Team F

Individual Lab Report 8

Progress Review 9

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1 Individual Progress

For this PR, I worked on the Drone and the exploration algorithm. This included the development and integration of the low-level movement commands with the localization developed earlier, GPS mapping for April Tags, a node selection heuristic for the drone, and a partially implemented A* for the rover.

1.1 Low level movement commands

From last PR, we demonstrated the ability to localize the drone with respect to an April Tag graph. For this PR, I integrated this information with the underlying move commands to direct the drone from one Tag to another. This required several steps:

1. Calculate the current heading of the drone
2. Calculate the required heading of the drone
3. Calculate the distance between the drone and the target
4. Apply a rotate command scaled by the difference in heading and a move command scaled by the difference in distance

This logic is fairly simple and very similar to the GPS navigation that was developed last semester but it included some specific challenges. They included high instability in localization resulting in a low pass filter, the inconsistency of April Tag detection during movement, the need to zero out the z axis during calculations, and the testing to optimize these paramters. They are described in more detail in section _.

1.2 GPS mapping

Since we are operating outdoors, we would like to leverage the fact that we have GPS capability. In order to do so, we need to assign a GPS location to each April Tag. The two main challenges here are calculating the locations of the April Tags and accounting for GPS/April Tag drift. The first challenge is a simple mathematical problem but due to difficulties in testing and some confusion with coordinate frames, it took some time to debug. There is also a lot of inaccuracy resulting from the April Tag detection and the GPS drift. At the moment I have implemented a low pass filter since it is simple to implement but it may not be the best approach. (Ideally we want to fuse sensor data with EKF but we have to define most of the frames ourselves and it is probably too difficult to debug at this stage).

1.3 Node selection heuristic

The heuristic to explore the environment is based on euclidean distance between the target and the goal. Simply put, it selects the node that is closest to the target and tells the drone to fly there. An implicit assumption that is made here is that at the normal flying height, the April Tags are close enough to each other such that flying to a node allows the drone to see the subsequent node. As a result, this greedy approach ensures that if there is a path, the drone can find it. We have not tested this outdoors yet since we need a large area with sunlight and it rained for the entire past weekend.

1.4 A *

A skeleton code for A* was written to give the high level instructions to the rover. With the drone, we are assuming unobstructed flying space so no obstacle avoidance is required. If we need it to fly to a certain node, it can fly there in a straight line. This is not the case for the rover. Instead, the rover must traverse across the edges of the graph as it is a constraint in our project. The A* algorithm chooses the shortest path between any two vertices in the graph. This has also not been tested yet.

2 Challenges

The biggest challenge is testing the drone outdoors. We are severely limited in terms of our opportunities of when we can test. Weekdays are normally not an option since there are too many students walking outdoors for safe testing and booking the lawn takes a lot of time. We tried testing at night but visual odometry doesn't work well. Last weekend it kept raining so no testing was accomplished then. As well, we have lost our drone when we tested it at night. This is because I was the only person testing it and wasn't able to stop it in time. See figure below for our best efforts at retrieval.

Figure 1: Unsuccessfully retrieving the drone

For the localization with April Tags, we have found that although it works moderately well indoors, it is much more difficult outdoors. The main problem is the wind. With April Tags, the drone must have vision of the tags or else it will not receive updates to its location. Due to the variation in outdoor wind conditions, it is very difficult for the drone to remain still in one location. Fortunately, we are also using GPS so this problem is not extremely high risk but GPS is much less accurate than April Tags. The second issue is that when moving, the video feed tends to freeze and the drone cannot detect April Tags. This is not a problem when we were manually testing since we always stopped the drone over the April Tags but this does not happen with autonomous navigation. The last issue is that the detections are very noisy. With localization of static objects (like other Tags), this was not an issue since we used a low pass filter and the latency was not a factor. However, with a moving object like the drone, a low pass filter is less desirable. We are using this at the moment simply because we don't have a better option (EKF package didn't work) but the lag from the filter combined with the video feed lag makes the navigation very slow. This is why in the video, the drone is moving extremely slowly.

3 Teamwork

Rahul and Pulkit worked on using their segmentation and detection progress from the last PR to enable the rover to avoid static obstacles. They are able to publish the relative position of obstacles onto a topic and give move commands based on that information. Danendra and Pratibha worked on the IMU integration and testing. In addition, Danendra has helped me a lot with the drone testing as we have decided that having at least two people is required to avoid the drone flying into the trees again.

4 Future plans

A high priority task for us is the testing of the drone. A lot of the progress that we have made have not actually been verified in outdoor environments. As discussed before, we are not really able to test during the weekdays. As a result, we have prioritize testing during the weekends and hope for good weather.

As well, the drone needs to be integrated onto a common network with the Husky. At the moment, they are on separate networks. The obstacle avoidance for the Husky at the moment is also rather simple - Pulkit and Rahul will implement a path planning algorithm that takes into account the global goal when avoiding obstacles.