Individual Lab Report #9

Akshit Gandhi

Team H (PhoeniX)

October 24, 2019

Team-mates:

Shubham Garg
Parv Parkhiya
Zhihao Zhu

Individual Progress

The tasks to be completed by the Progress Review 10 for me were: -

1. Continue working on a drone mission to fly through the window
2. Make mounts for the new extinguisher for the UAV and UGV

Drone Mission to fly through a window:

1. Pose control on the UAV
    a. Beginning of this sprint we decided to move away from the visual servoing approach and move towards a more robust approach using point-cloud segmentation and the pose controller on the UAV. The very first step in this approach was to get control of the drone using the pose controller. Getting the UAV to follow the XYZ-Yaw setpoints was important. Hence I worked on using the interface provided by the AirLab in the form of the core-autonomy-stack.
    b. There is no proper documentation for the autonomy stack and to use it we are heavily dependent on the SubT team which uses it. But it is very hard to reach with our single point of contact as he doesn't reply to our emails, slack messages and even personally going to his desk didn't help. Hence, I was on my own and we figured out a way to access the pose controller which was by killing the trajectory controller which connects to the pose controller. Post successful verification of this strategy I tried to fly the drone by publishing pose commands.
    c. We (I and Parv) did flight tests to verify the results and we realized that we were not publishing the velocities in the map frame. The map frame was initialized by the core stack and hence we had to figure out the transformations using the tf tree. Post the transformation of the local frame poses into the map frame I got the desired results.
2. Testing the Opening detection pipeline
    a. The opening detection pipeline has 2 stages: 1. Align perpendicular to the dominant plane normal which is aligned somewhat with the horizon 2. To go to the window center detected by the opening detection pipeline.
    b. So, for the first case, I wrote the code to test Parv's Normal alignment pipeline by subscribing to his data and converting it in the map frame and controlling the drone. My secondary role was to debug Parv's pipeline to make sure that the drone doesn't get caught up on any wrong command.
    c. The second case took at least more than 18-20 hours! The very first test which (me, Shubham and Parv) did was to hold the drone in front of the window and

manually test if we get proper coordinates for the center of the window. The coordinates were verified merely on the basis of visual judgment. We faced a lot of challenges in fine-tuning the window detection code. Since Parv and Shubham took the task on hand, I began writing a simple trajectory planner which can help the drone to move through the window.

i. I used a simple approach, where the drone first aligns in front of the window at a distance of 2m. Then it starts to plan waypoints which are 2m beyond the window. Hence the planning algorithm takes points in space which are 4m apart and then publishes multiple waypoints between these points.
ii. Since the code by Parv and Shubham was not robust, I wrote a dummy publisher to give my trajectory planner an initial guess of the window and then I was able to test the drone behavior autonomously.
iii. Once the complete pipeline was ready, I was acting as the safety pilot and Parv was on the computer to run the drone. We noticed that the drone was not following the waypoints generated by the trajectory planner. Everyone on the team thought that there was some bug in my planning. Everyone went through the code, but the issue was something else.
iv. After numerous flight tests, we started to test individual pieces again! And we found that the DJI drone, in a completely autonomous mode won't take any commands if there is an obstacle in front of it. Despite disabling the Obstacle Avoidance via the DJI Pilot App, we were not getting the drone to follow the velocity commands.
v. Hence, when I was checking the front stereo pair, I accidentally blocked one of the cameras and I realized that this disabled the range map on the controller! Thus, we blocked one camera with a piece of black tape and then we could get the drone to autonomously go through the window as we can see in figure 1.

Figure 1: UAV with front stereo cam blocked

Mounts for the new extinguisher:

1. In order to improve the existing fire-extinguishing mechanism, Parv and Zhihao ordered pumps and fire extinguisher sprays. I helped them out to do a trade study between the two by flying the drone manually and they went underneath the drone (at a safe distance from the drone) to deploy the extinguishing material. The projectile range was affected severely when we tried it out. But Zhihao came up with the idea of using a long pipe in front of the motor which significantly improved the performance. My other roles in this task were to test the pumps, sprays and flying the drone to test everything.
2. Apart from these, I helped Parv design a mount for the UAV, primarily I was working on attaching the pump to the base of the drone while he worked on setting the bottles up on the landing gear.

Auxiliary Tasks:

1. Since we are approaching FVD, I played multiple roles in helping Parv and Shubham debug their opening detection code. I literally went line-by-line to find implementation bugs in the code. I and Parv found a classic signed and unsigned int bug which caused a lot of seg-faults!
2. Since other team-mates are not well versed with CMake, they experienced compilation/build issues and I fixed those for them.

3. Helped Shubham test his state-estimation sensor fusion pipeline by manually driving the husky and recording a ROS bag for his post-analysis.

Challenges:

1. Testing the pose controller and figuring out how to command poses in the local frame of the drone
2. Debugging the obstacle issue with the drone was the most frustrating and annoying
3. Acting as a safety pilot when the drone enters through a window is very challenging as the team is relying on me to save the drone from a crash which could put us weeks back in the schedule if anything wrong happened. Thus it's a huge responsibility. If the window coordinates are not accurate, there is a high chance that we may crash as the margin on either side if less than 6 inches. Hence, we rely on highly accurate detection and state estimation. Figure 2 shows one of my most challenging saves!
4. Debugging the opening detection code
5. Testing the extinguisher. We tested the payload capacity of the drone with 2 fire extinguishing sprays weighing 600 grams each.

Figure 2: Narrow escape from a UAV crash

Teamwork:

Shubham was working on sensor fusion (making it more accurate) and the window detection code. Parv was working on finding the normal aligned with the horizon in the point cloud, extinguisher mounting, and testing, debugging the UAV flight test through the opening and debugging the opening detection code. Zhihao was also working on opening detection with

Shubham and he was also working on finding a solution for the extinguishing mechanism and he really surprised us with very weird yet effective solutions!

Future Plans:

The plans for the next presentation are to do missions with UAVs and UGVs to deploy water & work on the Global Planner in simulation:

1. Shubham – Continue investigating issues with IMU sensor fusion
2. Parv – Work on Global Planner for the husky and do longer missions with the husky
3. Akshit – Work on UAV missions and Global planner using AirLab stack
4. Zhihao – Work on the DJI interface to figure out powering the pump on the UAV, connecting a teensy to the DJI Manifold computer with rosserial, actuating the motor with an Arduino sketch and a relay.