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SLAM system for autonomous vehicle

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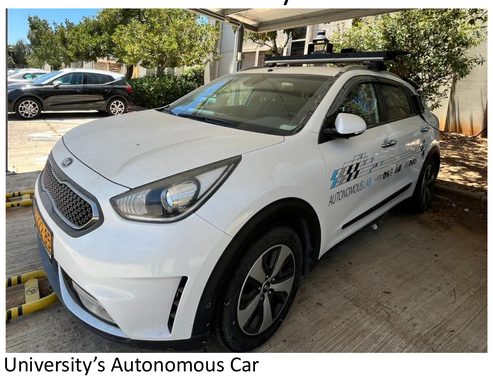
Introduction

SLAM (Simultaneous Localization and Mapping) is an algorithm commonly used in robotics and autonomous vehicles. The SLAM algorithm enables vehicles to navigate through unknown environments using sensors such as LiDAR, camera, IMU, GPS etc. To achieve this, a vehicle must be capable of both constructing a map of its surroundings and localizing itself within it. Our project is part of the university's project to develop an autonomous vehicle, where we are laying the foundation for the mapping and localizing of the vehicle. To achieve that we tested two chosen algorithms (LIO-RF and Fast Lio) on datasets in order to integrate them in the university's autonomous car.



University's Autonomous Car

Ouster OS1-128 Lidar

Motivation:

Our motivation came from the need to estimate the vehicle's precise position from a reliable SLAM algorithm into the university's autonomous vehicle, enabling it to operate efficiently in real world scenarios.

Implementation

- Reviewing a wide range of existing SLAM algorithms and selecting the most suitable candidates, while taking into consideration the used sensors (Ouster OS1-128 LiDAR and IMU model INS-DL).
- Installing the algorithms on a virtual machine in a PC environment
- Testing the algorithms on datasets and choosing two candidates.
- Installing the chosen algorithms on the autonomous car Jetson computers to further examine their performance on the car's computer and in real time situations.

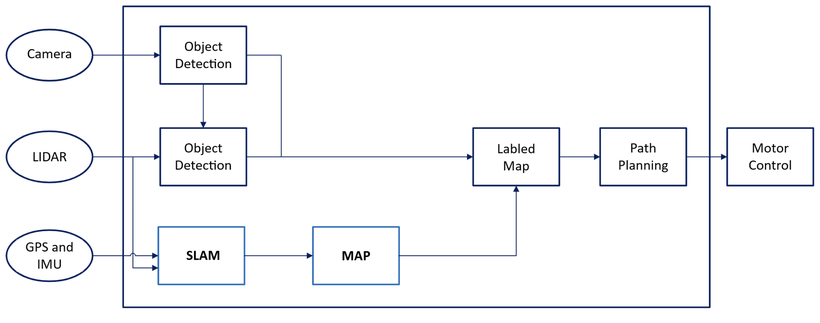
LIO-RF Algorithm

LIO-RF algorithm is a tightly coupled LiDAR inertial odometry system that is based on the LIO-SAM algorithm. The algorithm is aimed to have a better performance in highly dynamic environments, which is gained by the following method:
The algorithm first removes the moving objects, obtains a rough initial state estimation through the IMU, and then through iterative removal and scan-matching the more accurate poses in the dynamic environment are obtained. [2]
Finally, it keeps improving the car path over time by loop closing- connecting important points and fixing mistakes using a method called graph optimization.

Fast Lio Algorithm

Fast Lio algorithm is a lidar-inertial odometry system designed to allow LiDAR mapping and navigation through an efficient tightly coupled Kalman filter [1]. The algorithm's efficiency and accuracy come from two major components:
Registration of raw points to the map so that the point cloud 3D depicts the environment as accurately as possible.
Maintaining the map using the incremental kd data structure that ensures a high-speed performance.

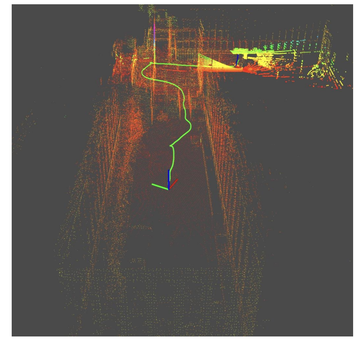
System Architecture



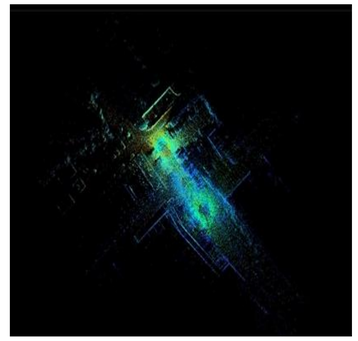
This diagram shows our autonomous vehicle uses sensors to detect objects, localize itself, and plan its path.
Our part focuses on the SLAM and MAP modules, which use IMU, and LiDAR data to estimate position and build a map.

Results

In the following pictures we can see the propagation of the 3D point cloud map generated by the SLAM algorithms.
Both graphs were generated based on datasets that match the vehicle's parameters (such as ouster os1-128 lidar).



Lio-RF database Map



Fast Lio Kitti database Map

Conclusions

The project provides a base for the development toward full autonomous navigation.
The map generated by the SLAM algorithm provides a reliable depiction of the surrounding environment.
The following picture shows the 3D point cloud data of the surrounding of the University's autonomous car as generated by the algorithm:

3D Point Cloud from the car

Bibliography

1. [1] https://arxiv.org/abs/2010.08196
2. [2] https://arxiv.org/abs/2206.09463