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Computer Science Project

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Lunar IoT Progress Report 2

After the first progress report, substantial progress has been made on the Lunar IoT project. The group (Julie, Sam, Emily, Lekh & I) has consistently met every week, whether it be online or in-person, to work on the project. As a reminder of the group roles:

- Julie has been responsible for working on ROS2, pathfinding, and digital twin development.
- Samhith has been responsible for working on ROS2, pathfinding, and battery/robot modeling simulations.
- Emily (PM) has been responsible for working on battery/robot modeling simulations and digital twin development.
- Lekh has been responsible for working on communication over an MQTT broker, as well as providing some input in all other areas.
- I (PM) have been responsible for working on computer vision and communication over an MQTT broker.

Every member of the group has contributed greatly to the progress of our project and we would not be at the position we are in today without any one of them.

Late in September, the group had placed an order for all the supplies necessary for completion of the Lunar IoT project. These materials (i.e. ESP32 cameras, MicroROS rover, LED lights, circuit boards, etc.) were all received sometime in early October and they have since

been split among the entire group, depending on who is working on which sector of the project. Working on computer vision and data/device communication, I have been in possession of ESP32 boards and colored LED lights.

Beginning with our goals for computer vision, our plan is to enable the rover to identify battery stations and objectives on the lunar surface using the colored LED lights that will be placed on the demo models. To do so, I have had to create a Python program using OpenCV, a computer vision package, to isolate pixels in the rover camera's field of vision that lie within a certain hue & saturation range. The program I created has successfully identified the colors of red, yellow, blue, green, and white (the colors of our LEDs), however, there have been false positives due to lighting situations. Although I have tried to adjust the code to accommodate for lighting changes, there still remain some false positive identifications. Julie has thus stepped in to help with adjusting the HSV ranges and we now have a better working color identification function.

Another purpose to incorporate computer vision in our project is for subject mapping. The rover should be able to move between objectives and battery stations in the most battery and time efficient path. To do so, our group will employ the A* algorithm, which is typically used on a weighted graph. To create this graph, we plan to use an overhead camera that will split the area of the table into a coordinate grid. However, one of the issues with overhead cameras is image distortion, a curved or nonlinear view of areas further from the center of the image. My approach to fix this issue is to create a program which scans the table surface and maps each pixel into a fixed area in a 2D shape, similar to using a camera to scan a piece of paper. The end result would be a flat image of the table, devoid of any distortion, that we could then split into a grid based on size. After having coded this solution, however, the group realized that it might be too heavy of a

workload to have an ESP32 camera continuously send its camera steam to the rover over an MQTT broker. We have now decided to pursue a solution using TinyML, which will result in much more efficient data transfer. Our redirection is rather recent though, so we have not yet made substantial progress on this aspect of the project.

Another pressing matter is getting data to be communicated between devices via an MQTT broker. Battery stations and objectives will each be equipped with an ESP32 board that will be programmed to subscribe to a topic on an MQTT server and publish their battery information to another topic when requested. I am in charge of creating the code to do so. One challenge that I faced while working on this part of the project was coding in C++. I am unfamiliar with this programming language, so I have had to take the time to learn the basics and follow tutorials to get the ESP32s to successfully connect to wifi and publish/subscribe to MQTT topics. Despite this challenge, the ESP32 boards now do what they have been planned to.

Taking into account the progress of the entire group, we have met most milestones on our Gantt Chart (pictured below). We have successfully configured the rover, which is now able to move and connect to wifi, simulated the robot in a digital environment using Unity and Cesium, and worked on asset tracking of objectives and battery stations. We are somewhat behind schedule on battery modelling via PyBaMm, however, only by a few days. The group strongly believes that we will be able to accomplish this milestone, as well as all the other upcoming ones on the chart. We have also learned a great deal from this project, learning about advanced technologies, such as Dreamscape and WiFi HaLow, and also interpersonal skills through weekly meetings with students from Rowan University and employees from NASA Stennis Center. Although there is less than a month left and still a significant amount of work to be done on this

project, the group remains dedicated to completing it and will do our best to provide satisfactory work.