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## Personal Progress

In the 3 weeks since the last PR, I have been focused on working on making minor upgrades to the Flight hardware, continuing to test the system and gather data in flight tests, developing a LIDAR simulator for virtual point cloud generation and helping to formulate and debug the obstacle coloring.

For hardware, the system has been fairly robust to all of our testing. There was one addition and one minor modification. I added the FPV camera in place at the front of the quad on a small, lightweight 3D printed mount so that we could get the perspective of the pilot if this system was a helicopter and not a quadcopter. Additionally, the one minor modification that was made was lowering the mounting of the Jetson to reduce the occlusion with the LIDAR and to make the connection more robust. A picture of the before and after Jetson mount is shown in Figure 1.



Figure 1: New Jetson mount (left) and old Jetson mount (left). The new Jetson mount holds the computer lower to prevent occlusion and incorporates spacers in the design to reduce weight and increase stiffness.

The new camera mount, also 3D printed, is shown in Figure 2. The trick for this attachment was to make the mount as rigid as possible without sacrificing for any weight, since we are already at the margin for our weight budget.

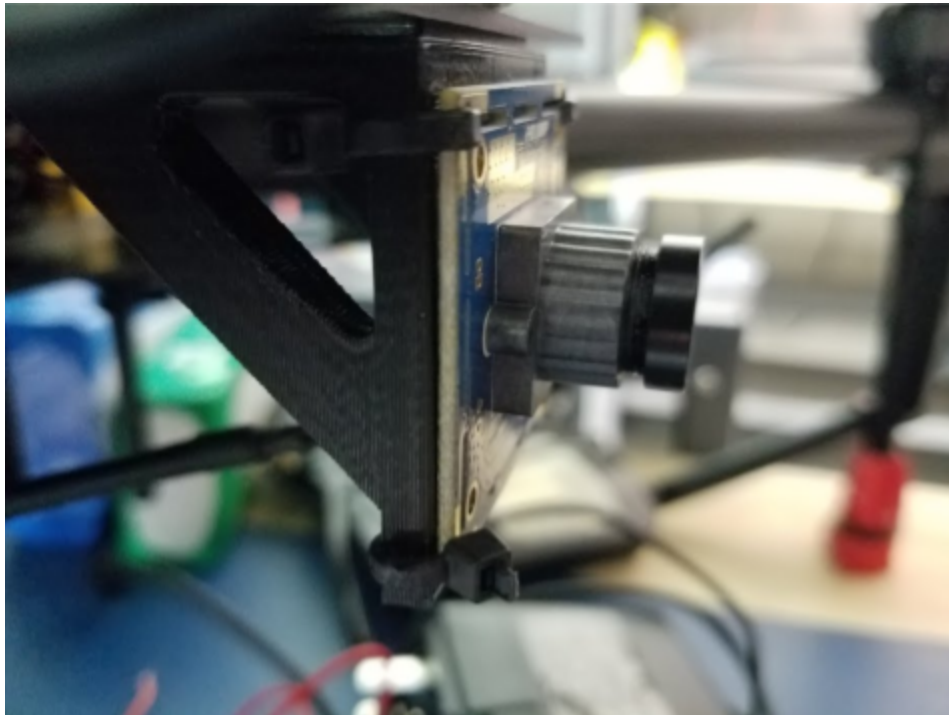


Figure 2: 3D printed camera mount, attached to the front of the quadcopter to provide as close a model as possible to what a pilot in a real helicopter would experience. Note the structural ribs to prevent diving board effect while still optimizing for weight.

Flight tests are proceeding well and we have been able to get a lot of good data for detecting obstacles. A list of the flights that I was directly involved with are detailed in Tables 1-3. An additional flight that I helped plan but was not present for is briefly described following the tabulated flights.

**Table 1**

<b>Flight Number 1: Obstacle Test 3/4</b>	
Takeoff Weight	3.65kg
Duration	~9 minutes
Tests Performed	<ul style="list-style-type: none"> <li>• Quad flown near obstacles (trees, poles) from forward direction</li> <li>• Obstacles approached while banking</li> <li>• Obstacle seen while passing by obstacle on left and right</li> </ul>

Notes	<ul style="list-style-type: none"> <li>• All data logged on Jetson</li> <li>• Video of flight recorded for reference</li> </ul>
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**Table 2**

<b>Flight Number 2: Obstacle Test 3/11</b>	
Takeoff Weight	3.65kg
Duration	~9 minutes
Tests Performed	<ul style="list-style-type: none"> <li>• Quad flown near around outside NSH</li> </ul>
Notes	<ul style="list-style-type: none"> <li>• All data logged on Jetson</li> </ul>

**Table 3**

<b>Flight Number 3: Obstacle Test 3/11</b>	
Takeoff Weight	3.65kg
Duration	~1 minutes
Tests Performed	<ul style="list-style-type: none"> <li>• Quad flown near around along Cut</li> </ul>
Notes	<ul style="list-style-type: none"> <li>• All data logged on Jetson</li> <li>• Flight stopped prematurely due to low battery temperature warning</li> </ul>

After these collection of tests to get data of the quad near obstacles, we ran a similar test to the one that we did on March 3rd, but this time with the FPV camera installed and working.

I have also started work on developing a LIDAR simulator in Gazebo so that we can generate custom virtual point clouds for the testing of our system, and eventually to have a full stack simulator to train pilots on the system. I originally started with an open source version of a LIDAR in simulation, but I wasn't able to get that to build properly (more on that in the challenges section). In that event, I decided to get started on building up my own simulator and familiarizing myself with the Gazebo environment.

I started by creating a spinning LIDAR model based off of the Velodyne HDL32, of which there was more details on how to build up a model for on the Gazebo tutorials. My plan was to start building with the HDL32 model and to modify it as necessary for our means with the VLP16 parameters once I got the whole simulation working. I built up the physical model and added inertial physics to the model so that it would spin accurately. After that, I modeled the laser beams coming out of the sensor, and added the range data model along with Gaussian noise in order to more realistically estimate what we would be getting from the LIDAR in real life. The result of that progress is shown in Figure 3.

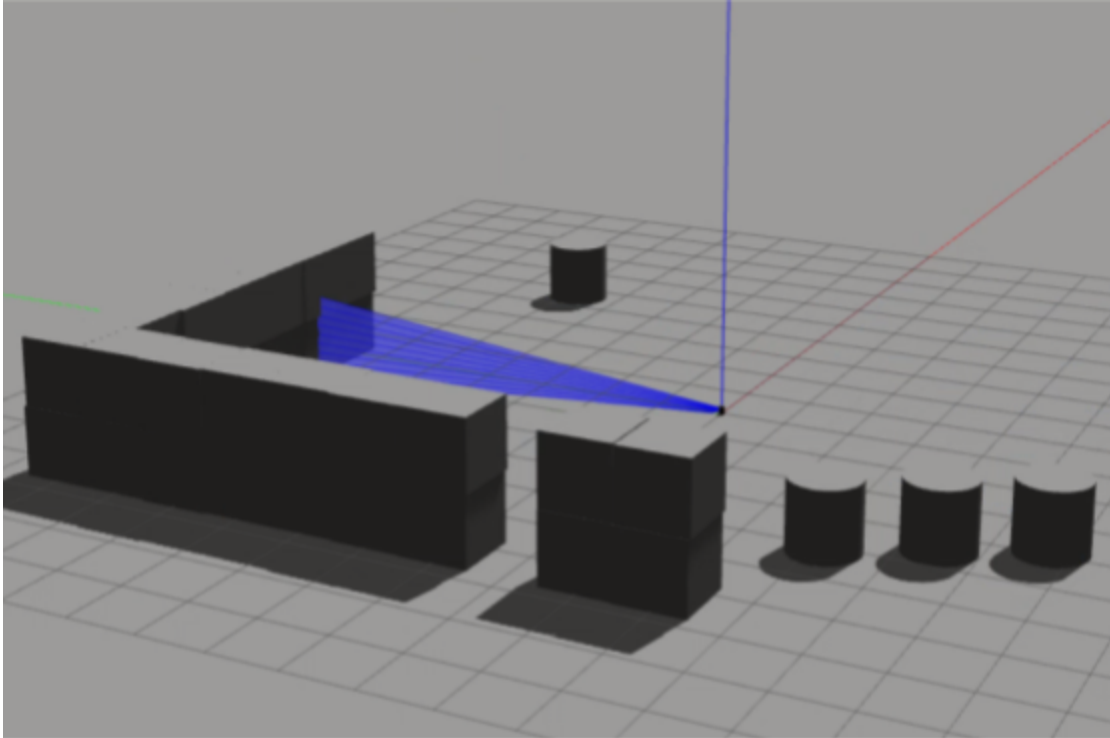


Figure 3: Gazebo model of the Velodyne Lidar interacting with user-placed obstacles in a custom environment. LIDAR is fixed in place and rotating at 10 rad/s

There is still a bit of work to be done to get this fully functional, but I'll discuss that in more detail in the future work section of the IRL.

For the coloring integration I helped Hari get started on integrating Joao's MATLAB code into C++, and helped get the framework for the coloring node setup. I consulted what existing architecture that we had when Shivang initially set up the image node and figured out how to best put in what we were already working on.

### **Challenges**

Right now, I'm working through some issues trying to do the integration between the LIDAR gazebo model and ROS. I'm new to Gazebo, so it's been a bit of trial and error getting everything to work so far, but I've been making progress. I initially tried to get a similar version of LIDAR simulator gazebo plugin working, but I haven't been able to get the software to build yet. There were some issues with header files and included libraries that I have not been able to sort out yet, so I have proceeded along a path where I am developing a lot of my own software instead and trying to tailor it to our specific needs.

A consistent challenge for us is weather for flying. It's been alternately very nice weather for flying and very poor weather, as evidenced by the change in weather these past few days. We've been able to do a lot of testing so far, but we've had to juggle our schedules in order to stay on time with our deadlines.

More of a minor thing, but when I was printing the new modifications to the hardware mounts on the quad, I was consistently getting Printer #3 jammed. I was able to get some help from Georgia resetting the printer, but after consulting with her (she has been having similar problems with that same printer), I switched over to printer #1 to finish off my job.

Some other issues that we have experienced as a team include a DJI change in the API from version to version that limits us in our ability to override pilot inputs. Shivang has been leading this investigation and has started work on reorganizing the code to accommodate for this issue.

We had a few issues with the integration of coloring and sound. We discovered that even though we eventually got the code to work on our individual laptops, the Jetson didn't process the obstacles correctly since the float representation was different on each machine. After realizing this we were able to fix the issue.

### **Teamwork**

**Joao:** Joao worked on the Matlab code for the coloring and sound warnings, as well as the Matlab code for the pilot override system.

**Shivang:** Shivang worked on running the flight tests to collect data, as well as developing the obstacle avoidance code in the DJI simulator.

**Hari:** Hari has been working on getting the coloring and sound warnings to work. He has also contributed to a few of the test flights. He has also helped with the visual of the Bird's Eye view based on the feedback we have gotten from NEA.

**Nihar:** Nihar has been working on refining the user interface and getting the FPV camera to work well with the Bird's Eye View. Based on the feedback from David Murphy, a pilot at NEA, he has been making changes to the user interface.

### **Future Plans**

The big items that we have right now are integration of the various systems in order to do a dry run test of the entire system on April 6th. For the obstacle detection in the user interface, that is close but needs refinement for the visuals and sound integration for 3 dimensions. For the obstacle avoidance, we have a working representation in Matlab, but we need to check it in the DJI simulator and on the bench before taking it out and flying it. To that end, some of the items that I am personally working on are:

- Velodyne LIDAR simulator and virtual point cloud simulation
- Flight planning and Testing

- Hardware Maintenance
- Tail (physical) for the quad to test with to visually see the dimensions of the “helicopter”
- Help where needed with software integration/debugging