Individual Lab Report 4

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Team B: Arcus

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Individual Progress

I was responsible largely for designing the sensor mounts, integrating and mounting the sensors, and helping with camera-IMU calibration the past two weeks. Additionally, I also worked with Logan to build a wooden mount for the UAV that would sit on a truck bed for data collection at the Lafarge quarry.

For modeling the sensor mount, I worked in Solidworks to create a design similar to the drafted design mentioned in the previous ILR. After a few iterations, I passed on my design to Logan, who edited and refined the design further. However, much of the original ideas were preserved. The general layout stayed the same, where the batteries were placed in a carriage directly underneath the base plate, the Velodyne was at the bottom, and the RGB camera was mounted in between the two carbon fiber rods. The envelope idea that encased the ends of the rods was kept, which was the piece that interfaced with the rest of the UAV, keeping the mount attached. Finally, a separate plate was created for the LiDAR as a “handle” because, ideally, this sensor should not be touched to avoid smudging of the glass surface.

However, there were also some changes that needed to be made to the original sketched idea. The sensor mount design from the initial brainstorm contained the batteries, mvBlueFox RGB camera, and Velodyne LiDAR sensor. It was later realized that the IMU also needed to be mounted with these sensors because different vibrations might be experienced by the IMU if it were mounted on top of the chassis. This also led to the design parameter that as few pieces as possible should separate the sensors from each other so that they were all experiencing the same dynamics from their environment and so it would be easier to correlate data read from each one. Therefore, the IMU and RGB camera were both integrated into the front subsection of the assembly, which is also where the batteries were placed. Additionally, the camera mount was previously sketched as adjustable to find a field of view that would intersect with the LiDAR, but it was clear that there was a potential slippage issue. Because the camera had a fisheye lens that allowed for a 180° FOV, I was able to project this FOV in Solidworks to find an appropriate angle and design an integrated mount that was already at the appropriate angle into the undercarriage. I also added hard stops that would keep the sensor mount rigid with respect to the chassis since the rods were free to slide along their axes. To keep the batteries secure, I added slots in the chassis for additional Velcro straps that would keep them strapped in but also allow for easy battery removal. As an aside, we have also added foam to the batteries to prevent against shock and vibrations while flying and landing. The front subsection, back subsection, and bottom plate of the undercarriage can all be seen in Figure 1a, 1b, and 1c, respectively. The assembled sensor mount assembly can be seen in Figure 2.

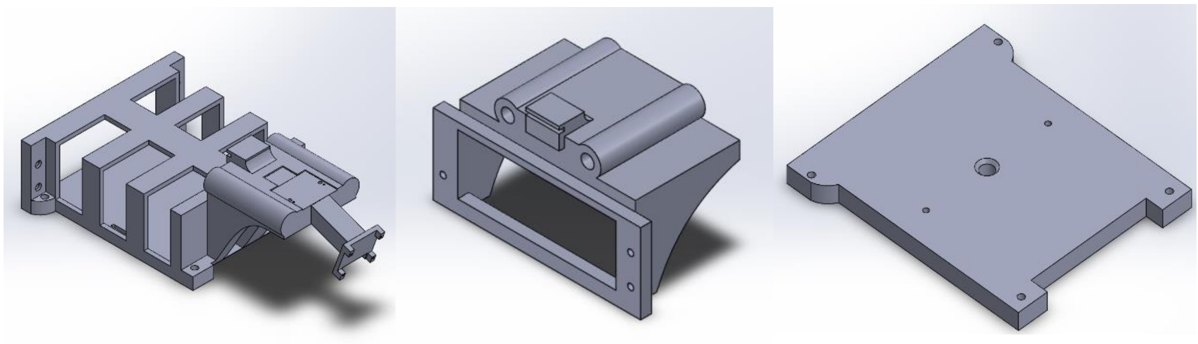

Figure 2: *Sensor mount assembly (a) Front subsection which holds batteries, IMU, and RGB camera, (b) back subsection, (c) bottom plate that holds the Velodyne*

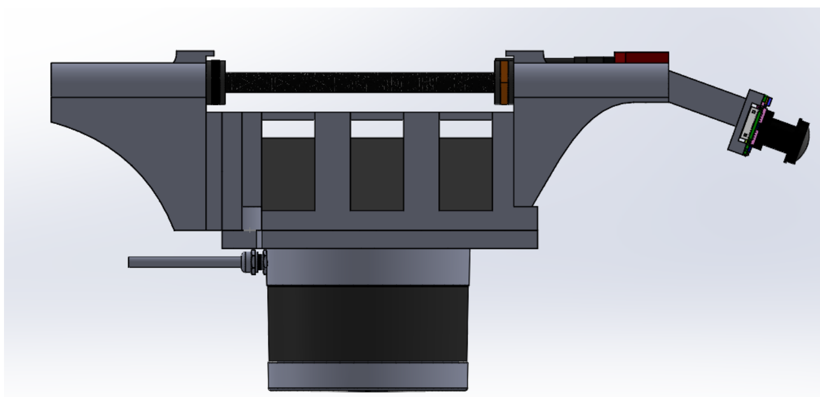

Figure 1: *Full sensor rig*

Although the general idea was captured for my version of the sensor rig, to reach consensus, I sent the model to Logan, who made some further alterations to the assembly. Namely, he removed all four walls that enclosed the battery carriage, extended the sides of the front and back subsections, and removed the hard stops, which turned out not to be necessary because the rods were inserted into rubber bushings with high friction. To make the parts lighter and improve the overall appearance, he cut out pockets of material and filleted the assembly. The UAV with the sensor rig can be seen in Figure 3, and the physical assembly can be seen in Figure 4.

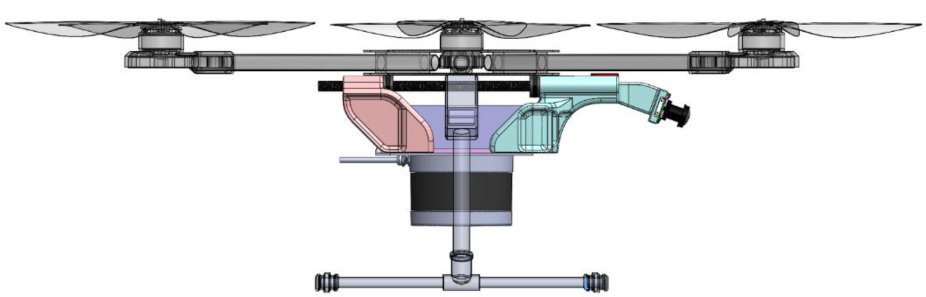

Figure 3: *CAD of UAV and mounted sensor rig that Logan refined*

Figure 5: Physical UAV with 3D printed sensor rig mounted.

Finally, I worked with Logan to assemble a wooden mount for the UAV for data collection at Lafarge. We based its height on the tripod that we used for the Velodyne and GPS mount the first time that we collected data at Lafarge. The mount consisted of two A-frames joined together by a bridge at the top that was where the UAV was mounted. It had two crossbars to prevent twisting and was seated with a rectangular base of planks seated in pre-existing channels in the truck bed. The mount and truck combination was, together, 9 ft. 10 in. high. The team, mount, and UAV can be seen in Figure 5 at the Lafarge quarry..

Figure 4: Data collecting at the Lafarge quarry with team B and Arcus (UAV).

Challenges

One of the challenges that I faced was in making the sensor mount design too complex. Originally, I had legs that extended down from the envelope to the battery carriage, but, after discussing with Logan, I saw that this actually weakened a part that needed to be quite strong. I basically reworked the part, creating a thick rectangular block that I took arc-shaped cuts out of to preserve some strength while also removing material.

Teamwork

Logan Wan: Logan was responsible for reviewing the power distribution board schematic and designing the layout; made revisions to the sensor mount CAD and 3D printed and fabricated the mounts; helped integrate and mount the sensors onto the UAV; and designed and built the UAV mount for data collection at Lafarge.

Angad Sidhu: Angad was able to resolve issues with the Kalibr image formatting and worked out the LiDAR-Camera Calibration, where the ROS package Velocam was being used. This involved troubleshooting different OpenCV versions to find which would work with Velocam.

Maitreya Naik: Maitreya was the lead on camera-IMU calibration, where he ran Kalibr to collect a few datasets and then further collected camera data using a ROS package for fisheye lens. He also reviewed the schematic and layout done by Logan.

Altogether, the team went out to the Lafarge quarry to bag some data from both the LiDAR and the RGB camera. Ricky was responsible for most of the software setup (we had help from our PhD advisor) and monitoring the data collection. Logan, Maitreya, and I set up the physical test setup on the truck bed.

Future Plans

For the next milestone, I will be beginning research into mapping and understanding how to update the mapping framework to support multiple modalities – i.e., RGB data to colorize a 3D point cloud map created by the LiDAR. On the hardware side, I will be further improving the sensor mount design; we hope to create an energy absorber layer or cradle for the Velodyne to prevent damage, as well as improve the strength of the overall sensor mount assembly through experimentation with 3D print parameters and making the base layer out of carbon fiber instead of MDF.