FlySense

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Team C: FlySense

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Individual Progress

During Fall Validation Experiment, we were able to demonstrate the capability of our pilot assistance system without actually flying it. The goal for this semester is to build a robust flying system using which we can show how FlySense helps pilots during takeoff and landing scenarios.

During the Critical Design Review we were able to redesign our Spring Validation Experiment to incorporate all the requirements and find a way to show how our system helps in mission scenario. Essentially, the idea is to make the Pilot Fly the course multiple times to check the performance with and without assistive features switched on. There were couple of additional capabilities that were added to support this:

1. First Person View capability:
2. A light weight tail to simulate the Helicopter like scenario.

These features are required to simulate a scenario similar to flying a helicopter where pilot can see in the front but it is difficult to maneuver during takeoff and landing due to long tail. Figure 1 shows a comparison of these features:

Figure 1: Quadcopter with a tail (left), Helicopter (right)

During this semester, Nick and I are responsible for designing, integrating and testing the flight system. To start with, we did a thorough weight analysis which showed we were overweight by 300g from DJI M100 max takeoff weight of 3.6Kg. We identified the following major areas where there was scope to cut down on weight:

1. Velodyne modification(200g savings): Remove interface box and the cable. The interface box is only used for voltage regulation and GPS time syncing. We consulted with folks at NEA who gave suggestions as to how we can remove box and cable without affecting operation.
2. Propeller guards removal(200g savings): We discussed this with Pilots at NEA who suggested that we should keep the guards on as we are going to be flying close to the obstacles.

We decided not to remove the propeller guards for now. If needed we will consider again to remove them later.

Component selection:

There were a few major components which were required to be selected properly to develop a robust flight system. These are described in detail now:

1. **Communication:**

We had finalized earlier to keep communications on Wifi 802.11ac protocol to avoid interference with DJI radio and ensure all the subsystems can be connected seamlessly.
One of the biggest problems with wifi is that they don't give enough range especially for a flying system due to omni-directional antenna pattern. I looked into lot of different available wifi radios with Patch or yagi antennas. After careful analysis, I selected Ubiquiti AC-M wifi access point, shown in figure 2 along with Ubiquiti UMA-D Directional antenna shown in figure 3.

Figure 2: Access point

Figure 3: Ubiquiti UMA-D Directional antenna

Team F-Falcon Eye was interested in the same units and took the initiative to test and confirm that the units are functional and provide video downlink from a drone. Further testing will be done soon to confirm that these units would work properly for our purposes.

Power module:

The power module was selected based on following requirements:

1. minimum 5A current capability at 12V
2. Lightweight
3. suitable for drone applications

Castle creations 2.0 BEC voltage regulator was found to be most suitable for our purposes as it is widely used in drones and provide small form factor. It is shown in Figure 4.

Figure 4: Castle creations 2.0 BEC

Some developmental tests will be done prior to using this system on the quad.

Onboard Computer:
The team had procured Jetson TX2 last semester but it wasn't used due to the weight and size of the development board. During last semester Jetson TK1 was being used which had wifi connectivity issues and lower processing capabilities. To rectify these issues, we started exploring other options and came across carrier boards for Jetson which were light enough to make the Jetson TX2 weight comparable to Jetson TK1.

After careful analysis among the options available, Orbitty carrier board from Connecttech was chosen as it fulfilled most of our hardware interface requirements(1 ethernet, 2 usb ports, serial port, micro-sd slot). The drawbacks with this board were that it does not support CSI-MIPI lane for camera connection and unavailability of ssd interface. We have found workaround for both of these drawbacks. We are using a usb camera instead of one with CSI-MIPI lane. Also, we plan to store the flight data on EEPROM and transfer it to Micro-sd card after every flight and download the data after a few flights. Since our flight time will be around 7 mins, this would not be an issue.

USB Camera:
The camera was selected on the basis of following criteria:
1. High field of view(>90 deg): As it will be used for flying in First person view mode
2. Light weight
3. Powered via USB
ELP USB camera was selected as it met all the requirements and has a low form factor.

Flight:

Nick and I were responsible for setting up the quadcopter and conducting flight tests. We started by reading user manuals and configuring the parameters on M100. We also did some basic hardware checks to ensure the quad was in good shape to fly. The Figure 5 shows DJI M100 in air:

Figure 5: DJI M100 First flight

Following are the statistics from the flights conducted so far:

1. Flight day 1: 3 short flights, 2 minutes each. System was found to be stable but was getting pushed a little by wind.
2. Flight day 2: 1 flight conducted, 5 minutes after mounting GPS with a mast and removing the propeller guards as they were found to be causing instability when flying in windy scenario. The flights went smooth.

By this progress review our aim was to be able to fly the quadcopter with dummy weights and overall weight of 3.6Kg. We have integrated the system with dummy weights but haven't been able to fly so far due to unsuitable weather conditions. I am also practicing RC flying in a drone flight simulator so as to be ready when we start flying in First Person View (FPV) mode.

"STOP" functionality to prevent collision with obstacle:

Joao and I are responsible for implementing the Obstacle avoidance functionality. Joao is working on the algorithm development and I am responsible for implementing the code that interfaces with DJI flight controller for pilot override functionality.

The basic functionality is to override the pilot commands whenever necessary to stop the quadcopter before hitting the obstacle as shown in Figure 6. This functionality will be implemented in the form of a limiter function i.e. the pilot controls will only be limited and not completely modified. This is done to not hinder pilot's control as much as possible until absolutely necessary. Also pilot will be allowed to take the control back any time by switching the flight mode on the remote controller. This will act as a safety feature to prevent anything bad from happening.

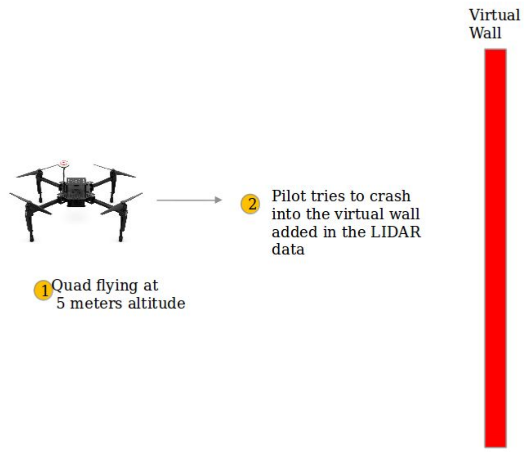

Figure 6: "STOP" functionality to prevent collision

This code will first be tested in DJI flight simulation environment by adding a virtual obstacle in the point cloud.

Challenges faced

- One of the biggest challenge was to get the weight of the quadcopter down. We did a careful analysis of everything that would go on-board. This allowed us to understand where we could cut down on weight. The solution we found of removing the interface box from Velodyne is not an ideal one but it seems to be the only option.
- Finding a wifi router which works at 5Ghz with a directional antenna. There aren't many wifi routers available which are suitable to be used with drones, that's why finding one with decent range was a challenge. I did thorough analysis of what was available and checked with experts on discussion forums to understand what would work best for our scenario.

Teamwork

Name	Contribution
Nihar Tadichetty	• Research on voice command recognition using deep learning. • Research on Image segmentation and classification to generate label for the obstacles. • Setup Jetson TX2 development environment for deep learning.
Joao Fonseca Reis	• Obstacle avoidance algorithm development • Sound warning heading correction
Harikrishnan Suresh	• Setup Jetson TX2
Nicholas Crispie	• Flight System setup, preflight checks, flight testing • Flight system component selection • Flight system layout design in CAD • Overall project management

Plans

Milestone for Next Progress review: Flight system integrated with Velodyne, Jetson (No camera): System should be capable of collecting data. Flight tested.

Overall Team Tasks:

- Flights with dummy weights -->Shivang, Nick
- Jetson TX2 setup complete --> hari
- Communication system tested and working --> Shivang, Nick
- Flight system integration: Veolodyne mod, quadcopter wiring--> Nick
- Flight with Velodyne, Jetson Onboard --> Nick, Hari and Shivang
- Sound warning heading code fix--> Hari
- Pilot override capability tested in simulation--> Shivang
- Coloring Point cloud code--> Joao
- Obstacle avoidance standalone code ready-->Joao
- FPV video reception at Epson headset tested, standalone-->Nihar

My Tasks:

- Flights with dummy weights
- Communication system tested and working
- Flight with Velodyne, Jetson Onboard
- Pilot override capability tested in simulation