Autonomous Line Coverage with a Husky Robot

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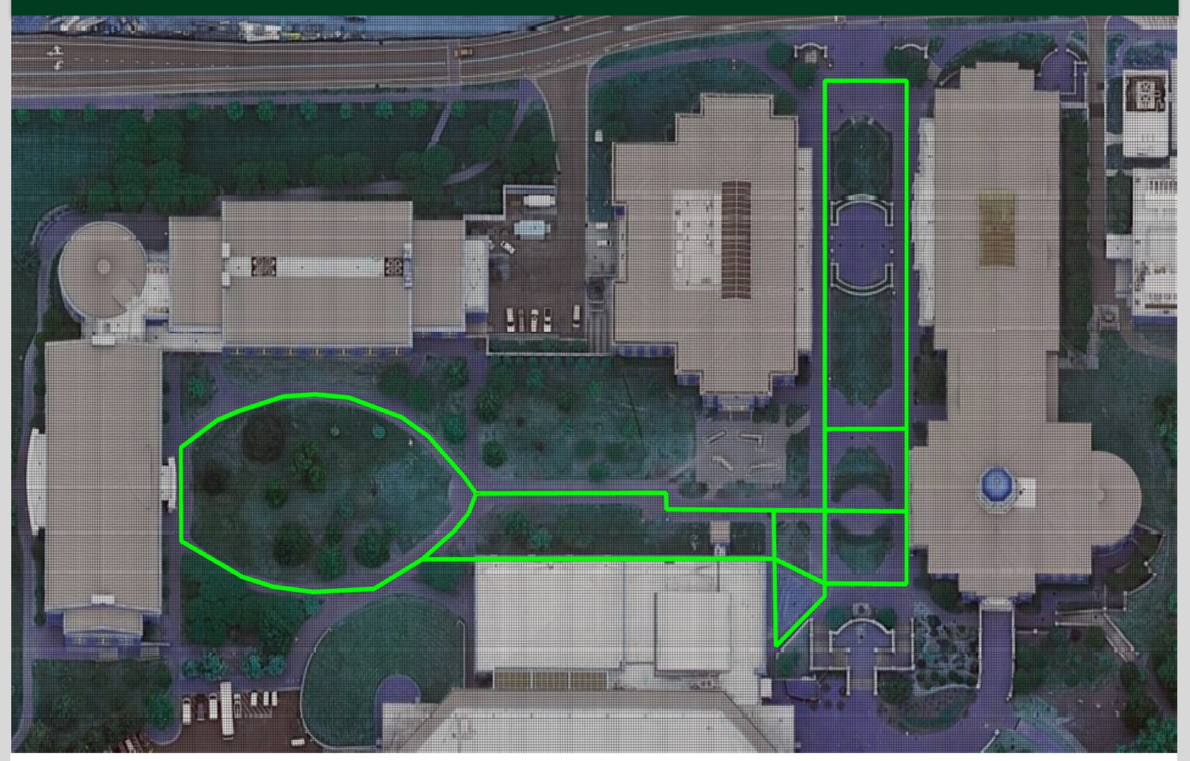
Motivation

- Using a ground robot to inspect damaged road networks in an environment which is unsafe for people (e.g., after a hurricane or earthquake).
- Evaluating the integration of Line Coverage path planning and SLAM navigation to achieve autonomous and accurate coverage of a road network.

Line Coverage

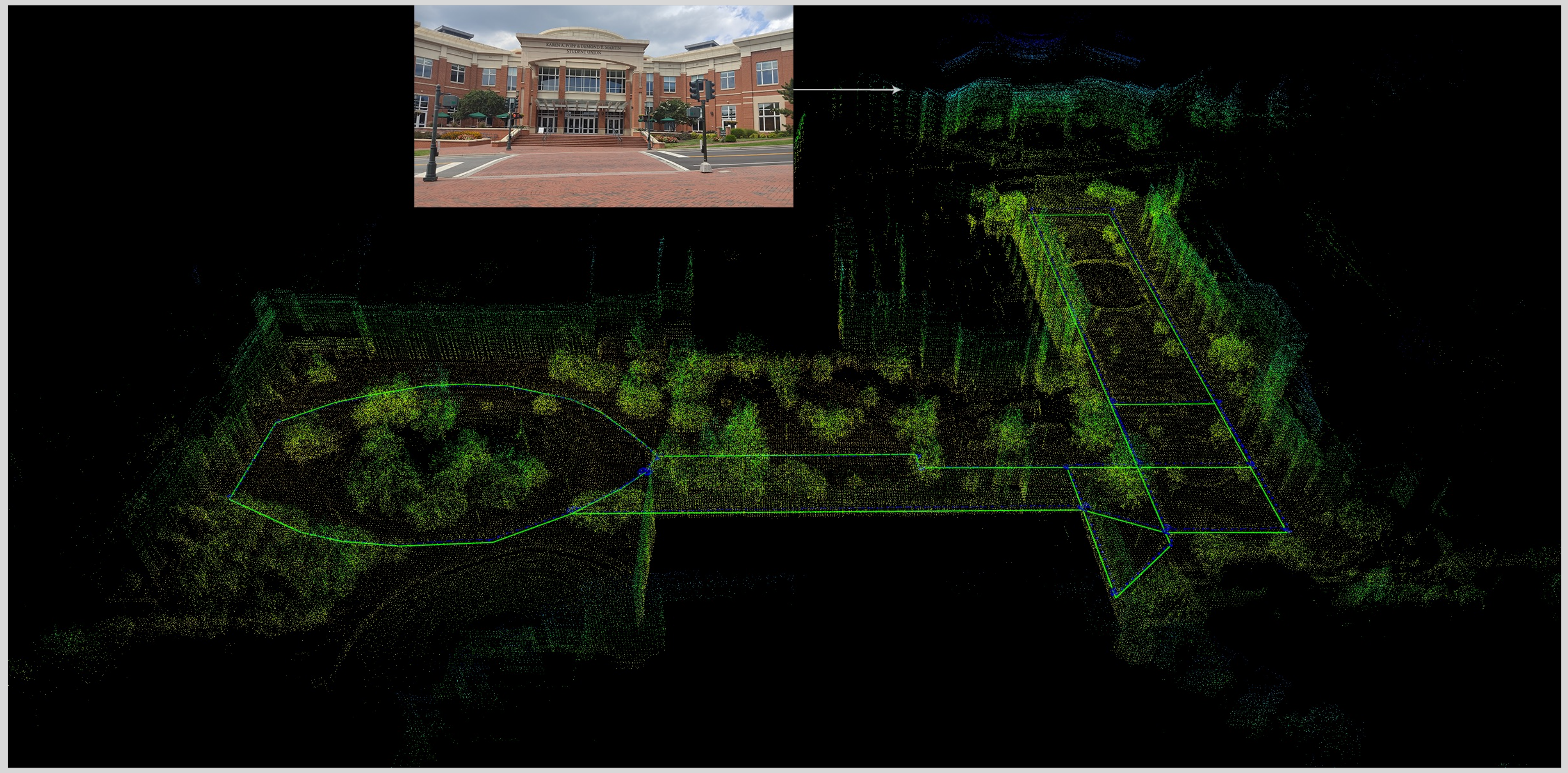


- The *line coverage problem* is to find a route plan to go through all required edges of a graph while respecting a robot's or vehicle's resource constraints (e.g., fuel, battery capacity, travel time).
- Using the Line Coverage Library [1] recently developed at UNC Charlotte, we can create a route plan with the minimum cost, such as travel time.
- The map data was generated from OpenStreetMap, then converted into UTM (Universal Transverse Mercator) coordinates.

SLAM and LeGO-LOAM

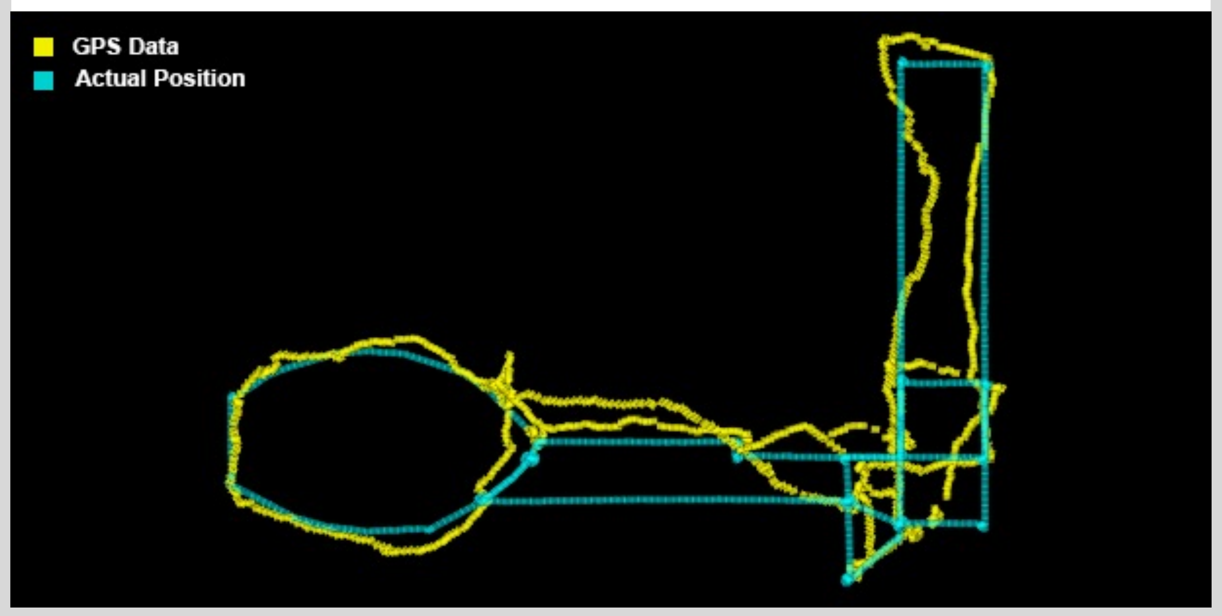
- SLAM (simultaneous localization and mapping) is a method used for autonomous vehicles to build a map and localize the vehicle in that map at the same time.
- We used the LeGO-LOAM (lightweight and ground-optimized LiDAR odometry and mapping) library [2] in this project to address the SLAM problem.

Husky ground vehicle with LiDAR and IMU (inertial measurement unit) sensors



What We Did

- Used OpenStreetMap website to get the data of all walkways we need to inspect.
- Used Line Coverage Library to get an optimized route to service all specified edges.
- Ran LeGO-LOAM program on the Husky robot to get estimated position and orientation of the robot as it traversed the route.
- Developed a program to control the velocity and orientation of the robot to keep it on the path and go to the target point.
- Built a 3D point cloud map of the observed environment.



Results

- Obtained a high-resolution 3D point cloud with an autonomous vehicle.
- Using just the LiDAR and IMU sensors, the accuracy is very high. The robot deviated less than 0.5 meters from the path.
- The average distance between GPS (Global Positioning System) estimated position and actual robot position over the route is about 5.7 meters.

Future Work

- Using computer vision to keep the robot in the center of the path.
- Improving the control algorithm to detect and avoid collision with obstacles and people.
- Estimating energy cost and time taken on varying terrain.

1. S. Agarwal and S. Akella, **Approximation Algorithms for the Single Robot Line Coverage Problem.** *Algorithmic Foundations of Robotics XIV (WAFR 2020)*, Springer, 2021
2. T. Shan and B. Englot, **LeGO-LOAM: Lightweight and Ground-Optimized LiDAR Odometry and Mapping on Variable Terrain**. *IEEE/RSJ International Conference on Intelligent Robots and Systems*, Madrid, Spain, October 2018

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