Robotic Navigation using LiDAR

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Introduction

Robotics continues to increase its prominence in technology through focus on improvements in machine learning and autonomy. A useful remote sensing technique in this regard is light detection and ranging, also referred to as LiDAR. This uses light to allow a robot to navigate and update location in real time.

Employing LIDAR and other hardware, research was conducted on self-navigating robots. Using a Raspberry Pi 3, a single board computer (SBC), to facilitate communication with LiDAR, a robot was able to maneuver and function on its own. The ROS2 Foxy Robot Operating System, a system of libraries allowing the robot to map and model the environment, was also used.

The goal of this research is to have multiple sensors on the robot that perform distinct functions based on information processed by LiDAR. This allows the robot to navigate a space independently, adapt to environmental changes, and to live track a moving object.

Assembly

Building a robot that can autonomously drive began with exploring TurtleBot3. This is a kit that provides everything (including motors and wheels) needed to start working with and controlling a robot with LiDAR. I converted the operating system on an older Dell computer to Ubuntu 22, a Linux operating system, that allows for easier implementations of required software. Then, I connected a Raspberry Pi 3 to Wi-Fi, and uploaded the proper libraries and files needed for the SBC to control the OpenCr motor controller board and LDS-02, the LiDAR module. The assembled TurtleBot3 can be seen in Figure 1.

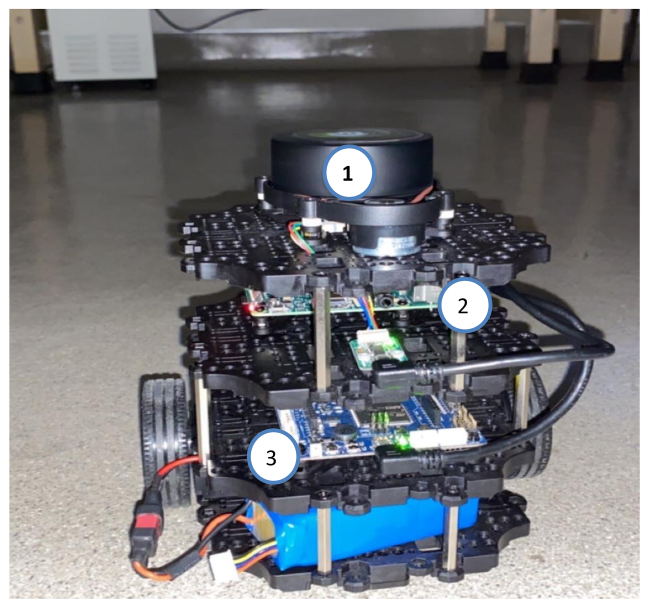

Figure 1: The fully assembled TurtleBot3 is seen to the left. The OpenCr (1), the Raspberry Pi 3 (2), and the LDS-02 (3) are shown.

Mapping and Movement

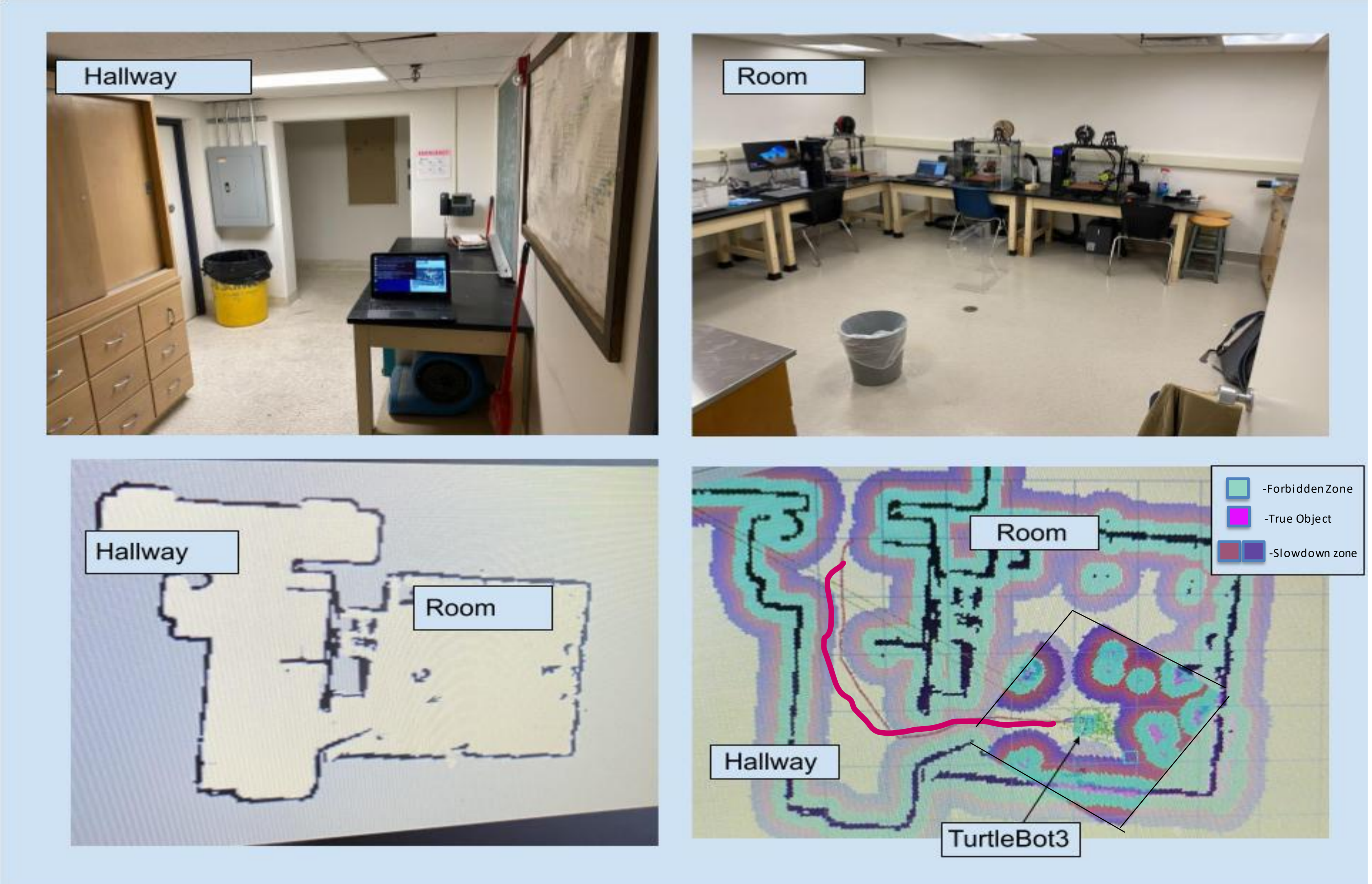

Figure 2: The top two figures show the actual environments that the LDS-02 scanned. The bottom left shows the baseline map of the room generated using the ROS2 Cartographer. The bottom right shows the map file combined with the LiDAR data (the square seen around the TurtleBot3) that are used to navigate to a desired target location. The red line is the TurtleBot3's path to the target.

The next step was to test the robot's navigational capabilities in different environments. Figure 2 depicts one test using a hallway and lab room. In this test, I established a link between the SBC and Dell computer using Wi-Fi. I launched ROS2 Cartographer, a program that constructs a baseline map of the room and hallway using the LDS-02 mounted on the TurtleBot3. Using the TurtleBot3 keyboard, I remotely controlled its movements to create the map. This map is continuously updated by LDS-02 readings interpreted by the RViz2 Navigator, which is an application that combines real time LiDAR readings with the baseline. The red line shown in the lower right picture in Figure 2 depicts the path created by Navigator. I then examined different navigational variables, such as the robot's ability to distinguish obstacles at a separation defined in Navigator. Figure 3a shows the result in low light levels. Figure 3b shows the environment that was explored. With the target fixed, the TurtleBot3 successfully navigated the same obstacles given different initial positions. For each initial position, the Navigator seemed to choose the most efficient path to the target.

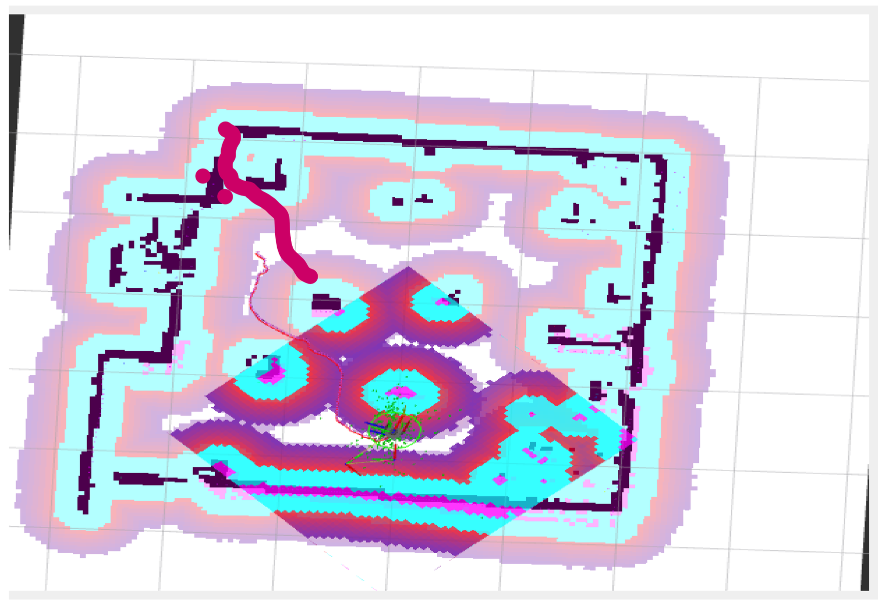

Figure 3a: Seen here is a Navigator map of the environment in low light.

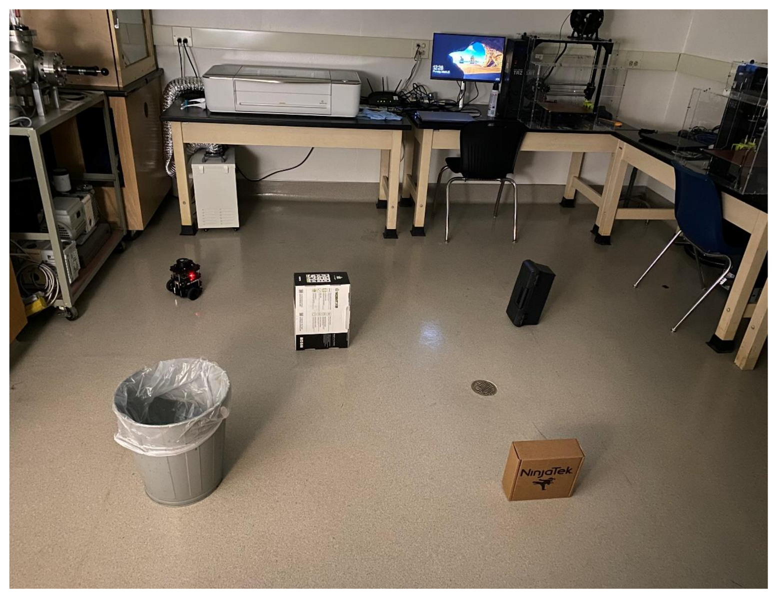

Figure 3b: Shown are obstacles that TurtleBot3 had to avoid in the dark.

Future plans

There were quite a few technical issues that I had to struggle with to get the LiDAR up and running, but now I have a robust system. I plan on placing the LDS-02 on a new tracked robot (Figure 4) for better mobility that will include the use of motor controllers, an Arduino Mega microcontroller, and various sensors (Figure 5).

Using SolidWorks, I will design different removable sensor packages to be mounted on the chassis. Each package serves a different purpose. For example, one package could collect temperature, humidity, light, and CO2 level data. Another package could be designed to convert the robot into a Mailbot.

The long-term goal is to create a robot that can independently operate and perform functions determined by the package attached to the robot. Using the LDS-02 will assist in mapping and adaptively navigating an environment in real time.

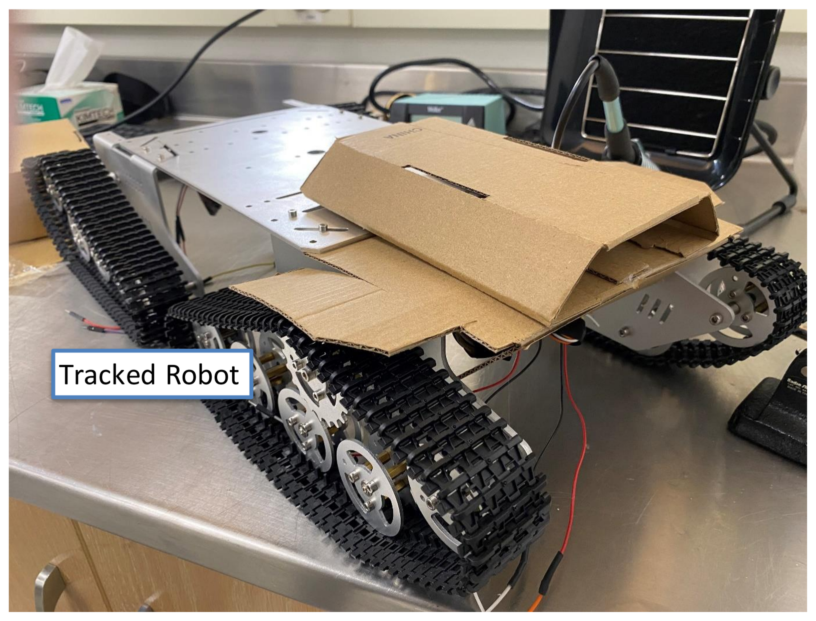

Figure 4: The tracked robot is shown with a cardboard prototype mount for the LDS-02.

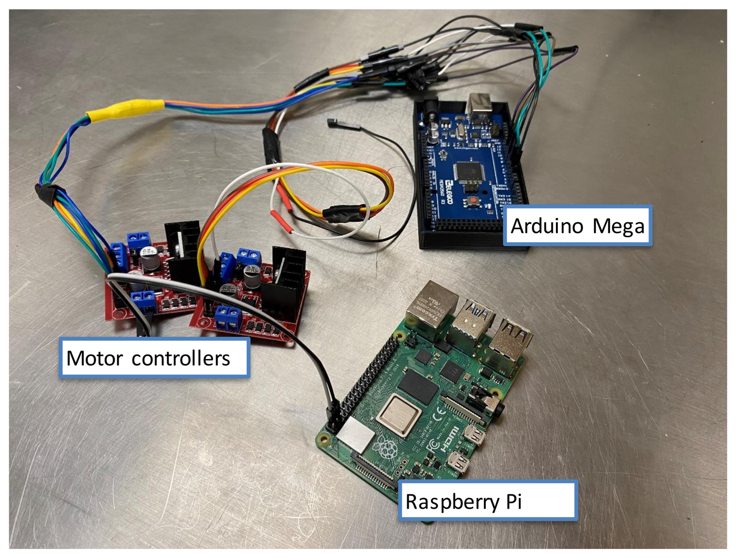

Figure 5: This shows the motor controllers paired with the Arduino Mega, which are operated by the Raspberry Pi 3. This could comprise one package.

References and Acknowledgments

References

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