Intelligent Autonomous System Project3 Writeup Checkup

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Introduction:

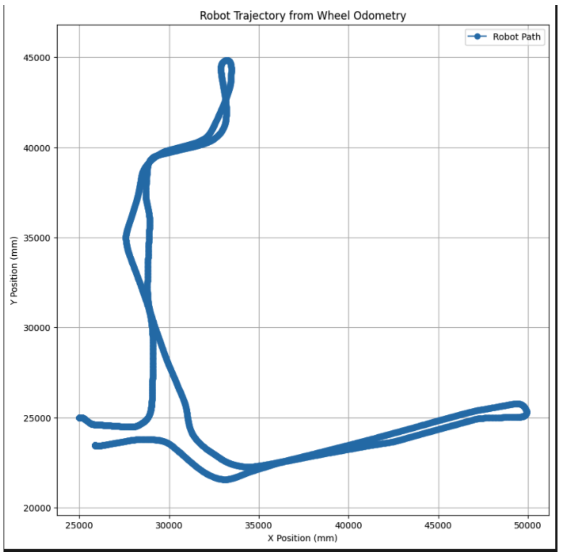
For the third project in the Intelligent Autonomous Systems course, we were given the task of implementing mapping and localization in an indoor environment using information from wheel encoders and range sensors. We integrated wheel odometry information from a mobile robot with a 2D laser range scanner (LIDAR) in order to build a 2D occupancy grid map of the walls and obstacles in the environment. We were provided with training sets of odometry, inertial, and range measurements from a mobile for this project. But the purpose of this writeup is only to give my current progress in this extensive project and showcase that I have successfully plotted the trajectory of the mobile robot and plotted all the LIDAR data points and mapped it out to look somewhat like the indoor environment. The code is in a python notebook called "partialOdometry.ipynb" and is split up into 3 Cells total. Cells 1 and 2 accomplish tracing the robot's path and plotting the LIDAR data points but Cell 3 is a work in progress of trying to plot the occupancy grid map.

Tracing Robot Path

In Cell 1, I employed wheel odometry to reconstruct the trajectory of the robot. I first gathered the encoder ticks from the robot's four wheels, which informed me of the incremental motion. These ticks are converted into distances traveled per encoder count. By taking the difference in wheel distances, I derived the change in orientation, which is essential for directional tracking.

The algorithm proceeds iteratively; at each timestamp, I updated the robot's orientation using the difference in distances reported by the left and right encoders. The orientation is normalized to ensure it remains within the range of [-π, π], keeping track of the robot's rotational state around a complete circuit. Then, I calculated the average distance traversed by both wheels to determine the linear displacement since the last measurement.

I incorporated this displacement into the robot's current position in a 2D plane by projecting it onto the X and Y axes. This projection is based on the updated orientation, taking into account the robot's heading. By repeating this process for each set of encoder data, it effectively constructs a continuous trajectory of the robot. The result is a detailed path that reflects both the linear and angular movements made by the robot, allowing me to visualize its journey as a plot in millimeters on the X and Y plane. This method delivers an odometry-based navigation path without relying on external references, demonstrating the robot's ability to track its position solely from its wheel movements.



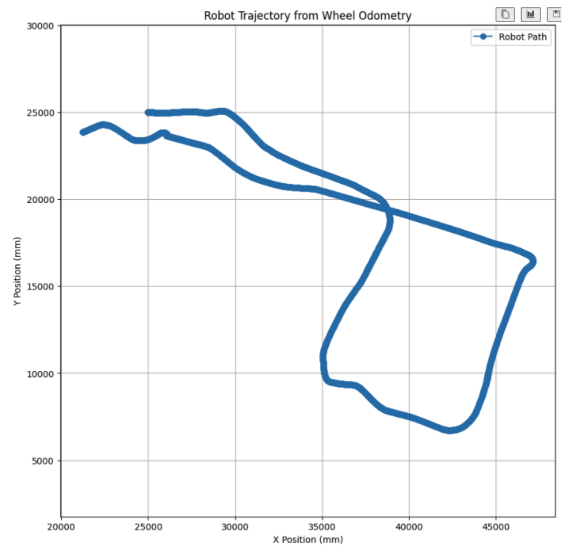


Figure 1: Robot Trajectory from wheel odometry (Encoder 20 left, Encoder 23 right)

Making a 2D map

In Cell 2, I created a 2D map of the environment by visualizing the LIDAR range readings. To achieve this, I iterated through the LIDAR data, which includes the angles and distance of each reading, to calculate the absolute positions of the LIDAR hits in space. Using the robot's trajectory data, I transformed these relative LIDAR measurements into global coordinates.

Each LIDAR data point is converted from polar coordinates (angles and distance) into Cartesian coordinates (x and y), considering the robot's current position and orientation. This allows the representation of the environment as seen by the LIDAR sensor from the robot's perspective over time, effectively mapping the surroundings.

By plotting these points, I am able to visualize the environment in which the robot has moved, showing walls, obstacles, and other features as detected by the LIDAR. This scatter plot provides a comprehensive view of the area, offering insight into the spatial relationships. This visualization represents the first phase of the project, establishing a foundational understanding of the robot's interaction with its surroundings and setting the stage for subsequent navigation and localization tasks.

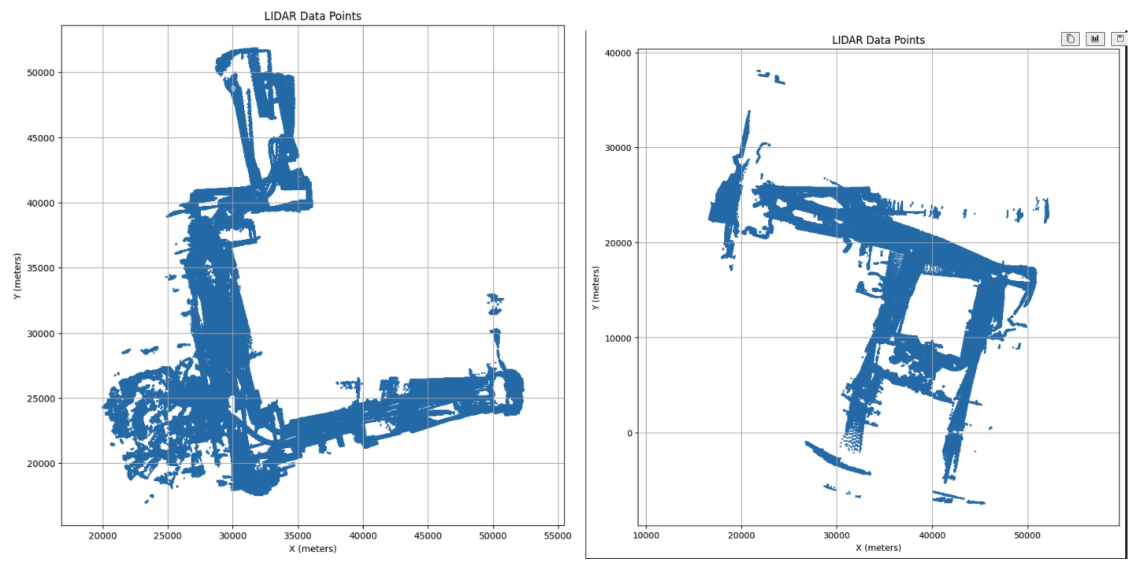


Figure 2: LIDAR Data Points plotted (Encoder 20 left, Encoder 23 right)

What's left to do:

Moving forward, the next steps for progressing in the project include refining the visualization in Cell 3 which is the code that plots the occupancy grid map through the use of the LIDAR data. The aim is to resolve the current challenges in the code and achieve a functional occupancy grid map. This map differentiates between free space, occupied areas, and unknown regions, allowing for a more complex representation of the environment. To accomplish this, I am currently troubleshooting and optimizing the code to ensure that the occupancy grid reflects accurate readings from the LIDAR data without taking a long time to process and to print out circular-arc-looking-walls. The end goal is to have a robust and reliable map that can be used-for navigation and to further develop the code to complete the full SLAM project code.