Individual Lab Report - 3

Lunar ROADSTER

Team I

Author: **Ankit Aggarwal**
Andrew ID: ankitagg
E-mail:
ankitagg@andrew.cmu.edu

Teammate: **Deepam Ameria**
ID: dameria
E-mail: *dameria@andrew.cmu.edu*

Teammate: **Bhaswanth Ayapilla**
ID: bayapill
E-mail: *bayapill@andrew.cmu.edu*

Teammate: **Simson D'Souza**
ID: sjdsouza
E-mail: *sjdsouza@andrew.cmu.edu*

Teammate: **Boxiang (William) Fu**
ID: boxiangf
E-mail: *boxiangf@andrew.cmu.edu*

Supervisor: **Dr. William "Red" Whittaker**
Department: Field Robotics Center
E-mail: *red@cmu.edu*

February 28, 2025

Carnegie Mellon University
Robotics Institute

1 Individual Progress

1.1 Wheel

The new wheel design iteration is based on observations made by testing the wheel in the Moon Yard. We observed that the grousers were too thick and could not dig deep enough into the ground to provide the required traction. Additionally, the wheel rim and overall strength were over-designed to meet our loading requirements. Hence, the new wheel iteration has thinner grousers and a thinner rim, as shown in Figure 1. Based on the next test, the wheel's grouser lengths may be altered, and the overall diameter of the wheel may be changed.

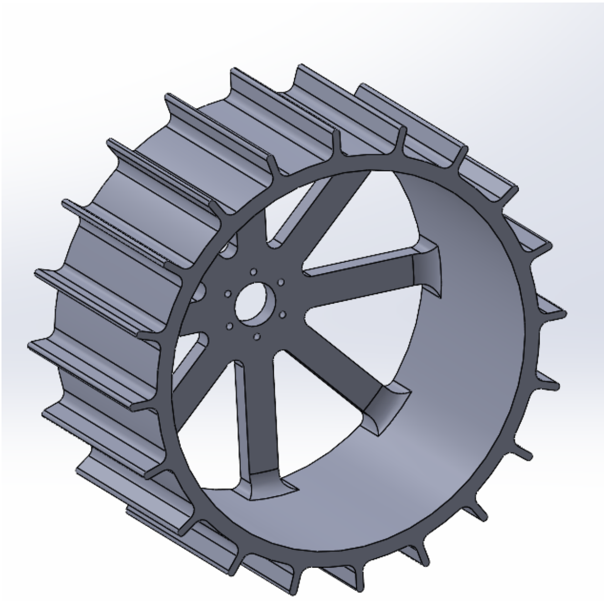
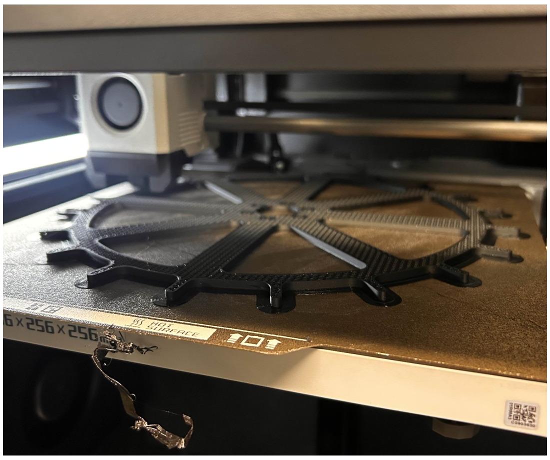


Figure 1: New Wheel Design Iteration

The 3D printing of the wheel is a long process, taking more than 20 hours each time. This causes many prints to fail and overall delays due to printer availability. Figure 2a shows a printed wheel, and Figure 2b shows the printing process.

(a) Printed Wheel

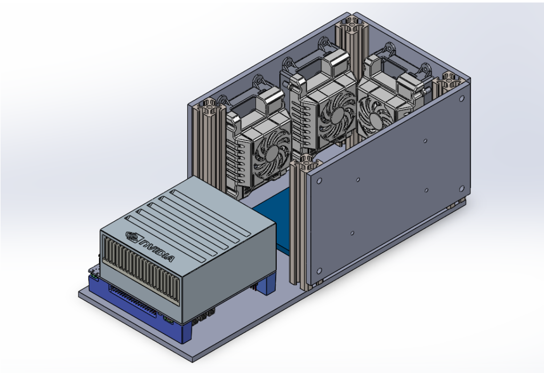


(b) Process of 3D printing in the Bambu X1

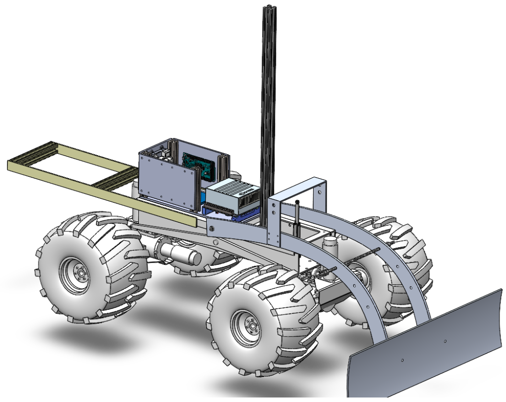
Figure 2: 3D printing the new iteration of the wheel

1.2 Electronics Box

I designed an electronics box to minimize the space the electronics take while maintaining secure connections. To optimize the space, I began by placing the RoboClaws (motor drivers) and Arduino vertically instead of horizontally and mounting them in a U-shaped enclosure. Figure 3 shows the design of the E-box.



(a) E-box Design



(b) E-box mounted on the drive system

Figure 3: CAD Design of the New Electronics Box

The walls shown will be laser-cut using an opaque acrylic sheet. I also plan to add a lid with a hinge to the top face to ensure accessibility while allowing protection against sand. Since we cannot accurately estimate the space that the wiring will occupy, I will design the lid after creating an initial physical assembly.

Since the PDB design has not yet been finalized, I have added a placeholder on the bottom face of the box (shown in blue). I will optimize further when we finalize the PDB.

1.3 Mapping

Using the FARO Laser Scanner, we mapped the Moon Yard and generated a point cloud. We took 3 different scans from distinct points, as shown in Figure 4, and stitched them together to form the final point cloud.

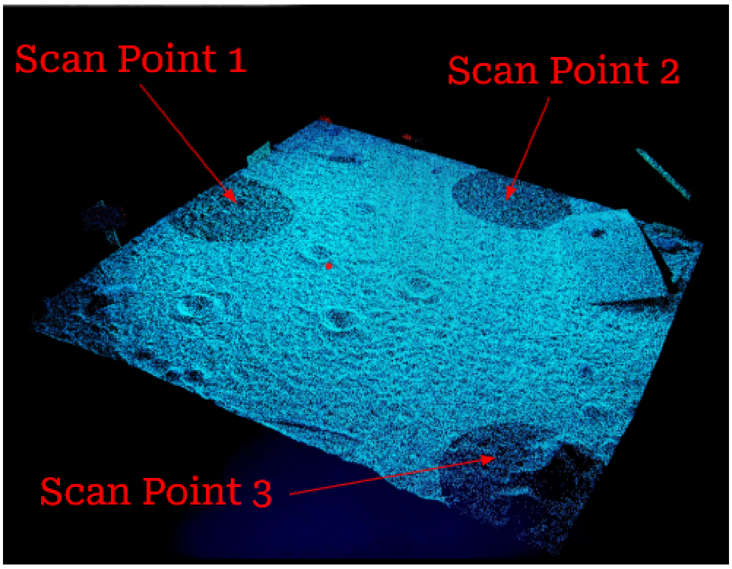
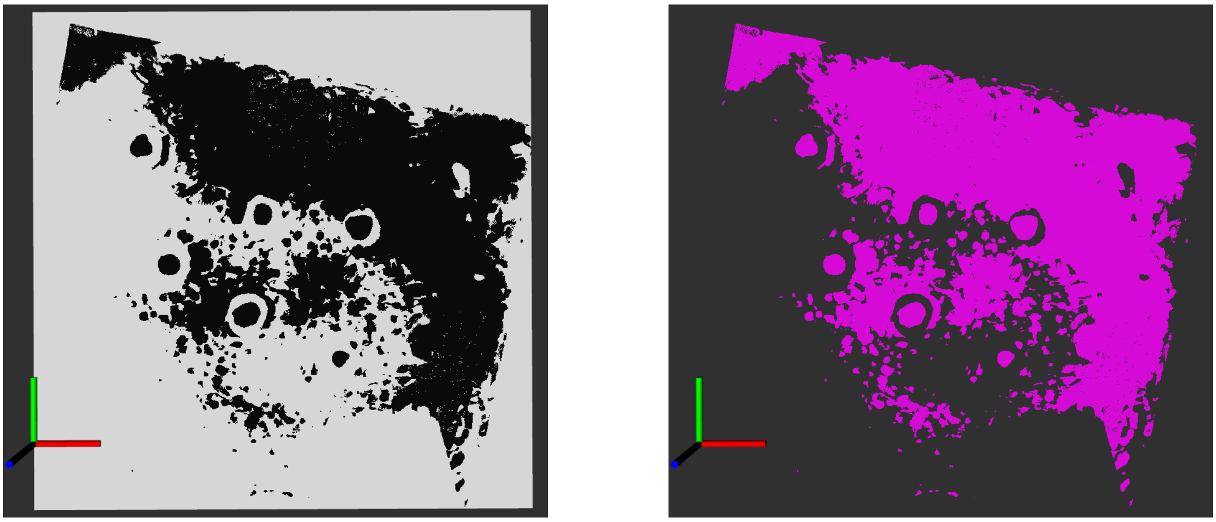


Figure 4: Moon Yard Point Cloud

Based on this, Simson and I created an occupancy grid and a cost map by thresholding height values, shown in Figure 5.



(a) Occupancy Grid

(b) Cost Map

Figure 5: Maps visualized in Rviz

As seen in the maps, there are a few visible craters. However, due to the inherent unevenness of the terrain, the simple method of thresholding with height values does not give us the best output. To rectify this, we used RANSAC, which improved the result but not to a satisfactory extent.
We set up a sound methodology to create an occupancy grid based on the FARO's output. Next, we will dig deeper into craters in the Moon Yard to distinguish them from inherent unevenness and create a better map.

1.4 Dozer Manufacturing

Figure 6: Dozer Assembly

I aided Deepam throughout the manufacturing of the dozer assembly, shown in Figure 6. Each of the parts was designed and manufactured in the FRC machine shop. The machining methods we used were:

1. **Dozer Blade:** We used a sheet metal rolling machine to bend an Aluminium sheet into our desired curvature.
2. **Dozer Arms:** The main design of the Arm was milled using a CNC router. Further, we used the vertical drill to create the required bolt holes.
3. **Cross Members:** We used cutting machines and Aluminium tubing to create the cross members that provide support and an actuation mount to the assembly
4. **Mounting L-brackets:** We cut and drilled L-profile aluminum tubing using hand tools to assemble all mounting brackets.
5. **Actuator:** We selected the required linear actuator using torque calculations around the pivot.

We also selected the required linear actuator using torque calculations around the pivot.

2 Challenges

For the wheel design, the biggest challenge is 3D printing. As the print is long (>20 hours), scheduling time with the printer is tough. Additionally, several prints have failed due to warping or extruder jamming. This has been causing delays throughout the design process.

For the Electronics Box design, estimating the wiring space is a challenge. I have only been able to assess by looking at the current wiring and will not be able to verify until the actual design is fabricated. This can cause issues down the line as the design may prove to be sub-optimal.

The manufacturing task was a challenge, inherently due to the complex design. We spent several hours iterating over the manufacturing parts. Additionally, the FRC shop timings are limited, causing delays in our work.

3 Teamwork

I collaborated with Deepam to manufacture the dozer assembly and conceptual design for the PDB. I collaborated with Simson to create occupancy maps from the mapped point cloud data of the Moon Yard. I collaborated with Bhaswanth to create the schematic of the PDB. To design the new electronics box, I used inputs from everyone on the team to ensure accessibility.

The following are my teammates' contributions to the project:

Bhaswanth Ayapilla: Bhaswanth's main work was in collaboration with William to implement the rover's localization stack. The global and local localization code is complete, and they will be testing it in the coming week. He also collaborated with Simson in mapping the Moon Yard using the FARO laser scanner, which the team will use for navigation. He helped Deepam to operate the linear actuator for the dozer assembly. Additionally, he collaborated with me in creating the PDB schematic.

Simson D'Souza: Simson worked on mapping the MoonYard using a FARO laser scanner in collaboration with Bhaswanth. He then processed the data to generate an occupancy grid map, which will be used for navigation. To obtain an accurate occupancy grid map, several parameters had to be tuned, and I assisted him with that.

Deepam Ameria: Deepam spearheaded the manufacturing of the Dozer Blade Assembly. Individual components like the dozer arms, blade, mounts, etc. were manufactured at the FRC workshop in collaboration with me. He also collaborated with Bhaswanth and I for actuator selection and implementation to make an active dozer assembly. He also worked on conceptualizing the PDB for our system by drafting out the power requirements of the system and benchmarking the components.

Boxiang (William) Fu: William's work collaborated with Bhaswanth to implement the rover's localization stack. This includes local localization (Odom to base_link transform) using the IMU and wheel encoders and global localization (map to base_link) using additional data from the total station. His work is also related to Simson's work, as the map Simson provides will serve as the map frame for localization.

4 Plans

Our goals for the next PR are to have the dozer assembly tested, navigation and localization finalized, and a tool planner methodology set up. My individual goals will be:

1. Test the wheel and manufacture the next iteration
2. Develop and test a methodology for the tool planner
3. Manufacture the new E-box design
4. Test the dozer assembly and make any required changes
5. Finish the design of the PDB
6. Help in overall localization and sensor placement tests