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Team C: FlySense
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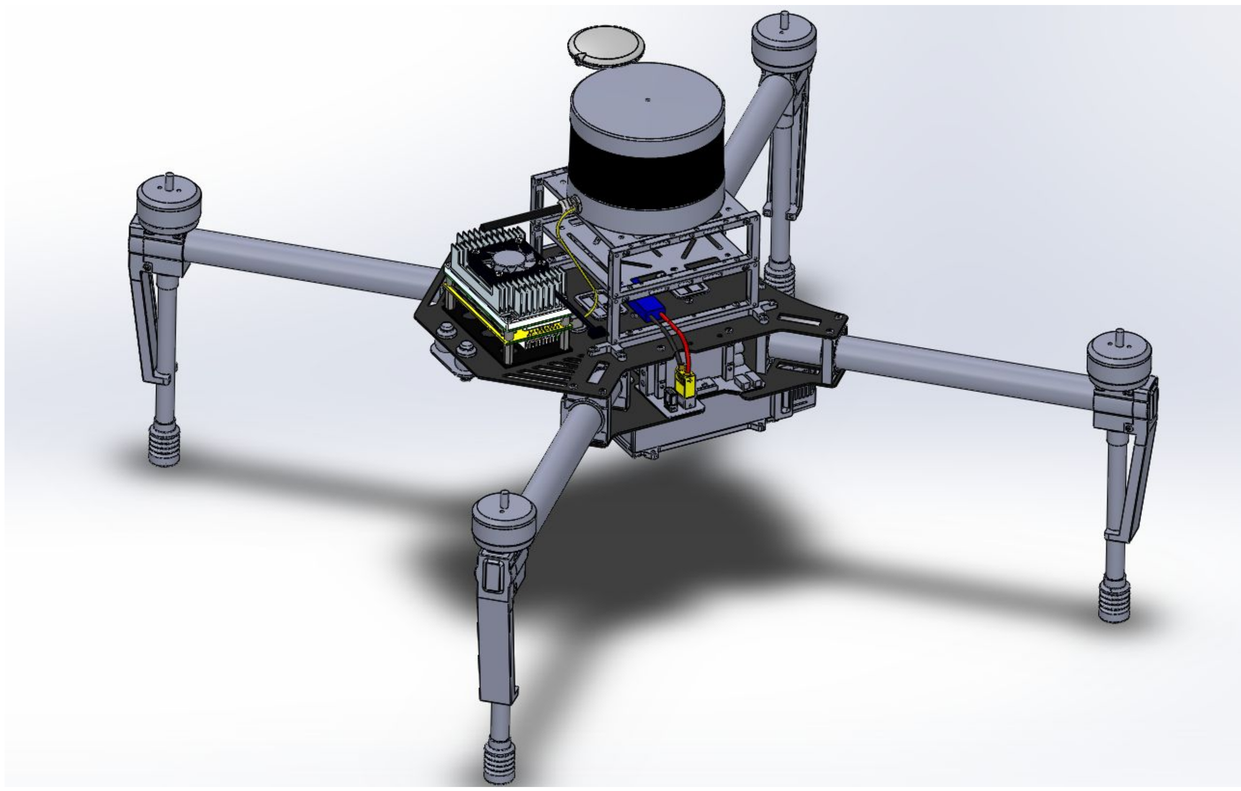
Personal Progress

The past two weeks I have been focusing on the hardware system and flight testing. The main issue here is minimizing the overall payload of the quadcopter while still having maximum functionality of the system.



I created a full CAD model of the Quadcopter setup as-built along with the other components that we plan to add to the frame to implement the system. This includes the planned wiring so we could get an estimate of how long each of the wires need to be, and also where we should route them, which will overall improve our weight-saving efforts and provide for more robust integration. As I was building up the model, I also worked with Shivang to provide a detailed weight sheet to find the takeoff weight of the drone. We weighed all the components that we had access to at the time and made estimates of the other parts based on similarly sized and shaped stand-ins. The final results are shown in the table on the following page.

Weight Plan

DJI frame (with Propeller fairings)	1924
Matrice 100 Propeller fairings	-200*
Battery	676
Velodyne without box and cable	800
Velodyne Cable	150
Velodyne Signal Box	100
Shave off Velodyne box and cable	-200
4 propellers	19.5
Jetson TX2	82
Heatsink with fan	67
Orbitty Carrier Board	41
Heatsink shaving	-20
LAN cable	8
Power cable + xt60 + fuse	16
Power to Lidar	10
Power to Jetson	10
TTL cable	5
Power module CC BEC	21
Camera	30**
Camera cable	10
Mounting Hardware	5
TOTAL	**3554.5**

I was initially planning on trying to remove the propellor fairings from the Quad, since that would save a chunky 200g grams from the overall takeoff weight, but after discussing our options with David Murphy, an experienced helicopter and drone pilot who works for NEA, he mentioned that if at all possible, we should keep those fairings on the quad in order to provide a measure of safety in case we come near obstacles. A collision with an obstacle with the fairing would cause the quad to bump up against it, but likely no damage, while a collision directly with one of the propellor blades could be catastrophic. Given that crashing is one of our high severity risks, we want to reduce the likelihood as much as possible.

Many of the weights in our weight plan had to be estimated based on what length of wire we thought we could run to create each connection. This is where the CAD model comes into play to plan out what we want so the hardware is arranged in the optimal position to minimize extra weight of connectors and wiring.

Shivang and I met with Silvio Maeta, who works in Sebastian Scherer's AIRlab, and got advice from him on how to remove weight and also the best hardware interface options for working with the Nvidia Jetson TX2. We have had numerous WiFI problems with the Jetson TK1 (about half the time it works on boot up, about half the time it doesn't), and we were a little worried of the overall weight of the code while still being able to run the software stack in real-time. Switching over to the Jetson TX2, which is much more powerful, has an updated kernel and has more developer support, make our lives a lot easier for the development process, but the TX2 development board is much heavier than the development board for the TK1. However, there are manufacturers that sell carrier boards that allow us to use the Jetson TX2 in a system with slimmed down weight. After getting some feedback from Silvio about the options, Shivang and I selected the Orbitty Carrier Board, highlighted in the table of options below.

Name	Astro Carrier	Elroy Carrier	Orbitty Carrier	Spacely Carrier	Cogswell Carrier	Sprocket Carrier
Part Number	ASG001 w/ XBG201	ASG002	ASG003	ASG006	ASG007	ASG008
Dimensions	87mm x 57mm (3.43" x 2.24")	87mm x 50mm (3.425" x 1.968")	87mm x 50mm (3.425" x 1.968")	125mm x 95mm (4.92" x 3.74")	178mm x 147.5mm (7.008" x 5.81")	87mm x 50mm (3.425" x 1.968")
Mini-PCIe	1x Half Size Slot or 1x Full Size Slot	2x Half Size Slot or 1x Full Size Slot	N/A	1x Full Size Slot	1x Full Size Slot	N/A
mSATA	1x Half Size Slot	1x Half Size Slot or 1x Full Size Slot	N/A	1x Full Size Slot	1x Full Size Slot	N/A
Video Outputs	1x HDMI	1x HDMI	1x HDMI	1x HDMI	1x HDMI	N/A
Video Inputs	1x MIPI CSI-2 (2-lane)	2x MIPI CSI-2 (2-lane)	N/A (USB & GbE Cameras Only)	6x MIPI CSI-2 (2-lane) OR 3x MIPI CSI-2 (4-lane)	N/A (USB & GbE Cameras Only)	1x MIPI CSI-2 (2-lane) OR 1x MIPI CSI-2 (4-lane)
Serial	2x RS-232/RS-485	2x RS-232/RS-485	2x 3.3V TTL	2x 3.3V TTL	2x RS-232/RS-485	2x 3.3V TTL
CAN	N/A	N/A	N/A	1x CAN 2.0b Port	1x CAN 2.0b Port	N/A
USB	1x USB 3.0, 2x USB 2.0	1x USB 3.0, 1x USB 2.0	1x USB 3.0, 1x USB OTG	2x USB 3.0, 2x USB 2.0, 1x USB CLIENT	1x USB 3.0, 1x USB 2.0, 1x USB OTG	1x USB OTG
Ethernet	2x GbE	1x GbE	1x GbE	2x GbE	5 x GbE (4x PoE, 2x PoE+)	N/A
Audio	1x Output via Codec, 1x Output via HDMI	1x Output via HDMI	1x Output via HDMI	1x Output via HDMI	1x Output via HDMI	N/A
SD Card	1x microSD Card Slot	1x microSD Card Slot	1x microSD Card Slot	1x microSD Card Slot	1x microSD Card Slot	N/A
Misc	1x Ext SATA, 1x I2C, 4x GPIO	1x I2C, 4x GPIO	1x I2C, 4x GPIO	1x I2C, 16x GPIO, 1x SPI	1x I2C, 4x GPIO	1x I2C, 4x GPIO
Input Power	+9V to 36V DC	+9V to +14V DC	+9V to +14V DC	+12V to +22V DC	+12V DC	+12V to +16V DC
Operating Temperature	-40°C to +85°C (-40°F to +185°F)	-40°C to +85°C (-40°F to +185°F)	-40°C to +85°C (-40°F to +185°F)	-40°C to +85°C (-40°F to +185°F)	-40°C to +85°C (-40°F to +185°F)	-40°C to +85°C (-40°F to +185°F)

Silvio pointed out that while the Orbitty is quite good, and the lightest of the options, it doesn't have SSD support, so it is hard to log large amount of LIDAR data. It does have an SD card slot, but the writing to an SD card does not have enough bandwidth to support the large amount of data generated by a LIDAR. However, this is not a huge problem for us, since out code (at least for now) does not take up a lot of space on the Jetson memory, we still have 16GB of logging space, which should be enough for short flights. Additional telemetry data for longer flights could be logged on the SD card.

Another thing that Silvio showed us was the lightening of the heatsink he did for his quadcopter. The heatsink is a heavy part of the Jetson TX2, and while a good chunk of it is needed to cool the board, he did say that it is possible to get some weight out of it. However, it is important not to remove the fan for the heatsink, since the forced convection is important, particularly when the ambient temperature is higher, as it will be in the Spring when we do our final testing. We incorporated his feedback into our total weight estimates. Additionally, we were able to find a lighter camera (11g instead of 30g), so we have improved weight savings there.

I have also been working with Shivang in developing a flight test schedule. We have initially completed some basic flying tests, and have plans in place for successive tests in the future, which tests in which we successively add weights to the quad before flying with the full payload weight to collect dynamics data for developing our control model, and then flying with the full hardware payload to develop the system.

Challenges

It turns out it is really hard to squeeze weight out of places where there isn't a lot of weight to be had. We will have to see how the actual integration shakes out, but we are looking like we are right at the limits in terms of acceptable weight for flying in order to still be in any sort of safe operating range. I've had a difficult time trying to balance weight versus safety and performance, and that will be a continuing battle for developing the system.

Additionally, the weather hasn't always been cooperative for allowing us to fly and test, so we are a little bit delayed, but we are working in parallel on other aspects of the software and hardware even if we can't test as often as we would like.

Teamwork

Shivang
- Component selection for quad hardware system
- Quadcopter flight test plan
- Obstacle avoidance control plan

Hari
- Replication of software stack on Jetson TX2
- Correction of sound warning software for 3D implementation

Joao
- Obstacle avoidance control plan

Nihar
- FPV camera work, hardware selection and software on Jetson TX2
- Voice commands
- Obstacle segmentation/classification

Future Work

Future work for the team involves finishing integrating the flying system and getting our software stack working on the flying drone. We will continue to do flight testing to gain insight into the dynamics for our controller model.

The following tasks we aim to complete/make significant progress on for the next IRL

- Flights with weights (Shivang and Nick)
- Jetson TX2 setup (Hari)
- Communication system testing (Shivang and Nick)
- Flight system hardware integration and Velodyne modification (Nick)
- Flight with sensor hardware (Hari, Shivang and Nick)
- Pilot override capabilities tested in simulated setting (Shivang)
- FPV video on Epson (Nihar)
- Obstacle avoidance code framework (Joao)
- Coloring point cloud (Joao)