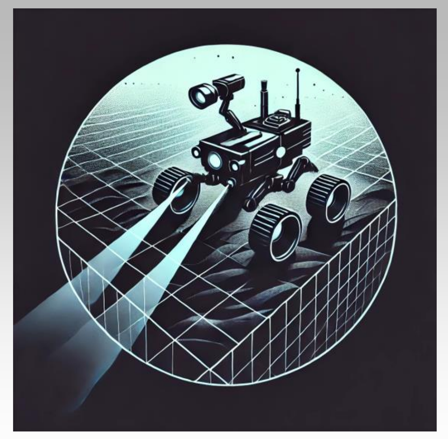

Exploring the Unknown: Autonomous LiDAR Rover Mapping

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Sponsor: Professor Kia

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Overview

In recent years, significant advancements in robotics, LiDAR technology, and autonomous systems have broadened the scope of exploration and environmental mapping. This project aims to utilize LiDAR technology to engineer high-resolution 3D mapping and obstacle detection algorithms, thereby enhancing autonomous navigation capabilities. The robotic system will integrate algorithms, including RRT*, SLAM, and frontier exploration, to enable adaptive scanning, mapping, and real-time decision-making with minimal human intervention. These autonomous capabilities present potential applications such as military reconnaissance, search and rescue operations, and remote surveying. This project's goal is to develop a LiDAR-equipped rover capable of autonomously traversing and refining its environmental model, facilitating exploration in uncharted terrains.

Figure 1: Our project robot: the JetRacer Professional ROS Kit.

Key Features

- **Autonomous Navigation**
  - Independently explores environment
  - Real-time decision making
- **Data Processing**
  - Creates point cloud with LiDAR data
  - Converts occupancy grid from point cloud
- **Path Planning**
  - Avoids obstacles while creating optimal path using RRT* algorithm
  - Utilizes SLAM algorithm to localize robot in territory
  - Frontier exploration
- **Motion Controls**
  - Precise rover movement through diverse terrains
  - Variable speed drive

Engineering Analysis

- We created a simulated environment of a complex indoor area as seen in figure 2.
- A theoretical rover was then sent into the environment following a preset path
- The rover took LiDAR scans throughout its journey to map the environment
- The map of the environment was fairly accurate aside from the robot hitting walls as seen in figure 3.

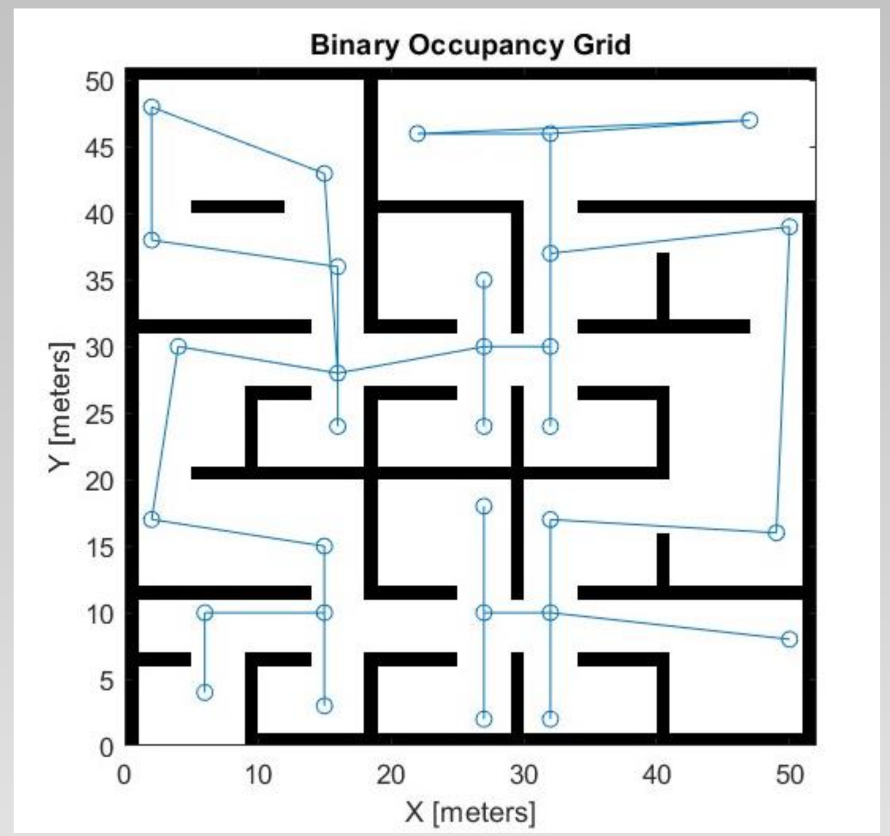


Figure 2: Theoretical environment with a robot exploration path

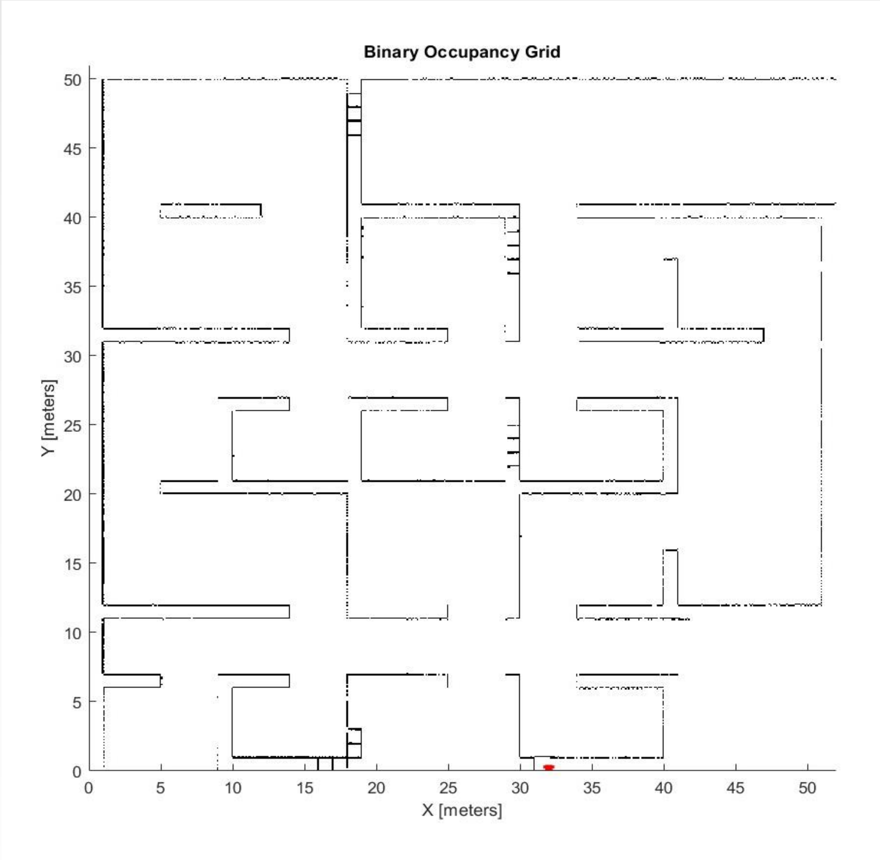


Figure 3: Occupancy grid created from LiDAR scans of the theoretical environment

Proof of Concept

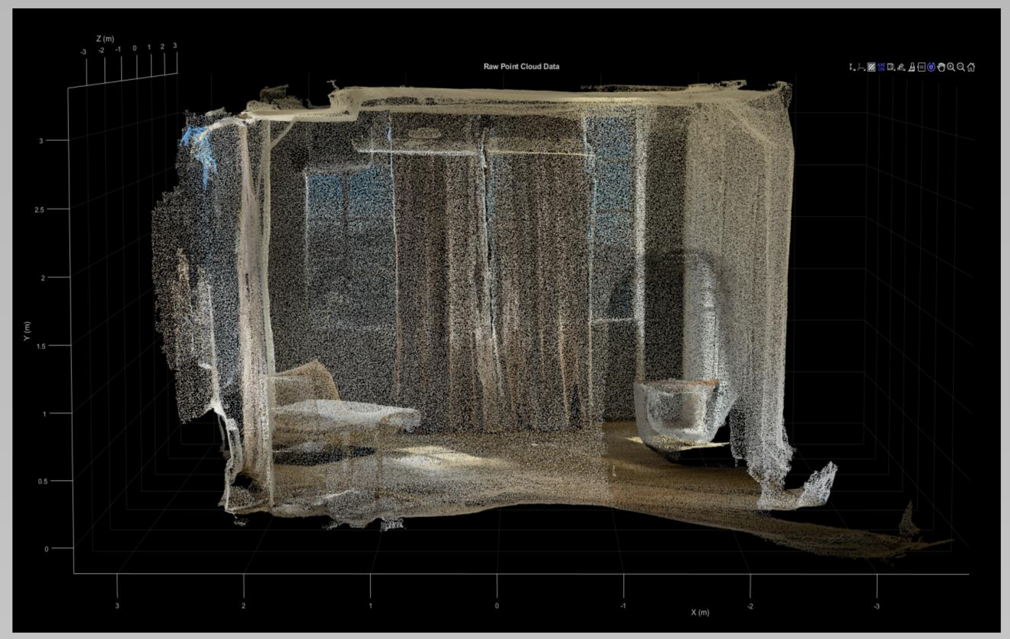


Figure 4: Point Cloud Data of a room on an XYZ-plot

- A LiDAR scan of a room was converted to a point cloud data file using a phone
- The camera feature of the phone simultaneously captured the colors and saved it onto the point cloud
- The file was plotted on a 3D graph using MATLAB
- The axis represent the measured dimensions of the room

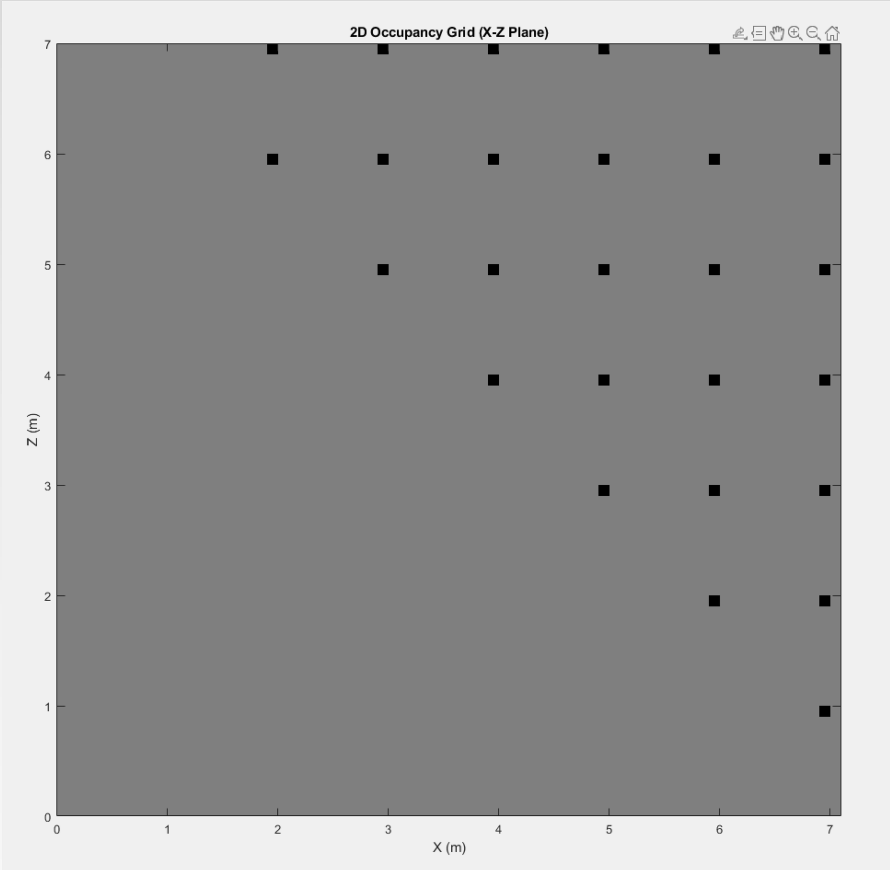


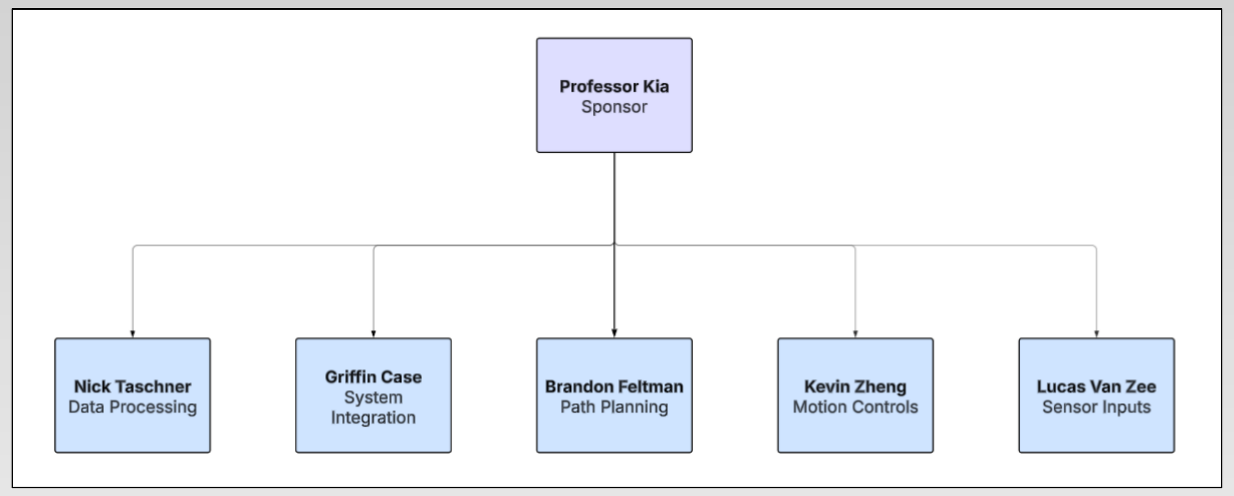
Figure 5: Occupancy grid of the room on a 2D plot

- 3D point cloud is converted to a 2D occupancy grid
- The Y-plane was eliminated to show an aerial view of the same room
- The black spaces represent occupied areas
- The gray areas represent clear zones

Future Improvements

- Upgrade to higher resolution Lidar to capture finer details, reducing noise and improving the accuracy of 3D reconstructions.
- Integrate camera to improve perception and mapping accuracy.
- Machine learning models can be trained on fused LiDAR-camera data to improve obstacle recognition and classification.
- Implement PID control to optimize path planning by improving trajectory tracking, reducing deviations, and enhancing real-time navigation stability.
- Testing RRT* algorithm on real rover, obtaining values for rover's ability to traverse certain terrain and plugging these values back into path planning algorithm.

Team Structure



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