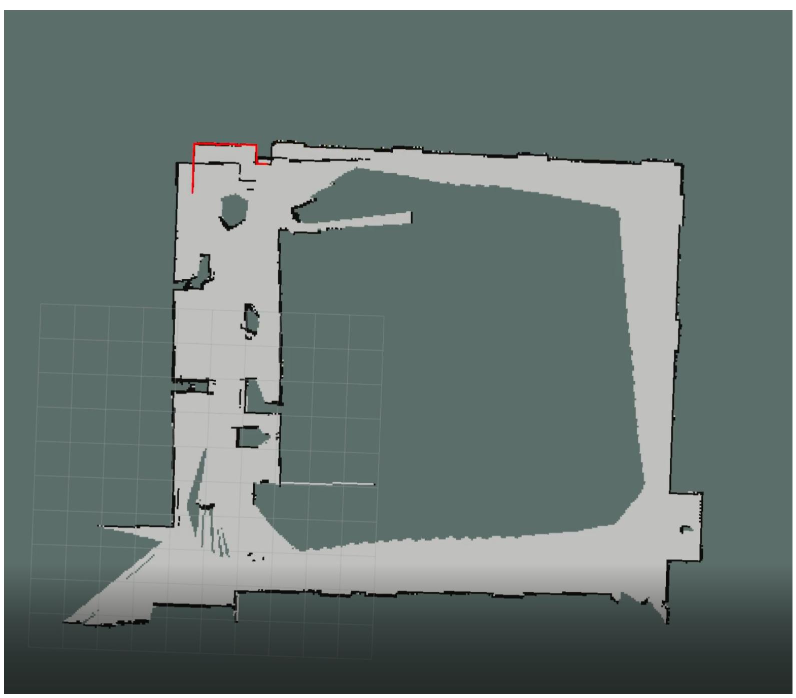

Figure 1b. Map Generated

Challenges:

One of the major challenges, which has not been resolved yet, is that small obstacles such as the legs of a chair, cannot be captured by the single-beam Hokuyo lidar very well. If the robot is not aware of such small obstacles in the environment, it may easily get stuck somewhere while operating in an indoor environment, where various kinds of such objects commonly exist.

The figure below shows the generated map of a small student conference room, where various chairs, table, television stand and obstacle blocks present. The map generated barely catches the information of the obstacles in the middle of the room, rather it gets the boundary of the room.

Figure 2a. A Student Conference Room with Furnitures

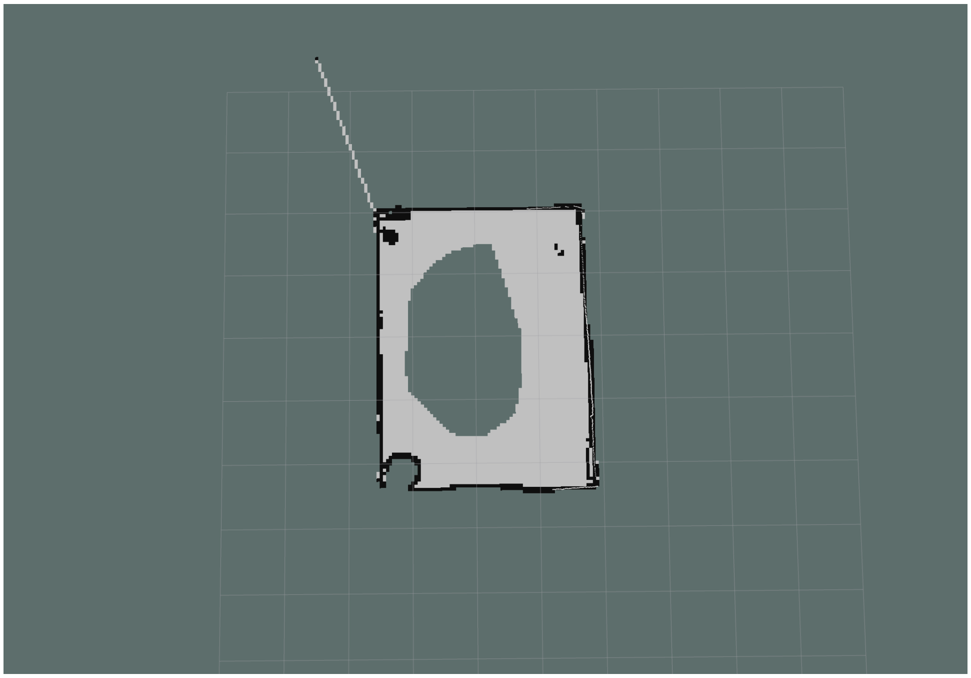

Figure 2b. Generated Map of the Room

We are exploring the solution to this issue by utilizing the RealSense RGBD camera on our robot. This will be discussed in the future plan section.

Teamwork:

This is the first progress review since everyone came back from the internship. It has been around four months since last time we worked on the robot. Therefore, most of the teamwork happened during the past two weeks was about project management, task planning, dividing the work and scheduling for the new semester.

Our team have had several meetings where everyone sat together and summarized what we have achieved during the previous semester, lessons learned, and made a detailed work plan using our new project management tool: Notion. We are aiming at a more efficient and collaborative working atmosphere this semester.

In terms of the collaboration of work between individuals, I worked with Paulo to brainstorm a solution to solve the lack of traction on different types of ground surfaces. We decide to add a bigger caster wheel at the back of the robot, such that the original small caster wheels does not have to support most of the weight, which may result in large frictions or dragging forces. I also discussed with Laavanye regarding the SLAM pipeline and sensors to use for our use cases. In addition, Jorge, Nithin and me are currently reviewing our existing software stack, and planning to define a clearer interface between each sub-systems and modules, as well as to clean up the existing code base.

Future Plans:

Our plan for the next two weeks is:

1. Explore visual slam, segmentation or obstacle avoidance by utilizing the RealSense camera installed on our robot, to resolve the limitation of single-beam lidar.

2. Install a new caster wheel on the base.

3. Finish resolving all left-over issues from last semester.

4. Discuss and finalize the pipeline of mapping, exploration and planning, including the interface among each sub-modules.

5. Improve the design of our state machine that controls the behavior of the robot, to make it more expandable and more robust.