Individual Lab Report - 2

Lunar ROADSTER

Team I

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1 Individual Progress

1.1 Mapping the Moon Yard

I am responsible for mapping the Moon Yard to generate a navigable map for autonomous robot operations. Initially, I utilized the FARO laser scanner to capture a 3D point cloud of the environment. However, post-processing proved challenging due to limited computational resources and the unavailability of compatible ROS2 packages. To overcome this, I attempted to use the ZED 2i camera, setting up its SDK and installing the necessary dependencies. However, I encountered compatibility issues with CUDA versions and difficulties integrating the SDK within a Docker environment.

To streamline the process, I transitioned to using the Intel RealSense D435i, which offers easier integration with our existing software stack and has extensive support, including resources available on the MRSD Wiki. I successfully set up the RealSense camera, installed the SDK, and verified that the sensor data was being published on ROS2 topics.

The objective is to convert the 3D point cloud data into a 2D costmap for navigation. To achieve this, I implemented the RTAB-Map (Real-Time Appearance-Based Mapping) technique to generate a map. As a preliminary test, I mapped our workspace and obtained point cloud data along with a corresponding 2D occupancy grid map as shown in Figure 1. However, the generated map does not currently classify craters with large diameters and depths as obstacles, which poses a challenge for navigation. My ongoing work focuses on refining the costmap to ensure accurate crater representation for safe and effective robot movement.

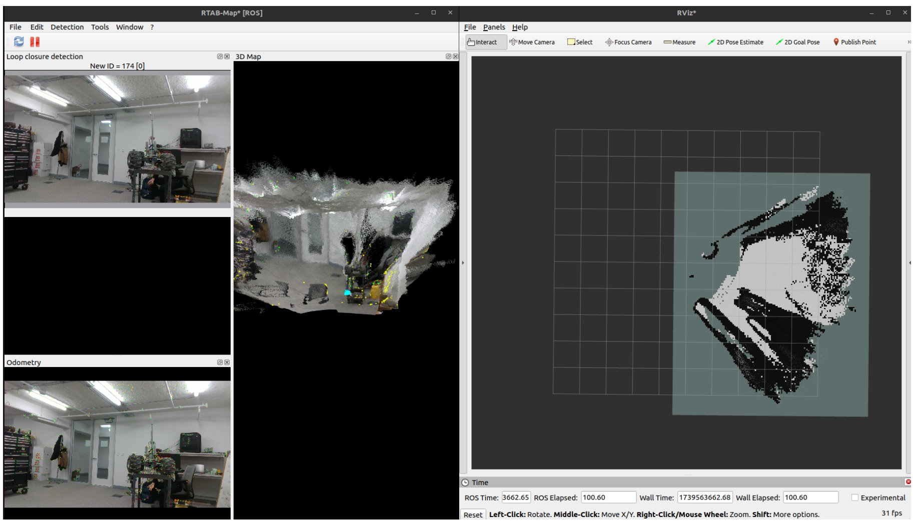

Figure 1: RTAB-Map and 2D occupancy grid map

1.2 Electrical Circuitry

Ankit and I are working to make the robot's electrical wiring more tidy and well-arranged. When the robot is disassembled, all wiring must be disconnected, making it difficult to correctly identify and reconnect components. To mitigate the risk of incorrect connections that could potentially damage components, I developed the electrical circuit diagram shown in Figure 2 to document the wiring layout.

Previously, the crater grader was equipped with a belly grader, which has now been removed. In place of this, we are integrating a dozer system driven by an electrical linear actuator. This actuator will be controlled by a RoboClaw 2x15A motor driver, which was previously connected to the belly grader. Additionally, we plan to replace the Intel RealSense D435i with a ZED 2i camera for improved perception capabilities. As the system evolves, the electrical circuitry will require updates to accommodate these changes. My current focus is on finalizing the circuit diagram and ensuring that all modifications are properly documented for future reference.

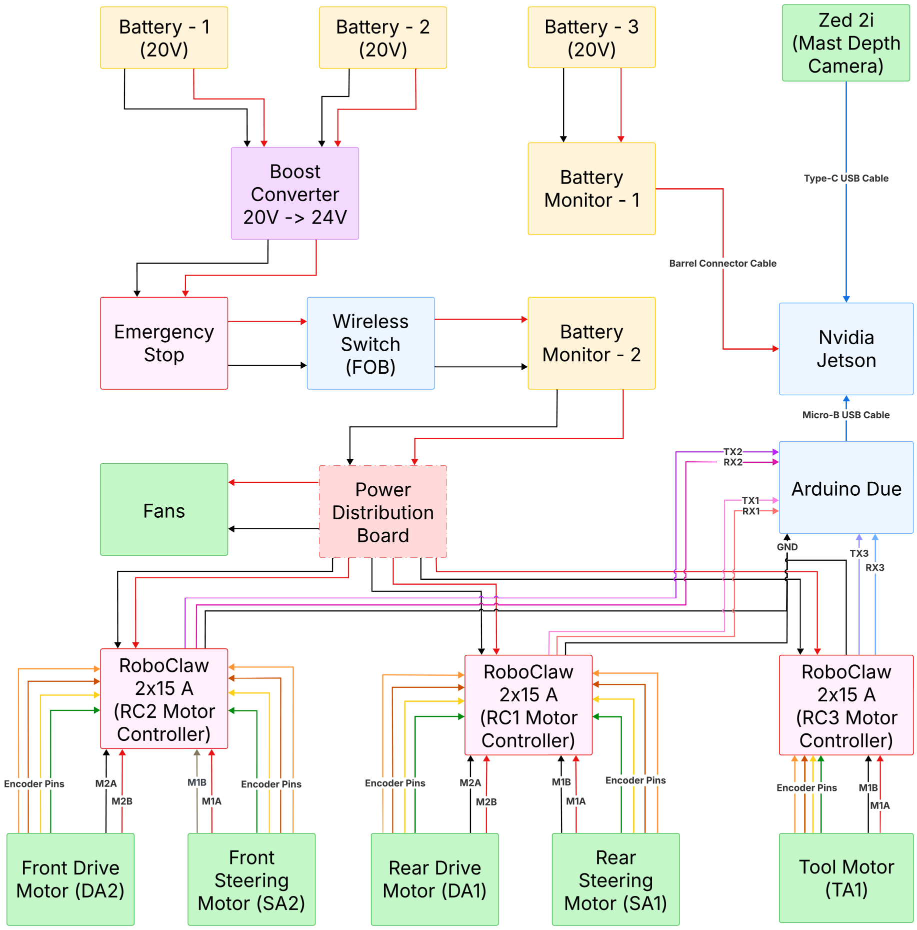

Figure 2: Electrical Circuitry

2 Challenges

One of the major challenges in mapping with the Intel RealSense D435i is the high level of noise in the depth data. Since I am using RTAB-Map to generate a 3D point cloud, the system relies on loop closure, a bag-of-words approach to determine location and refine the map for better accuracy. However, since I am currently performing handheld mapping, the noisy data makes it difficult to maintain consistent localization. As a result, the system frequently loses track of its position, leading to distorted maps that require restarting the mapping process from scratch. Additionally, the presence of noise in the depth data affects the accuracy of the 2D occupancy grid map, which is crucial for navigation.

To address this issue, I am considering mounting the depth camera on a small teleoperated robot or our main robot to improve stability during mapping. This approach would minimize the inconsistencies caused by handheld movement, allowing for more reliable data acquisition and a smoother, more accurate map of the environment.

3 Teamwork

Given my contributions outlined in the Individual Progress section, the following are the contributions of my team members.

1. **Ankit**: He worked on fixing the rover's drive system to allow the team to resume testing. For the steering system, he created a secure assembly and collaborated with Bhaswanth to introduce limit switches for robustness. He also collaborated with Deepam to discuss design iterations of the dozer blade. Additionally, he interfaced the IMU with ROS2, which enabled Bhaswanth and William to advance their work on localization. He took ownership of the PCB assignment, which facilitated the team to prioritize tasks on the project.

2. **Deepam**: He finalized the design of the dozer assembly, including the dozer blade, arms, mounting brackets, lifting mechanism, and linear actuator. He collaborated with Ankit to discuss iterations and ideas on the lifting mechanism, and with me to manufacture the dozer blade as shown in Figure 3. In addition, the team worked together to devise a structured test plan.

Figure 3: Dozer Blade

3. **Bhaswanth**: He worked alongside William in setting up the total station and developing the localization stack. He has also been working on visualizing the rover's pose on Rviz. He tried to get the already existing limit switches working, and this relates to Ankit's work on fixing the steering mechanism. His work also relates to me in interfacing the ZED camera with ROS, which will be used in navigation.

4. **William**: He collaborated with Bhaswanth to set up the external infrastructure for localization, which included configuring the total station, setting up the TX2 relay connected to the total station, and establishing the LAN network for data transmission to the rover. His work also relates to me, as the map I am generating serves as the world frame for localization.

4 Plans

Until the next lab demo, I plan to complete the mapping of the Moon Yard using the Intel RealSense D435i. To ensure that the data can be reused without needing to remap the environment repeatedly, I will record the sensor data published on ROS2 topics using ros2 bag files. Since RTAB-Map does not directly generate a 2D costmap, my next step will be to convert the 3D point cloud into a 2D costmap. I will also attempt navigation using the generated costmap.

One of the key objectives of our mapping process is to identify and avoid large craters, which is not inherently accounted for in the standard 2D costmap generation. To address this, I plan to develop a script to preprocess the point cloud data, including downsampling to reduce computational load and implementing a thresholding method to classify craters with large diameters and depths as obstacles. If this approach proves insufficient, I will explore the alternative of creating an elevation and traversability map based on known or calculated terrain characteristics and then translating that data into an improved 2D costmap for navigation.