Preliminary Trials with GoPiGo3 and LIMO Robots in the Virtual and Physical Realm
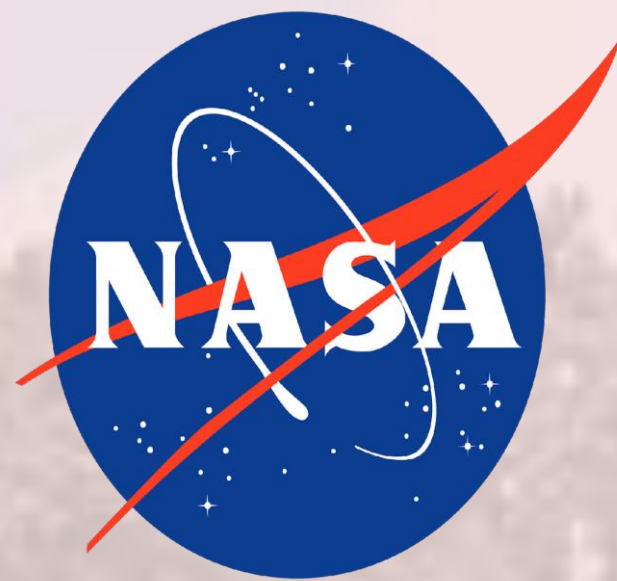
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Introduction:

Figure 1 shows the LIMO[1] and GoPiGo3 robots that were used in this experiential learning project over the summer. The physical robots are available at the robotics lab in UMES and some undergraduate students worked on them. The highschool students worked on this project remotely. They simulated the robots using Gazebo and Robot Operating System (ROS). Setting up the virtual environment introduced the students to the Linux operating system as well. Gazebo 3D dynamic simulator also allowed setting up a variety of virtual layouts including surfaces robots may encounter such as earth soil and lunar regolith. Researchers at NASA have used Gazebo to simulate lunar and martian environments for simulation studies with robotics.[2]

Testing LIMO and LiDAR in a physical environment:

The LIMO's camera can identify people and objects. The student is clearly visible as shown here (Figure 2), and is identified with a 96% certainty. The student that is sitting, however, can only be identified to a 41% certainty. The coordinates of both students are also shown in the terminal.
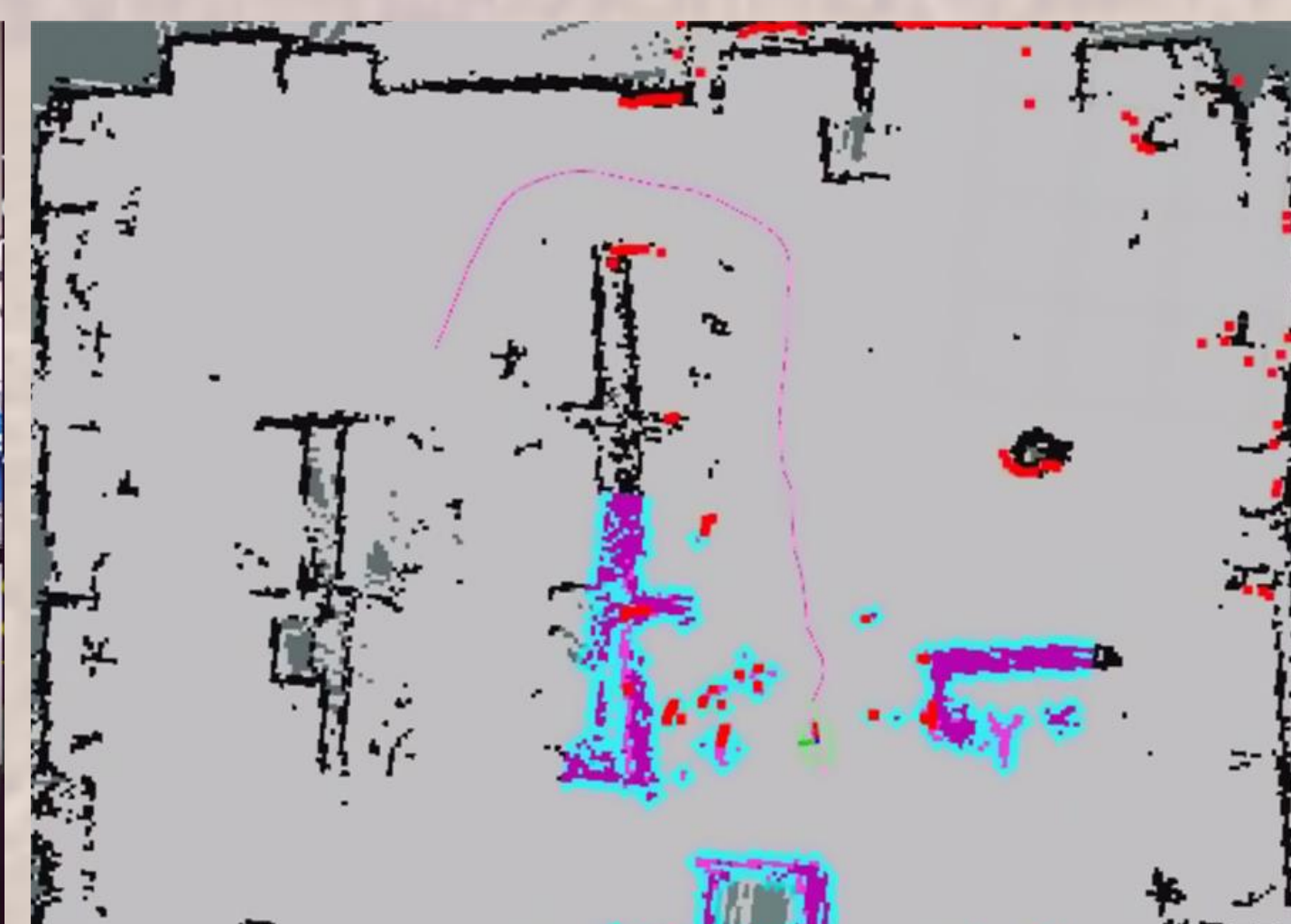

Figure 2. LIMO's camera identification of students

Figure 3. Map of robotics lab with GMapping and LiDAR by the LIMO navigating unobstructed

The LIMO robot is equipped with a LiDAR sensor, which it uses to scan its environment. A map of our research lab was made by driving the LIMO around with the GMapping[3] software running (Figure 3). The black line indicates what the LIMO understands is a stationary object, gray is clear floor space, red indicates what the LiDAR currently sees, and purple and blue is what it assumes is there from past scans. The red and green axis marks is where the LIMO thinks it is, with red being forward. The purple line is the path it intends to take to get to the set goal.
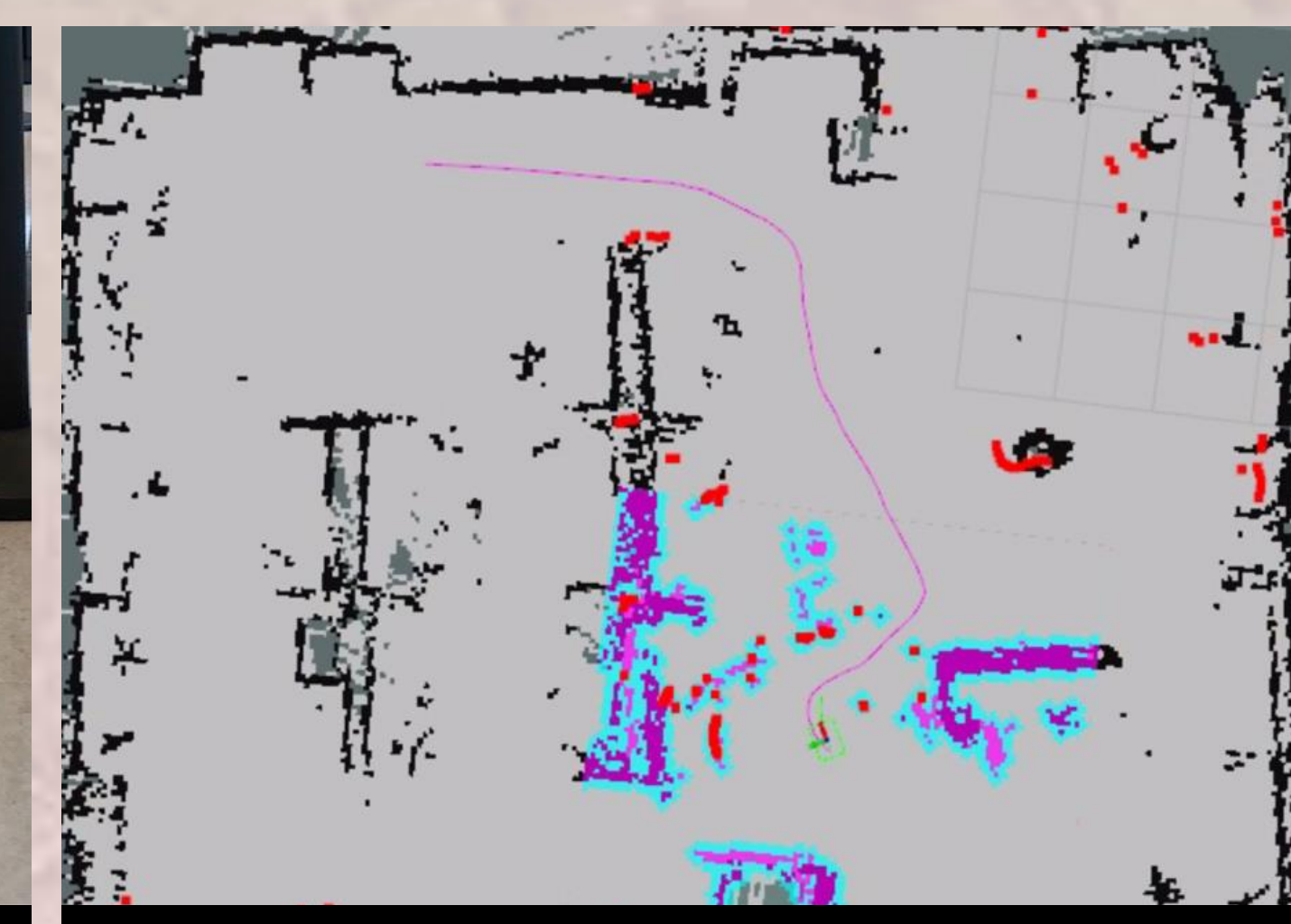

Figure 4. Student standing in original path

Figure 5. Updated path with student in the way

The LIMO automatically corrects it path to avoid the student. The student's shoes can be seen as the two large red dots in front of the LIMO and his past footsteps can be seen behind him. The LIMO will get rid of these after images when it confirms there is nothing there, it is with this method that the limo only maps stationary objects
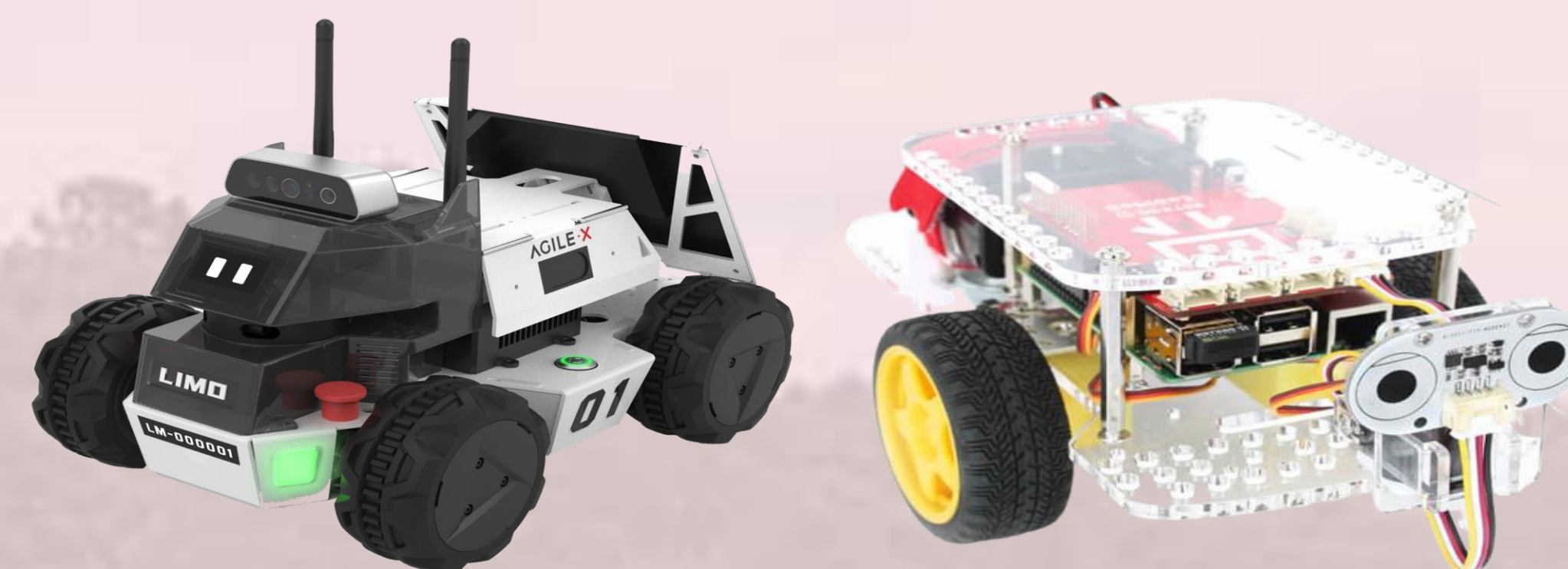

Figure 1. LIMO and GoPiGo3

Software:

Gazebo - A free and open-source 3D dynamic simulator that can simulate robots in complex environments

ROS - The Robot Operating System (ROS) provides hardware abstraction, device drivers, libraries, visualizers, message-passing, and more

Ubuntu - free and open-source Linux-based computer operating system

RViz - 3D visualization tool for ROS that allows users to view the simulated robot model, log sensor information, and replay the logged sensor information

Hardware:

LIMO - ROS-compatible mobile robot that uses LiDAR and other sensors for navigation by Agilex Robotics

GoPiGo3 - ROS-compatible mobile robot based on the Raspberry Pi that is easy to use and can be programmed with Python.

LiDAR[Light Detection and Ranging] - A remote sensing technology that uses light to measure distance.

Testing LIMO and LiDAR in a virtual environment:

Agilex also offers support for many of their products in simulating them in virtual terrains using Gazebo and ROS. To utilize them, the highschool students installed ROS Noetic on Ubuntu 20.04, and entered ROS commands in the Linux terminal to initialize the LIMO with visualization from RViz[4] and Gazebo[5]. Inspired by NASA's work with Open Robotics in creating a realistic lunar terrain for testing rovers, heightmaps and data from NASA's Moon Trek Portal[6] was used (Figure 5.)
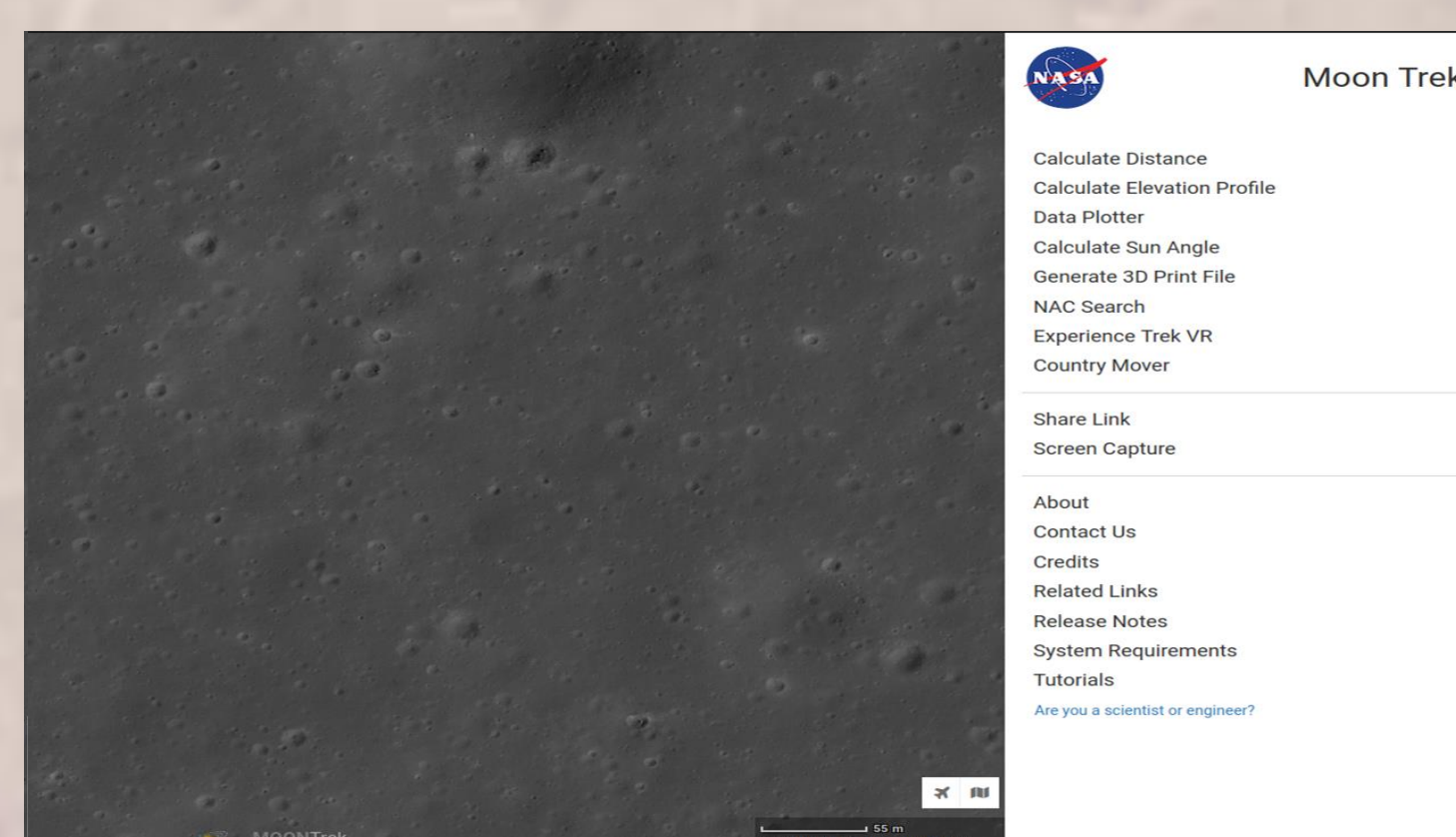

Figure 6. MoonTrek window of Apollo 15

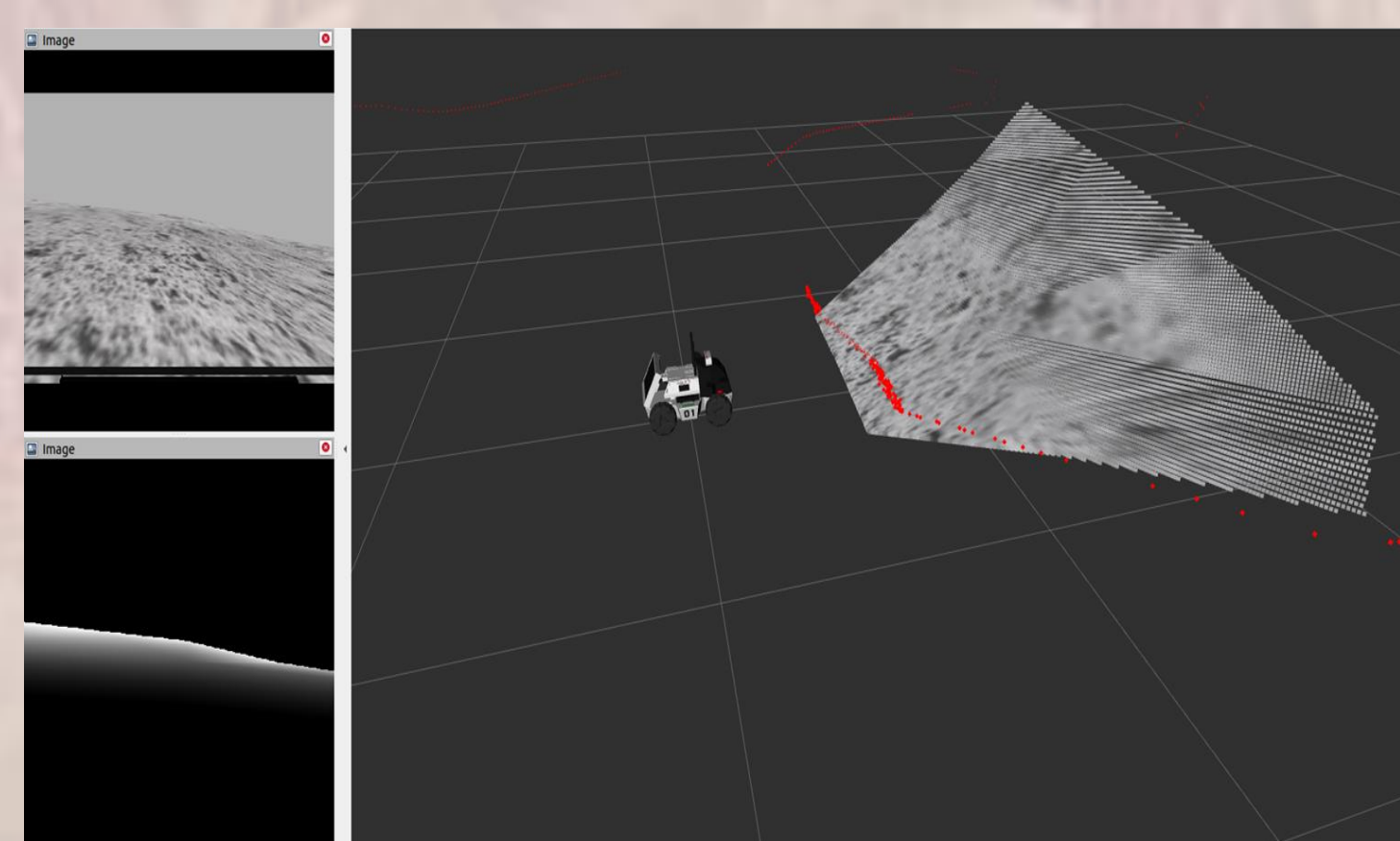Figure 7. Preliminary Gazebo simulation
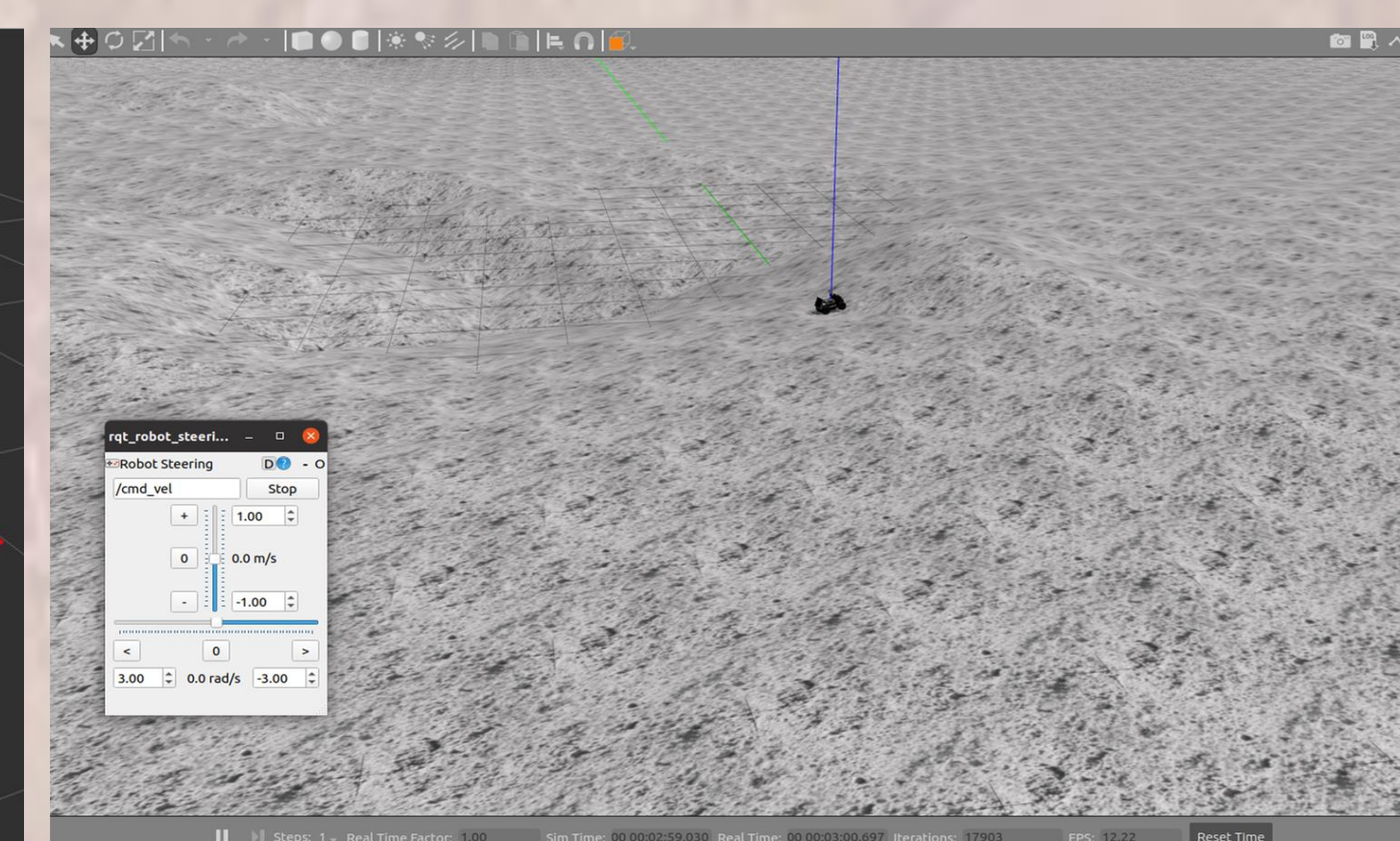

Figure 8a. RViz window of LIMO

Figure 8b. Lunar terrain in Gazebo

The RViz display shows the sensor data from the LIMO as it drives on the lunar terrain in Gazebo

The LIMO can be seen and driven on the generated lunar terrain in the Gazebo window

Exploring GoPiGo3:

The GoPiGo3 is a programmable piece of hardware that can be attached to a robot such as the DEXTER Line Follower. GoPiGo3 has its own Wi-Fi network and, upon linking one's computer to this Wi-Fi Network, can be programmed using Bloxter to make the Line Follower move forward, backwards, turn, or to follow a black line on a white background using the line_follow command. It can also be programmed in Python, allowing for a smoother following of the line by using PID Controls. The GoPiGo3 can be followed by the Moorebot Scout's (Figure 9) AI recognition capabilities and can map its environment by mounting an RPLidar Slam on top (Figure 10a). The RPLidar Slam and GoPiGo3 can be simulated in virtual environments such as Gazebo and Rviz (Figure 10b).
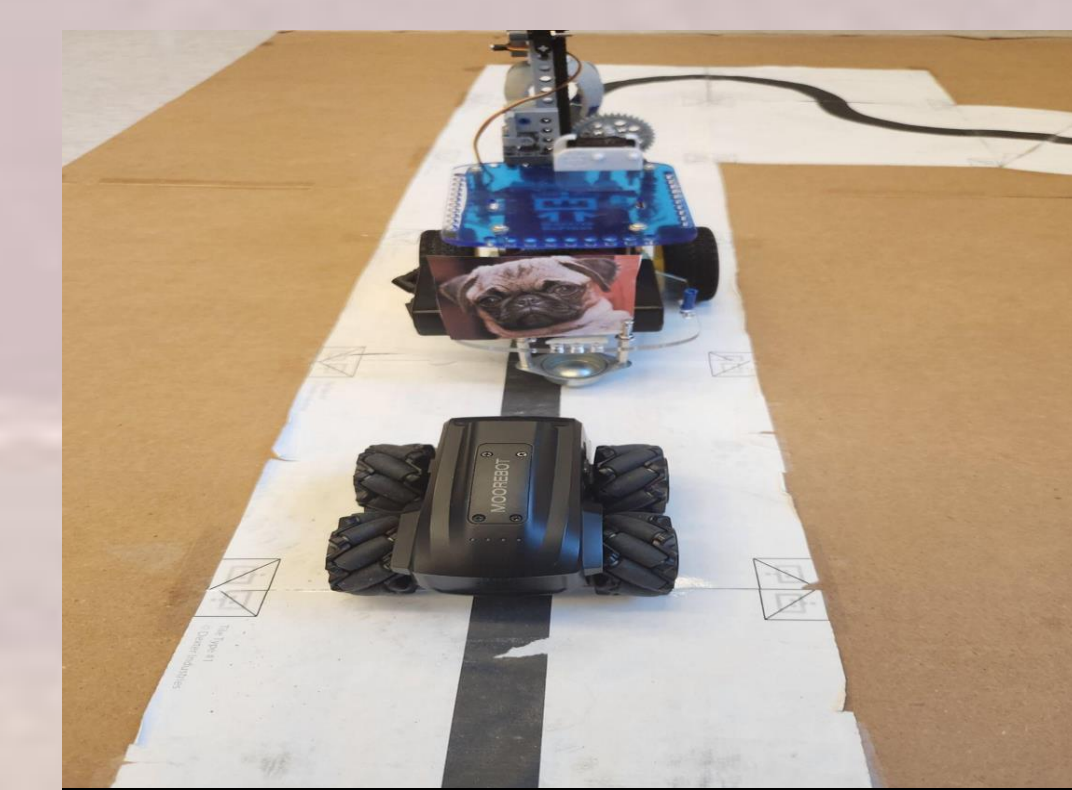

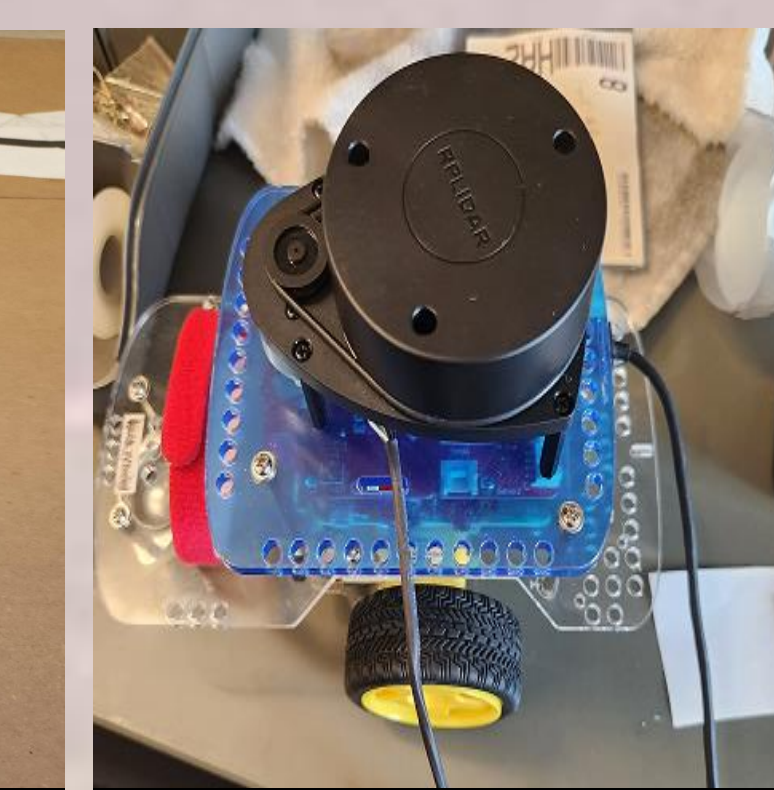Figure 9. Moorebot Scout following GoPiGo3

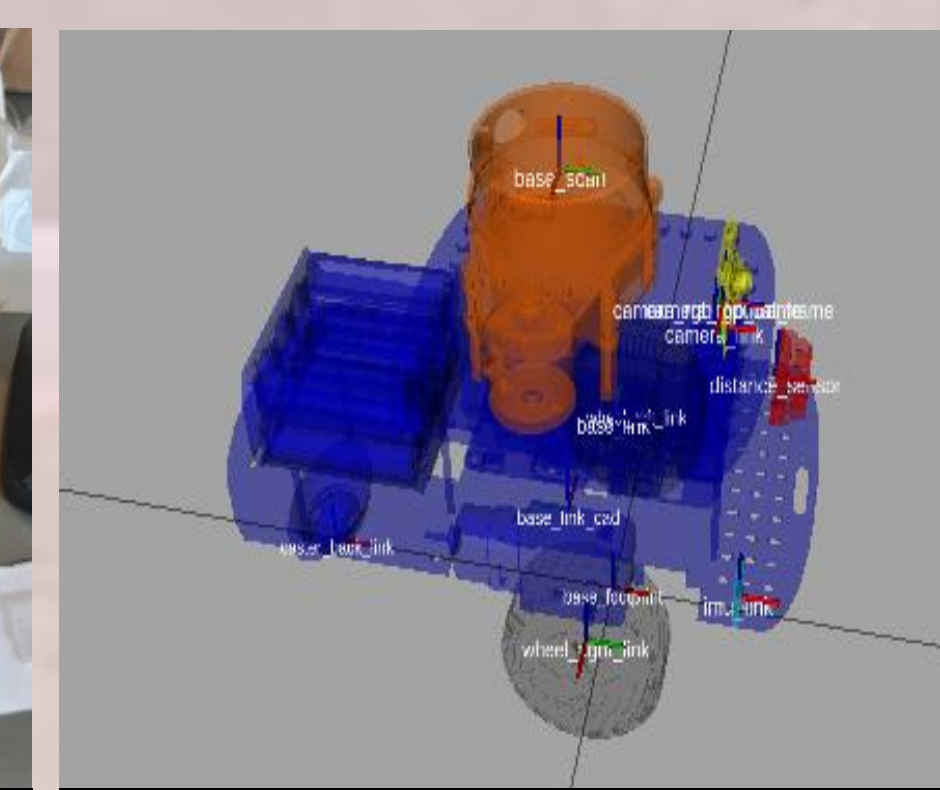
Figure 10a. Lidar and GoPiGo3

Figure 10b. Lidar and GoPiGo3 in RViz

The Moorebot Scout is a robot with programmable motion and AI recognition. It can be made to follow the GoPiGo3 by attaching a picture of a dog, cat, or human to the back of the robot that the GoPiGo3 is attached to. The LiDAR Simultaneous Localization and Mapping (SLAM) uses light from laser beams to map out its surroundings by measuring the time it takes for light to hit an object and rebound, in a manner similar to radar and sonar. It also simultaneously locates itself within the map it creates through SLAM. LiDAR-SLAM efforts with GoPiGo3 is currently underway.

Successes/Pitfalls/Learning outcomes:

- Initial difficulties with Ubuntu and ROS installation were overcome. Understanding and utilizing the MoonTrek data to create height maps and textures for the Gazebo world was challenging but over time and by studying documentation extensively, the success as reported in this poster was accomplished.
- LIMO was acquired by the robotics lab this summer, however it took longer than expected to get delivered to the lab which delayed some of the implementation plans.
- Working as a four member team where some members were not present in the lab and had to work virtually
- Moorebot Scout's Monitor mode followed target too quickly, crashing into GoPiGo3. Speed needed to be programmed in Scratch using the Scout app's Program mode.
- Scout was initially expected to recognize images placed higher up more reliably than lower down, however upon testing its AI recognition capabilities, the opposite proved true.
- Exposure to Linux operating system as well as Gazebo, ROS, Rviz, Gmapping and SLAM
- Learning about poster presentation basics (for some of the highschool students)

Conclusion:

The exposure has opened up several possibilities that can be explored in the future both in the physical and virtual domain. The highschool students are excited about continuing this work in the future in the virtual environment and remain in touch with the students in the robotics lab at UMES.

References:

[1] *Agilex Limo*. AgileX LIMO - AgileX LIMO Documentation. (2022). https://docs.trossenrobotics.com/agilex_limo_docs/
[2] M. Allan *et al.*, "Planetary Rover Simulation for Lunar Exploration Missions," *2019 IEEE Aerospace Conference*, Big Sky, MT, USA, 2019, pp. 1-19, doi: 10.1109/AERO.2019.8741780.
[3] Gmapping, https://wiki.ros.org/gmapping
[4] Rviz, https://wiki.ros.org/rviz
[5] Gazebo, https://classic.gazebosim.org/tutorials?tut=ros_overview&cat=connect_ros
[6] NASA MoonTrek Portal, https://trek.nasa.gov/moon/