Simulating Localization in a Landmark Sparse Environment

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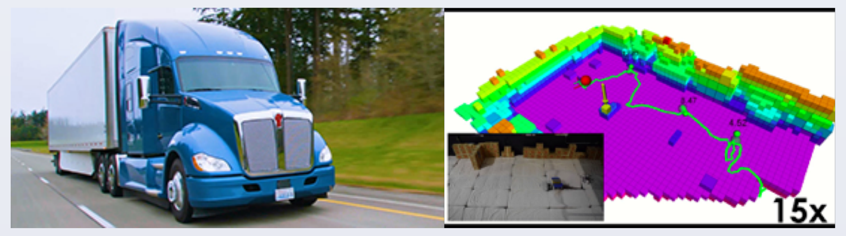
Introduction

How can you find your location on a map? This is the problem that a technique called “localization” attempts to solve. In smartphone applications, a global positioning sensor (GPS) is used. For autonomous vehicles, a light detection and ranging (**LIDAR**) sensor is used instead. LIDAR is has been successfully used for localization in indoor or dense urban environments. The goal of this project is to achieve localization with LIDAR in a very object sparse environment, like a field or an empty highway.



System Overview

There are two primary steps in our research using the data Paccar gathered from their truck at the test track:

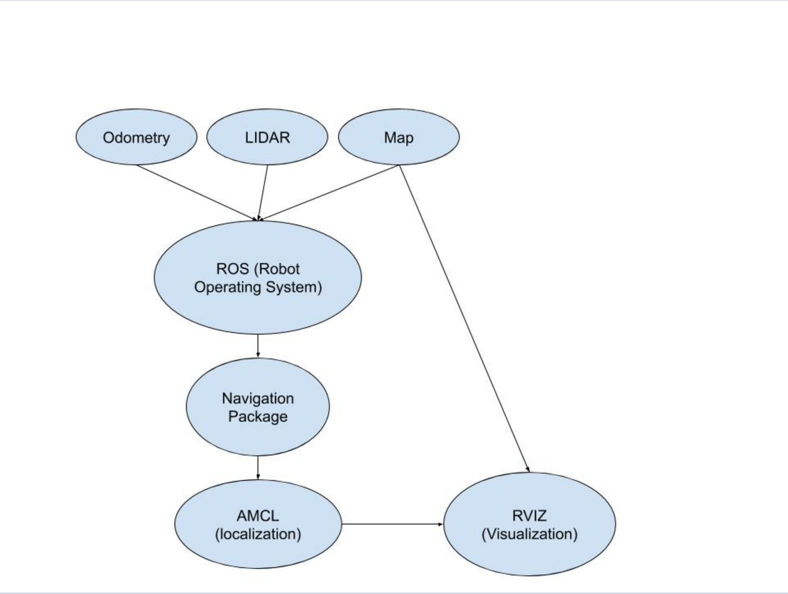
1. **Build a map.**
2. **Localize the truck within the map.**

Tools:

- Robot Operating System (ROS)
- Python (programming language)
- Rviz (visualization software)

Paccar Test Track

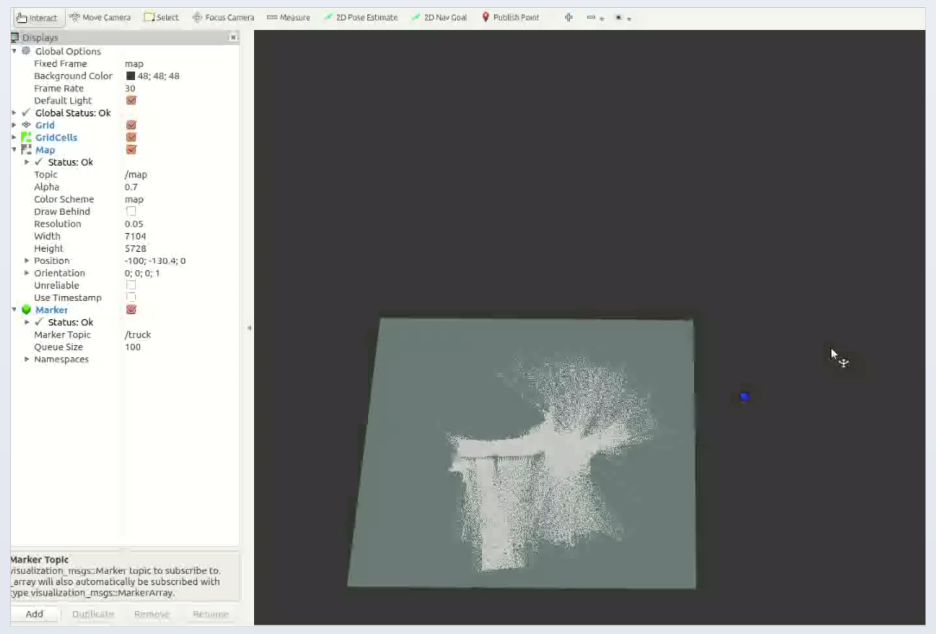
System Architecture



Map Building

- We used a technique called **Hector Slam**.
  - Uses LIDAR scan data to create a feature map.
  - Incorporates features from the track into the model
  - Open source ROS implementation

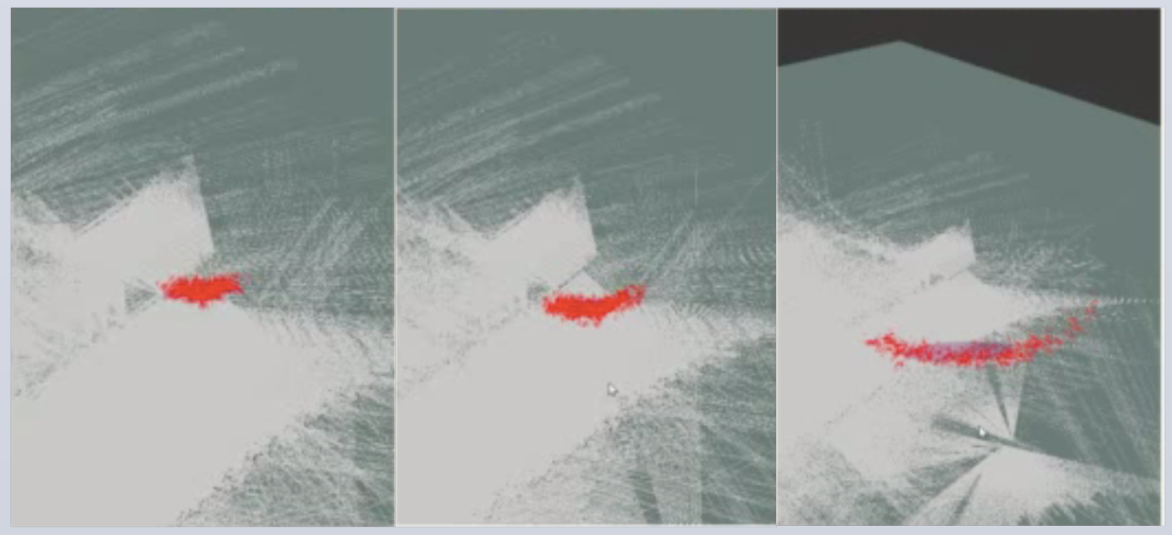
Map Building



Localization

- We used an approach called “Adaptive Monte Carlo Localization (**AMCL**)”
  - Determine position and rotation (pose) within a known map by using sensor feedback.
  - Uses probabilistic guesses about future states (particles) and iteratively updates them based on sensors observations .
  - Our model uses LIDAR as the sensor feedback, and vehicle odometry to generate the motion model’s future states

Localization Simulation

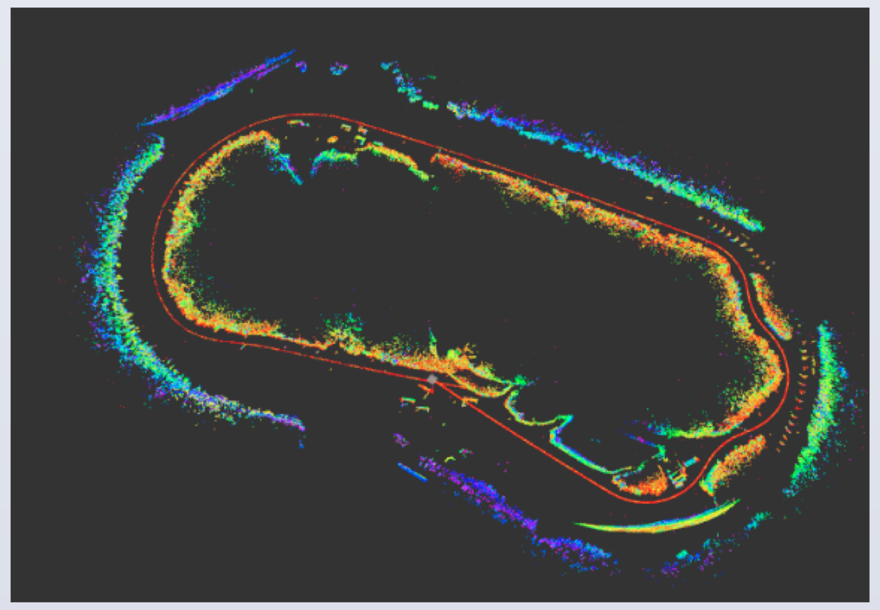


Results

- Using Hector Slam, we were able to generate a map that resembles the actual Paccar test track
  - Map reflected basic shape of track, which is the governed by the odometry of the truck

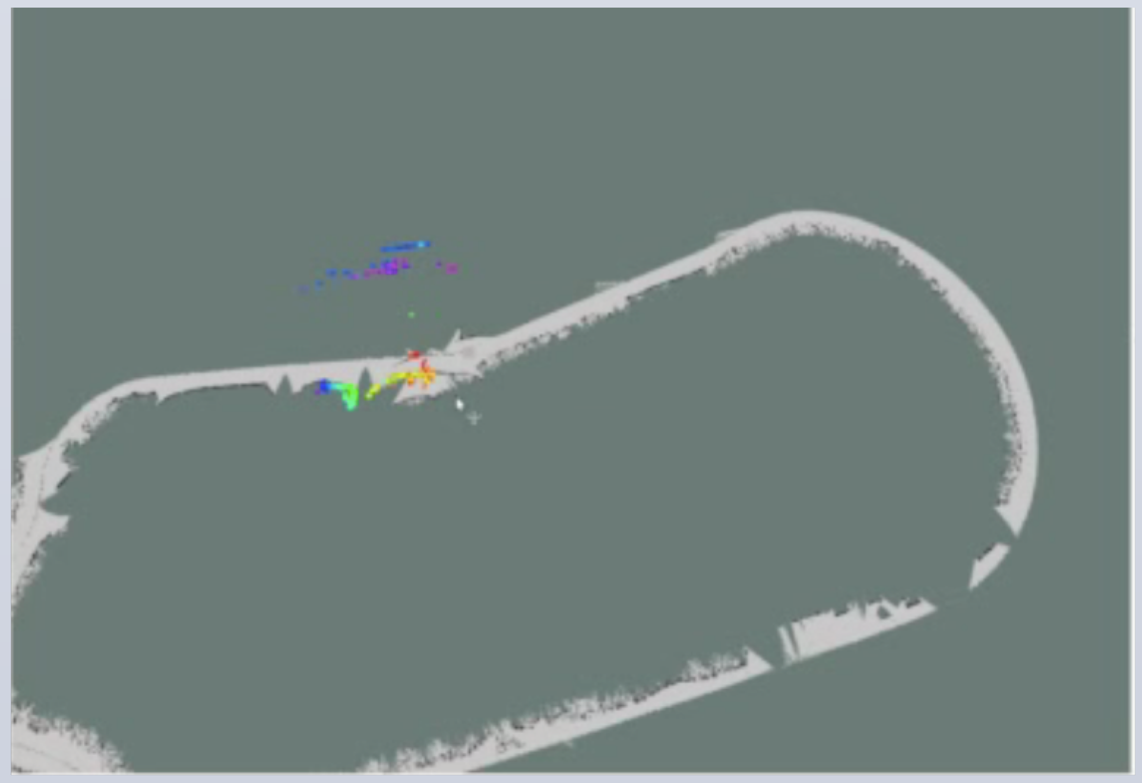
Final Map of Paccar Test Track

Sensor Inputs (LIDAR + ODOM)



- Using AMCL, we were able to compute localization on segments of the generated map
  - At times, the estimated position would lose tracking because of inconsistent LIDAR readings with the map

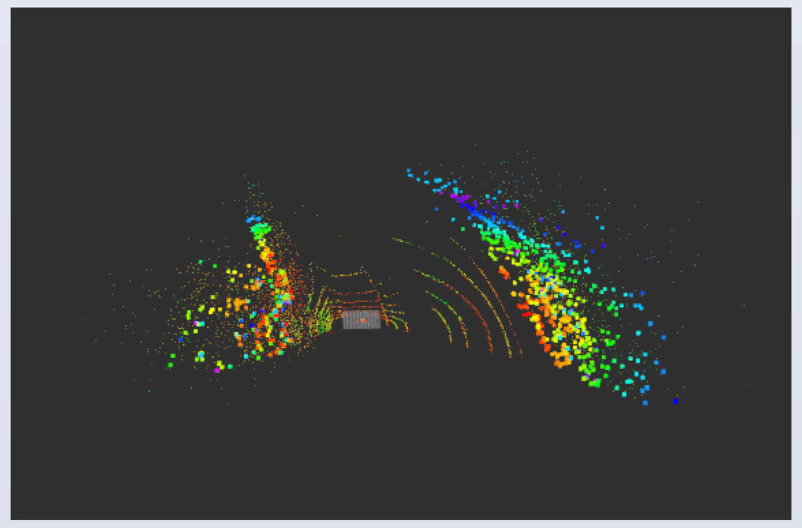
Tracking AMCL Pose in Map



Conclusions

- Given our map, AMCL-based localization using only LIDAR is insufficient navigation.
  - When simulating the estimated position of the car against the odometry (truck motion), the localization rarely found the path
  - Many gaps were apparent in the scan data, which makes sense in a sparse environment
- Generated map using lap’s worth of scan data not accurate enough for AMCL
  - Had many inaccuracies, which do not hold up well for AMCL
  - Could’ve been lack of data, or just insufficient landmarks around the track for the LIDAR to sense

LIDAR Data Visualization



Future Work

- Collect a lot more track data to construct a more accurate map
  - More runs around track could more accurately capture the true features of the test track
- Utilize RGB camera data sensor fusion alongside traditional AMCL
  - There has been research done in localizing using RGB cameras
  - Combining those techniques with LIDAR-based techniques could yield localization results
- Supplement odometry data with GPS-gathered data.
  - Theoretically GPS can be converted to odometry. GPS can be more accurate and provide better ground-truth localization.