Individual Lab Report #4

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Team H (PhoeniX)

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Team Mates:

Shubham Garg
Parv Parkhiya
Zhihao Zhu

Individual Progress

The tasks to be completed by the Progress Review 3 for me were: -

1. Carry out outdoor flight tests for gain tuning and flight stabilization
2. Study for Part 107 UAS FAA test and give the Knowledge Test.
3. Work on building the new reserve drone which adheres to MBZIRC guidelines
4. Write code for generating dynamic commands to the UAV and test it in simulation

UAV Flight Test:

We have faced issues with the stability of the UAV when it operates in manual mode and it is imperative to work on the gains as our UAV is huge in terms of size and weights. Basic tests such as takeoff and land were done in the Position Hold mode of PixHawk; in simple terms the position hold mode makes it easier for the pilot to control the drone as the controller takes care of maintaining the x, y and z position in 3D space using GPS. Test was carried outside the RoboLounge.

Once we had a flight test, task was to look at the logs from the flight controller and see the commands being given to the UAV by the controller, if we I a very high sensitivity to roll, pitch or yaw setpoint, I would tune the appropriate parameter and check if it works as intended or not. The whole test was carried under AirLab student supervision who has experience with gain tuning for UAVs. I had done this test in past as a Remote PIC (Pilot in Command) and we tuned the gains during that test, but during the test on 03/22/19 the UAV crashed, and I had to investigate the cause for the crash. The flight logs revealed that the wind was more powerful than the capacity of the controller to resist it which led to drifting of x, y and z position. As I mentioned we used Position Hold mode and thus GPS reported a change in position which was countered with a very high control signal to resist the wind which made the drone unstable and lead to the crash. Hopefully we just lost one propeller and GPS mount.

UAS Test:

In order to fly any drone above 0.55 lbs. and below 55 lbs. one needs to have a UAV Pilots license (if the person is flying the drone for commercial purposes), but with a lot of helipads around in Pittsburgh, majority of the area is under the Class D airspace and thus to fly any drone which fits in the above specs one needs to have the license. The test requires studying the Part 107 manual published by FAA (found here) and practice by taking mock (test here). The test is aimed at checking if the Pilot has the knowledge of various aviation terms, laws, rules, duties and responsibilities which include knowing how to read the METAR report,

how to read a sectional chart which looks something like this:

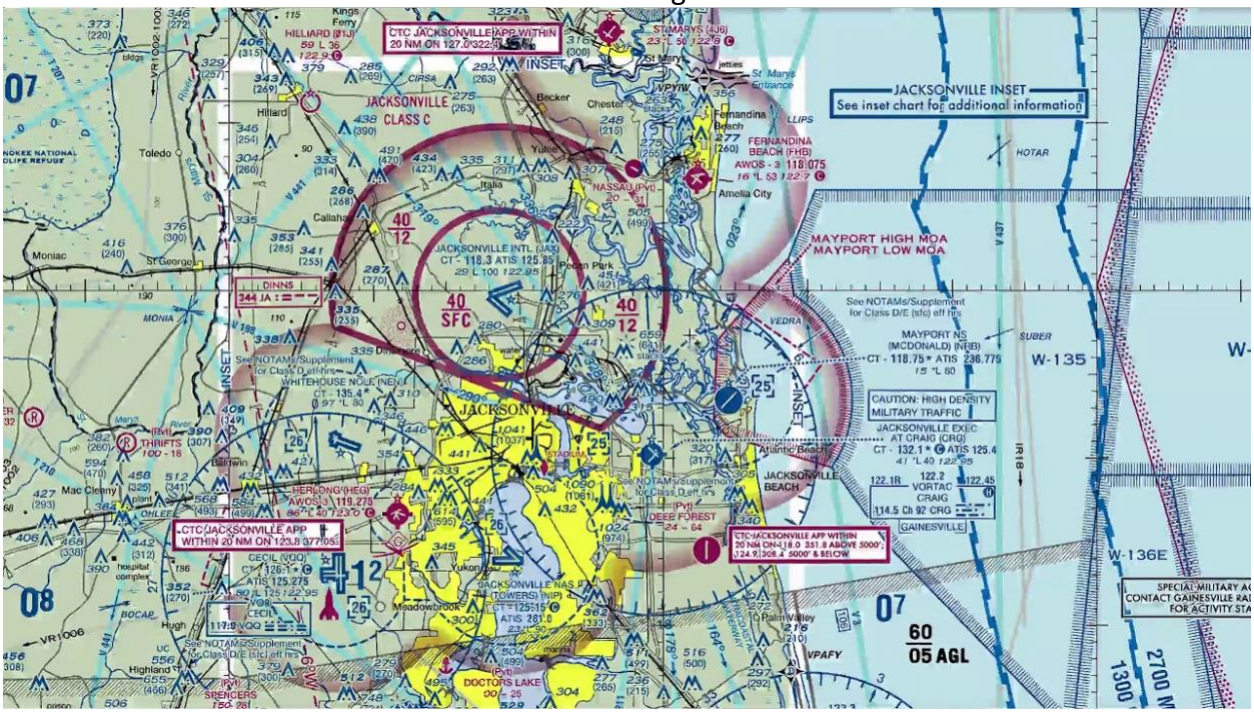

Figure 1: Sectional Chart of a region

I took the test at Alleghany County Airport on March 09, 2019. Test consisted of 60 questions and to pass the test one needs to score 70%. I passed the test with 87% score and got the temporary license which will help me to fly the PhoeniX UAV outside.

Building the reserve drone:

The team including sponsors realized that we are having difficulties with drone repairing after a crash and affected the schedule negatively we sought to buy parts so that they would arrive during the Spring Break and the team can work together to build the new drone. The current PhoeniX drone is not adhering to the challenge size constraints and thus with the new drone we shortened the arm lengths to fit the drone along with the props in a form factor of 120 x 120 x 50 cm.

My responsibility was to shorten the arm length along with Parv and mount the arm, motors and motor mounts onto the drone frame. The task was done over the course of a week as some of the parts had not arrived and we had built the drone as and when they arrived. Currently the UAV is 90% complete and we just awaiting the arrival of 1 part.

Waypoint following in simulation:

One of the demos which we have for the spring validation demonstration is to have our vehicles follow a desired trajectory. As highlighted in the previous meeting we are using a ROS action server architecture which helps us write high level tasks like takeoff, land and followPoint

(x, y, z, yaw) along with the low-level message publishers for these tasks. I took the responsibility to write the code so that Shubham can test his SLAM subsystem and verify if the results from SLAM match to the desired command given. To make sure that there are no ambiguous states in the code execution as we don't want the UAV to be in any floating state, I tried the code several times in simulation. A video can be found here, which shows the UAV follow a 1m x 1m trajectory and land at the spot where it took off. Inherently the architecture is complex and can be seen in the ros graph below. Please note this is just a part of the whole ros architecture. For detailed view you can go here.

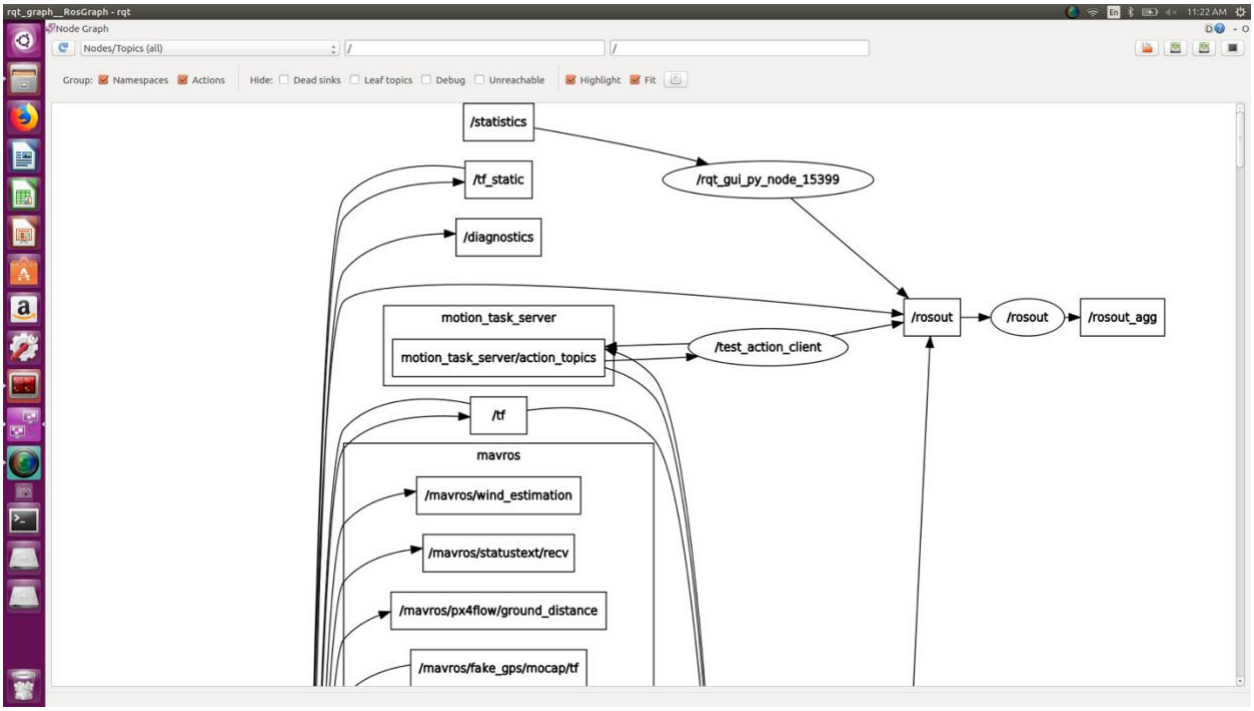

Figure 2: Partial ROS Graph

Challenges:

Studying for the FAA UAS test was time consuming and it had a gigantic syllabus to be covered. I started to study for the test well in advance as I knew I had many deadlines before the Spring Break. The test required me to learn more about effects of weather, knowledge on how to interpret sectional chart which is flooded with overwhelming information and took me a while to understand these two major concepts along with understanding of runway headings at airports.

The ROS action server architecture is very complex as it spins out a request of a particular task and there is a task scheduler which has a queue size of 1; meaning only 1 task can be active at a time so we can't run the fire detection and waypoint following tasks together. Which would

be a big problem when we go further so I had to develop a turnaround by embedding both of these requests into a object of a inherited class which can encapsulate two requests at a time. When I was writing the waypoint following code it was difficult to control the yaw of the drone and I had to dig into a number of forums but I have still not figured out a way to properly command yaw to the UAV.

Teamwork:

The team was split into two smaller teams where Parv and Shubham were working on fusing SLAM data on the UGV and UAV respectively so that we can parallelly make progress on both the vehicles. Zhihao was assigned the task of interfacing the teensy duino microcontroller with the Jetson so that we can control the water pump using the microcontroller given a high-level command by the computer. Shubham worked on finalizing the PCB and I was assigned to order the PCB parts along with the hot water bag which we intend to use in order to simulate the fire. Parv worked on some missions by just using the SLAM data in order to control the UGV and he realized that outdoors we were not able to get enough features. I worked with Shubham by giving him a trajectory which he can use to test his SLAM output and verify the results using Rviz. Apart from this the whole team participated in building the new drone during the course of the past two weeks.

Future Plans:

The future plans for the next presentation are:

1. Use 1 UAV and 1 ground robot in **simulation** to perform the full mission specified as part of challenge 3. (Everyone in the team will do their assigned job)
2. Demonstrate fire extinguishing by pointing laser towards a hot vessel. (Steve/Akshit)
3. LiDAR and ZED camera sensor fusion on Husky (Shubham/ Parv)

Apart from these tasks the team will also look into getting more features for the SLAM subsystem.