Realistic 3D Point Cloud Generation

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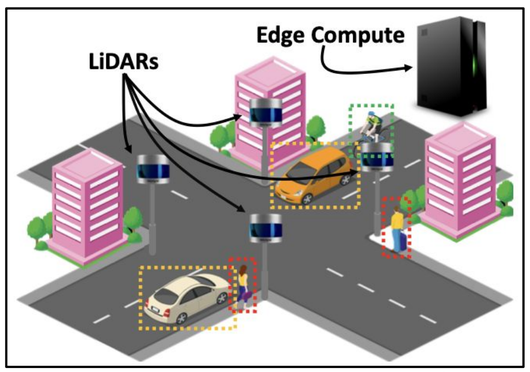
SHINE
Summer High School Intensive in Next-Generation Engineering

Introduction

In the Networked Systems Lab led by Professor Ramesh Govindan, we create a networked software for autonomous vehicles to ensure they safely navigate a traffic environment. The software sends data from LiDAR sensors attached to vehicles to the cloud, which processes the data and instructs the car to perform the optimal task. A specific topic of research includes Net-Driving, which rather than attaching LiDAR sensors directly onto a vehicle, multiple LiDARs are positioned at a traffic intersection. By doing this, we can have a more complete view of the traffic at the intersection by stitching the multiple LiDAR views together.

Research Goal

One specific research area regarding autonomous vehicles includes Net-Driving. After reading the research paper about Net-Driving, one of the limitations that I noticed was that Net-Driving fails to prepare for sensor failure or noise. As part of my project, I learned more about the effects of noise and point drop-off by collecting point cloud data in a simulated environment. We aim to make our systems more robust and realistic by adding noise and point drop-off defects to virtual scenarios.



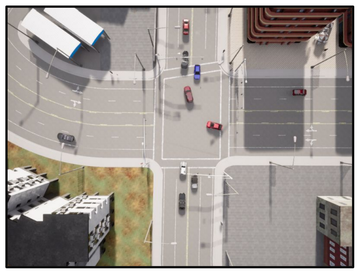
Net-Driving scenario at intersection with four LiDARS

Research Process

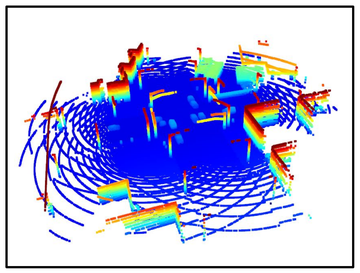
- Read various research articles and papers about autonomous vehicle systems and LiDAR sensors, including about Net-Driving, to get high-level understanding of the concepts
- Brainstorm the research idea from the readings
- Get familiar with Ubuntu development environment
- Studied how to operate the CARLA simulator
- Read and analyzed CARLA codes to become familiar with how the simulator works
- Wrote codes for CARLA data collection replicating Net-Driving scenario with four static LiDAR sensors, different levels of noise and point drop-off, and data collection
- Studied point cloud transformation and implemented the function using Open3D

Background

Point Cloud
Data points collected using a 3D laser scanner and plotted in 3D space
CARLA simulator
A simulator for autonomous driving research used to train and develop autonomous urban driving systems
Open3D library
Open-source library that supports development of software dealing with 3D data
Transformation
Translation, rotation, scaling, skewing, reflection, and orthogonal projection performed on point cloud data



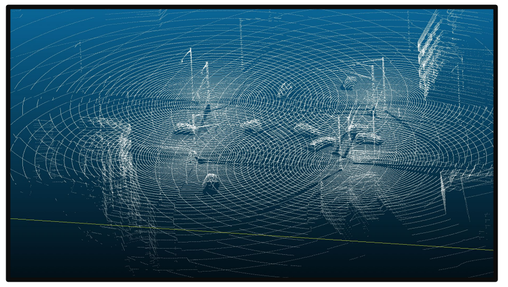
Bird eye view of driving scenario from CARLA



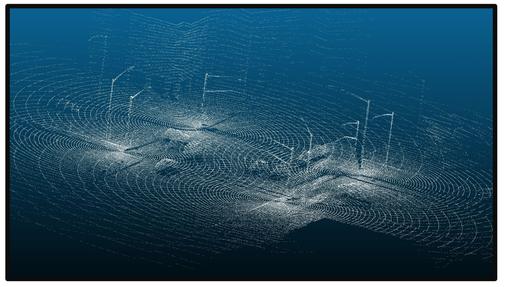
Stitched point cloud visualization from Open3D

Results

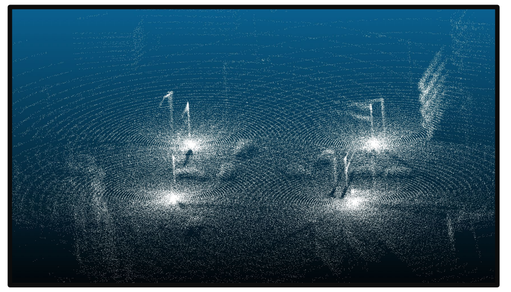
Noise Level = CLEAN



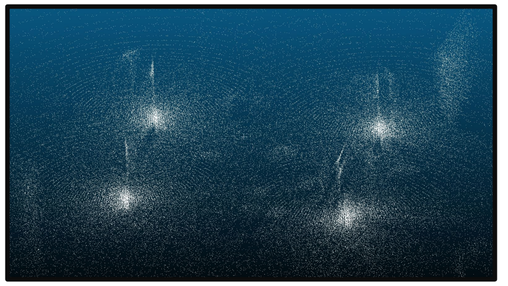
Noise Level = LOW



Noise Level = MID



Noise Level = HIGH



[CLEAN] STD of noise model = 0.0, Drop-off ratio = 0%
[MID] STD of noise model = 0.3, Drop-off ratio = 45%

[LOW] STD of noise model = 0.0 Drop-off ratio = 45%
[HIGH] STD of noise model = 0.7, Drop-off ratio = 75%

Further Steps

- Investigate limitations of sensor failure and occlusion of intersection due to natural elements using CARLA and Unity
- Using more realistic datasets, test the system and measure its performance of autonomous driving

Citations

[1] Fawad Ahmad, Christina Suyong Shin, Weiwu Pang, Branden Leong, Pradipta Ghosh, and Ramesh Govindan, "Cooperative Infrastructure Perception," Under Review.
[2] Alexey Dosovitskiy, German Ros, Felipe Codevilla, Antonio Lopez, and Vladlen Koltun. "Carla: An open urban driving simulator". arXiv preprint arXiv:1711.03938, (2017).
[3] Zhou, Qian-Yi, Jaesik Park, and Vladlen Koltun. "Open3D: A modern library for 3D data processing." arXiv preprint arXiv:1801.09847 (2018).

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