# CARLA-Based Sensor Fusion for Improved Trajectory Mapping

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# Introduction

This guide integrates camera and LiDAR data for Simultaneous Localization and Mapping (SLAM) in AV using the CARLA simulator

Objectives:

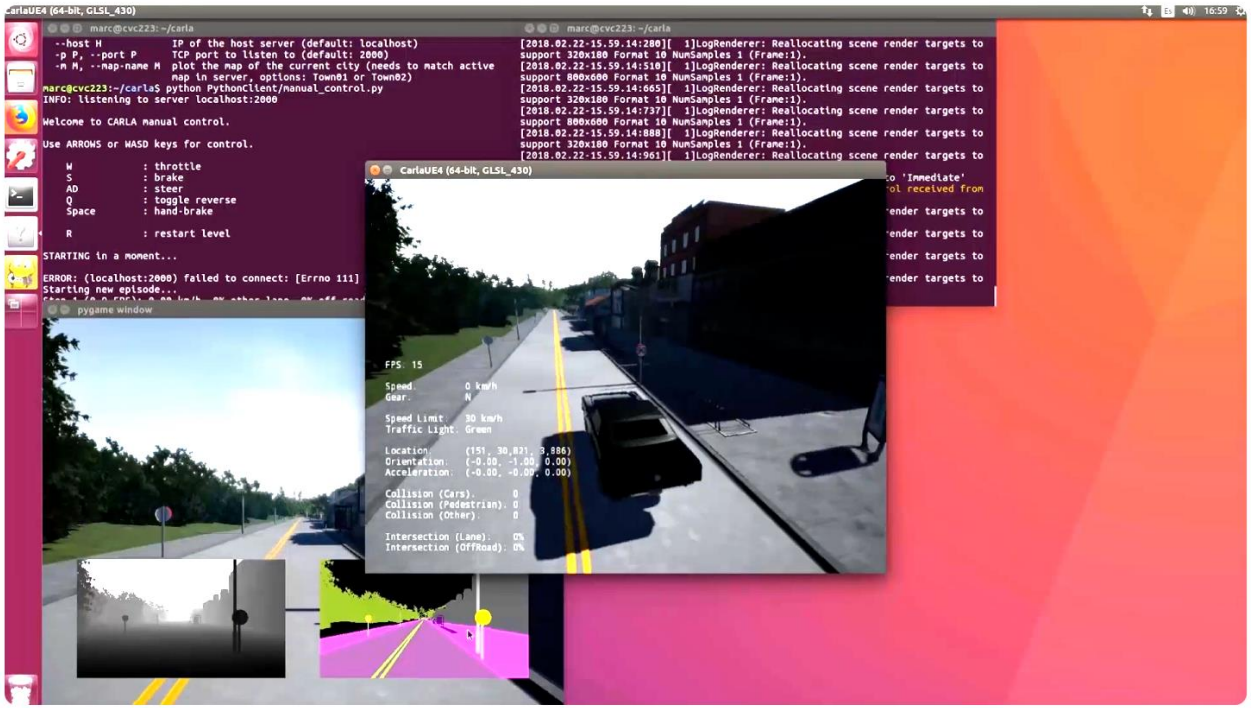
- Estimate vehicle trajectory using visual odometry from camera data
- Build a 3D mapped point cloud of the environment using LiDAR data
- Combine trajectory and 3D map data to enhance localization and navigation

Tools and Technologies:

- CARLA Simulator for data generation
- OpenCV, Open3D

# Methodology

# Methodology: Jupyter Notebooks

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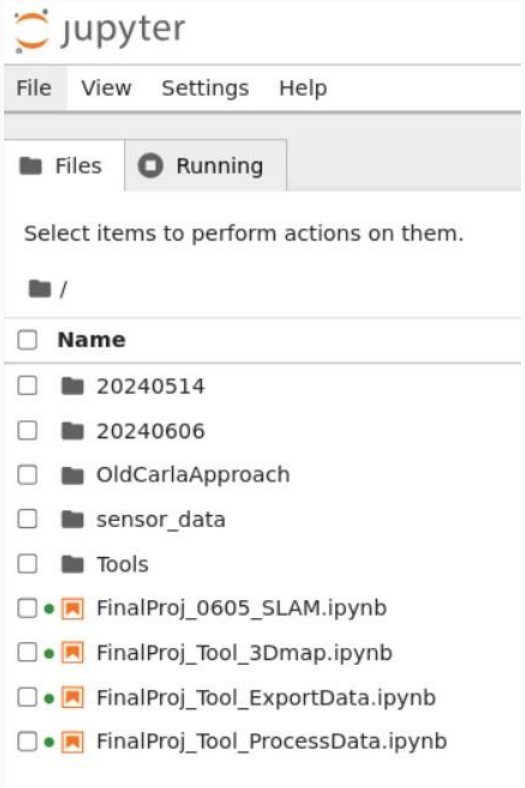
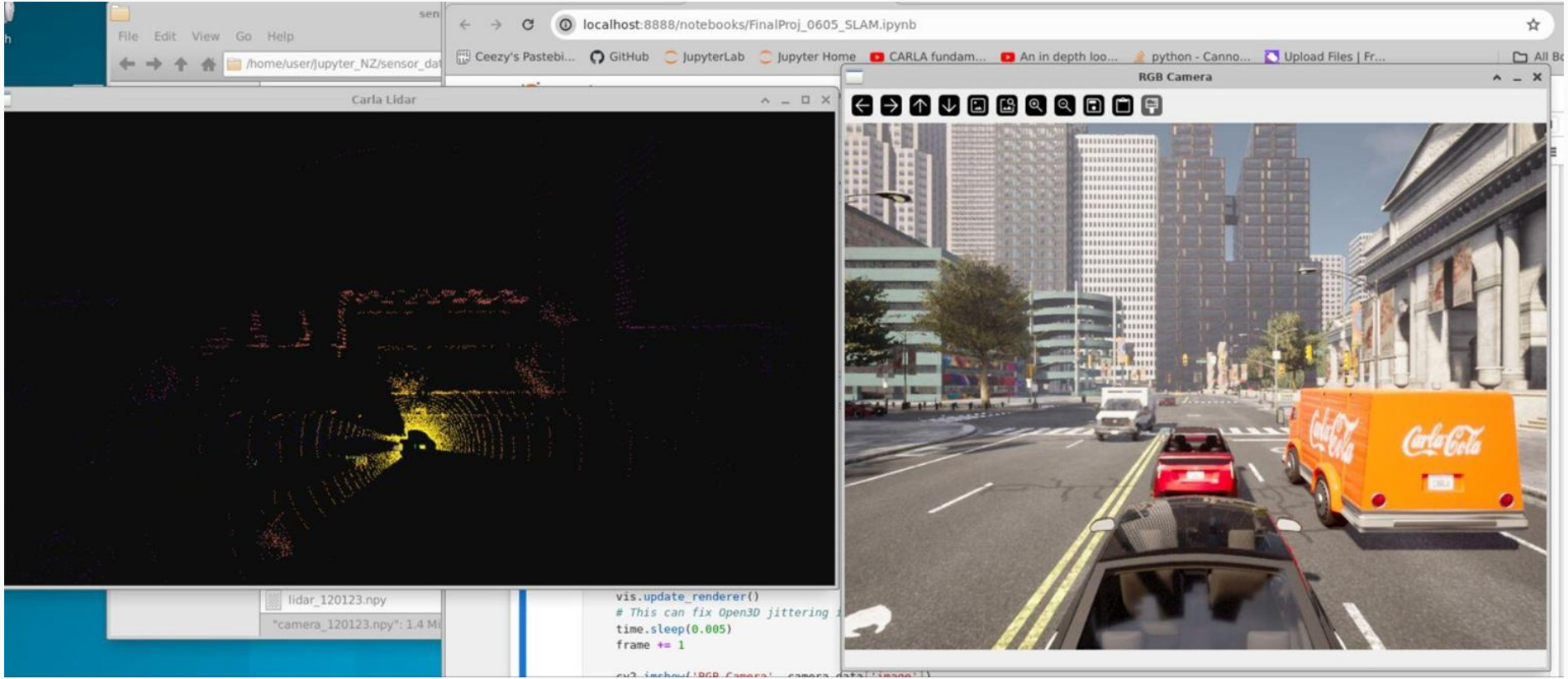
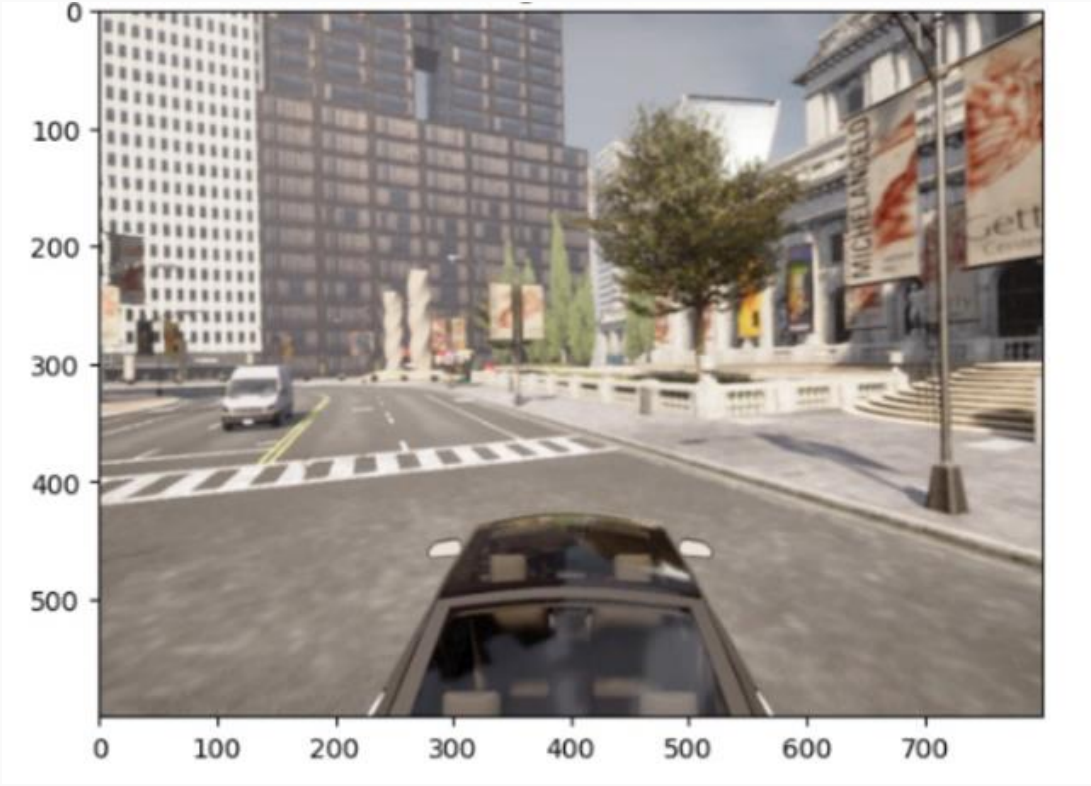


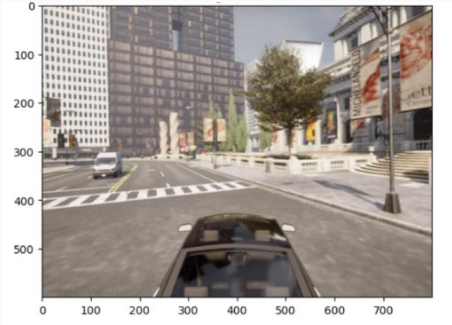
# Methodology: CARLA Working

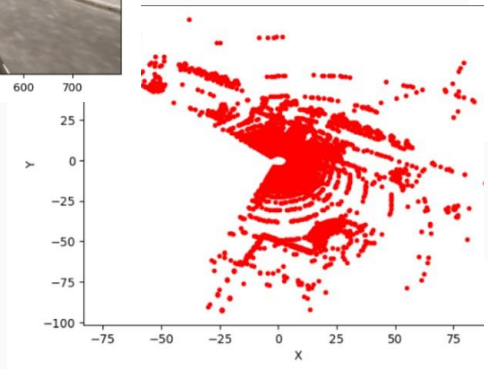


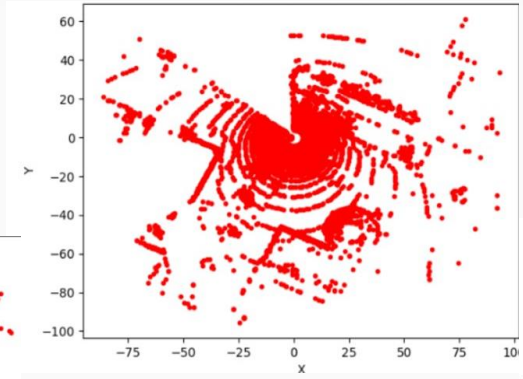
# Methodology: Data Export Camera

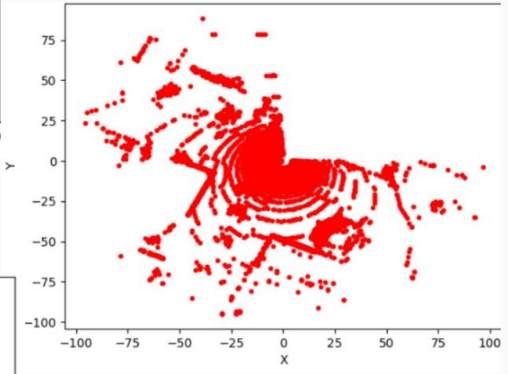


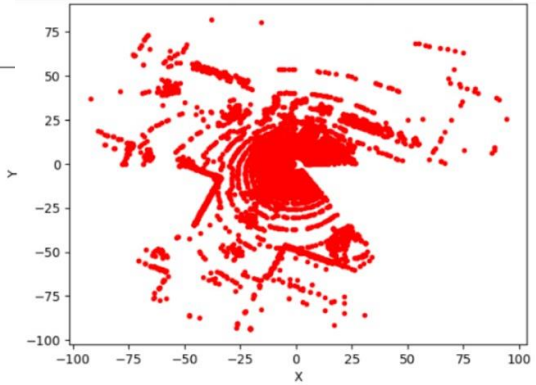
# Methodology: Data Export LiDAR



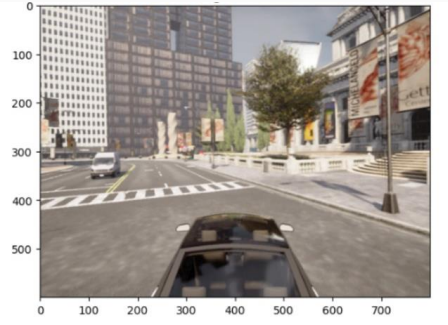



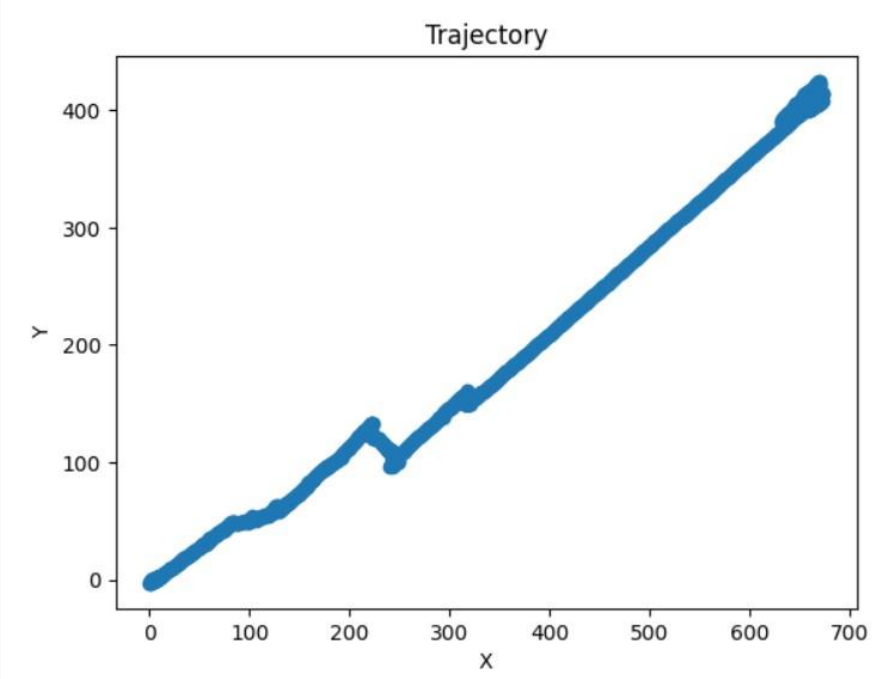



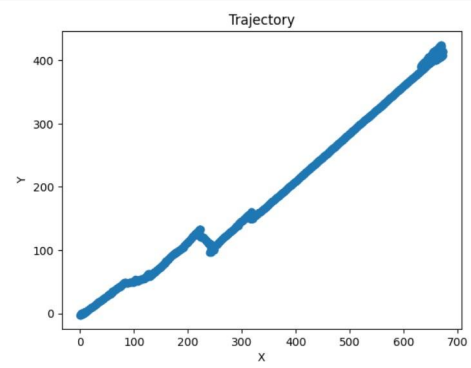
# Evaluations

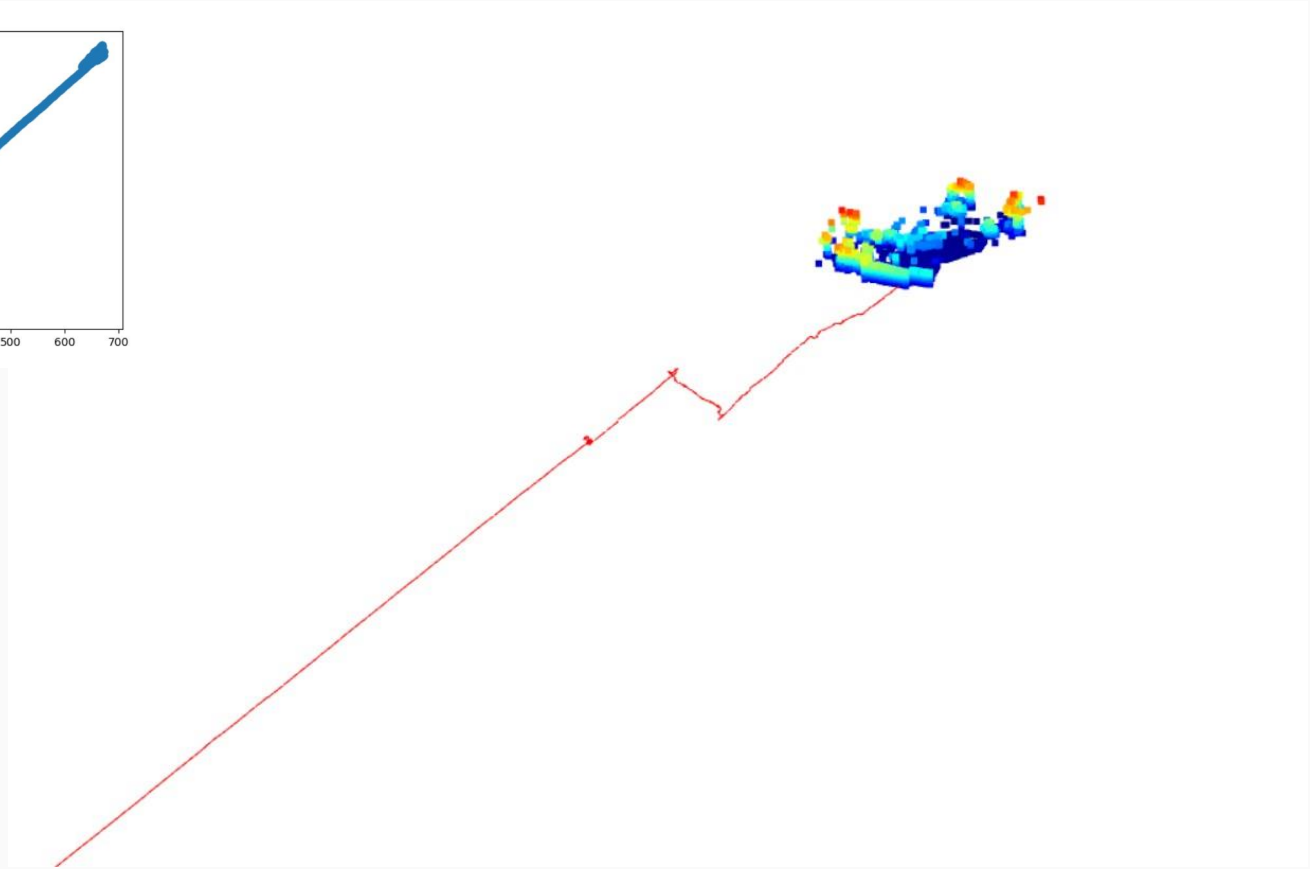
# Evaluation: Odometric Trajectory



# Evaluation: Point Cloud + Trajectory



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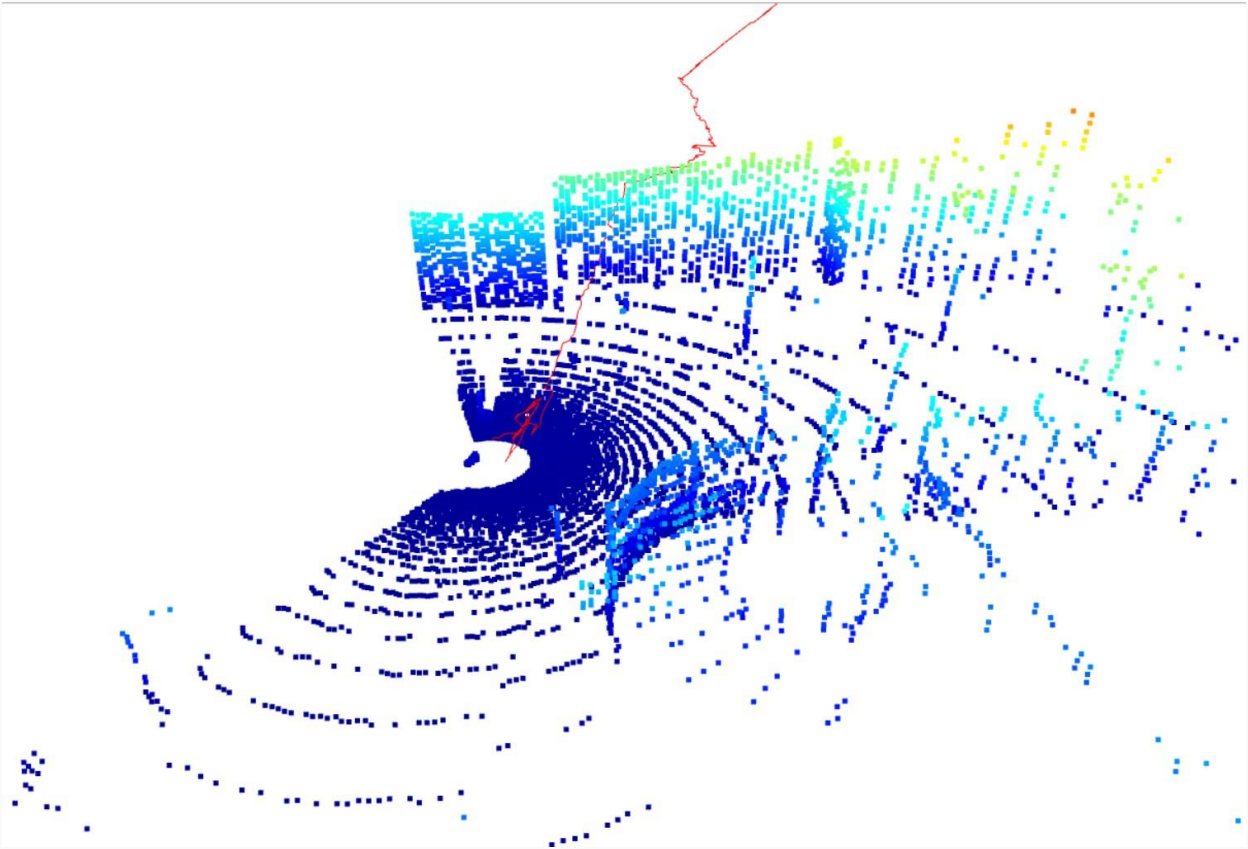

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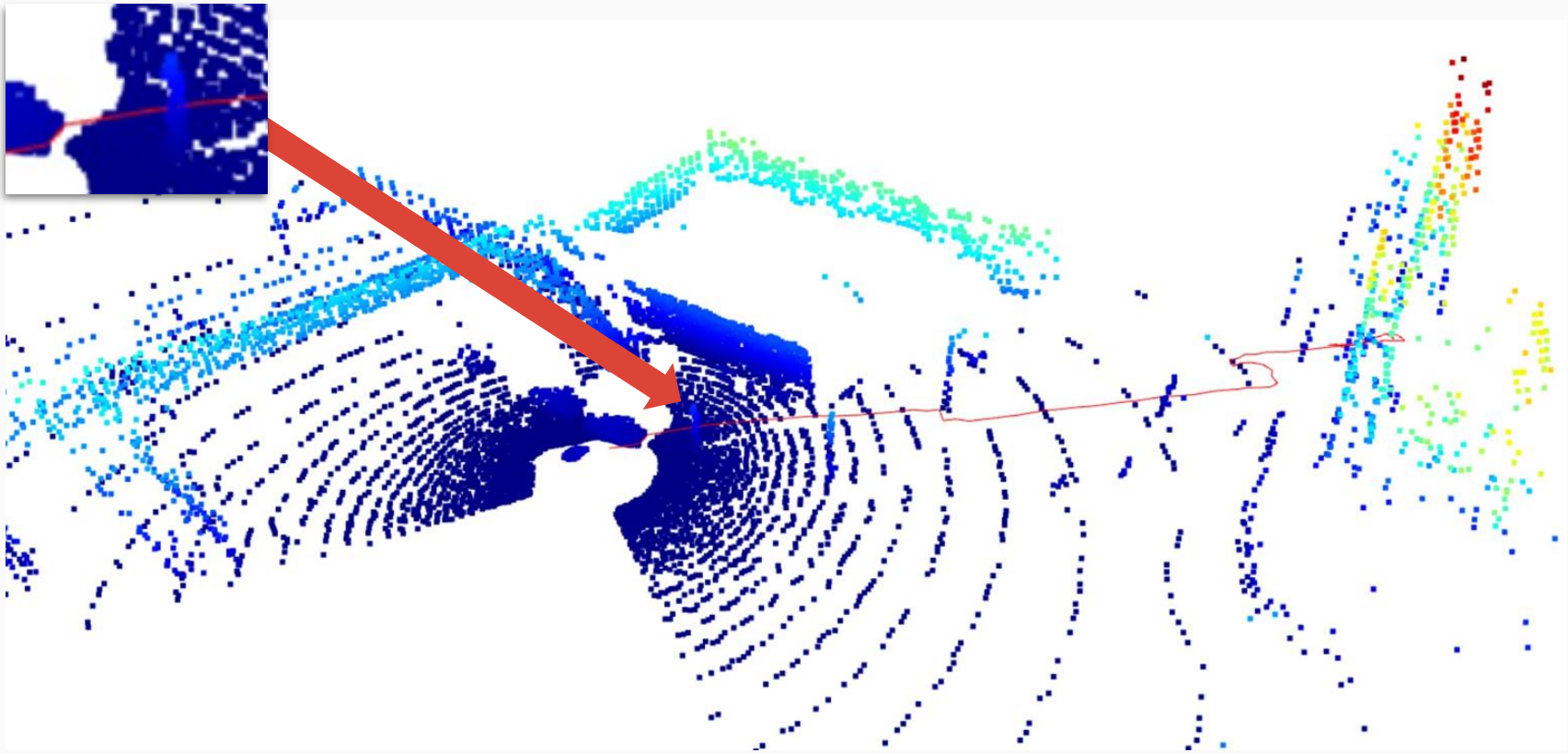
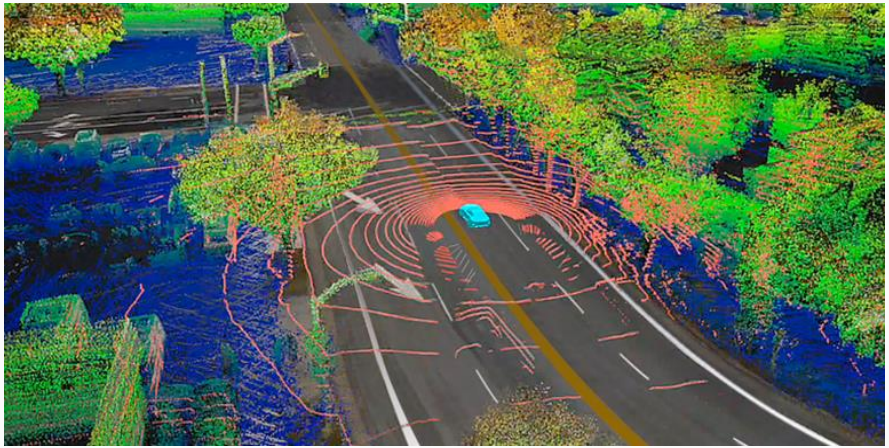


# Related work

# Mapping

Creating a map of the environment:

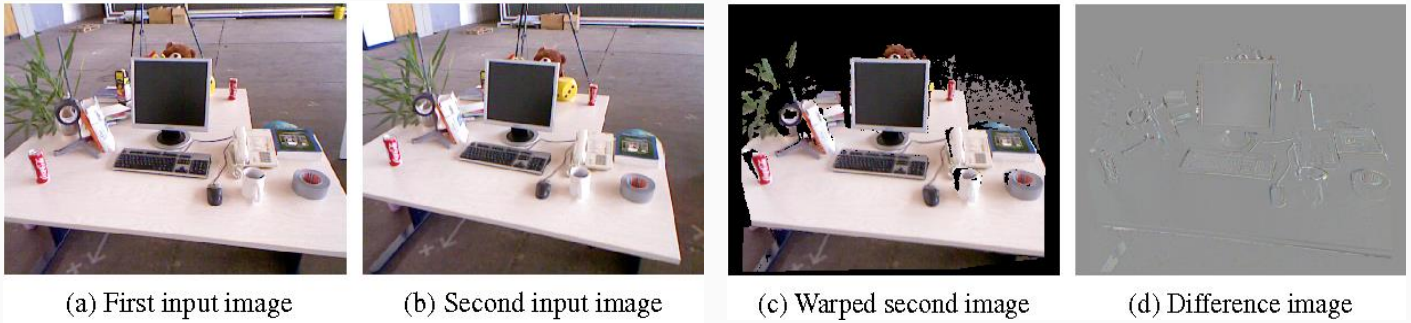
- HD Maps for Autonomous Vehicles
- Semantic SLAM for Dynamic Environments

# Localization

Determining vehicle position and orientation:

- Determine vehicle position relative to a starting point or within a global map
- Simultaneous Localization and Mapping: Extract and track distinct features in environment

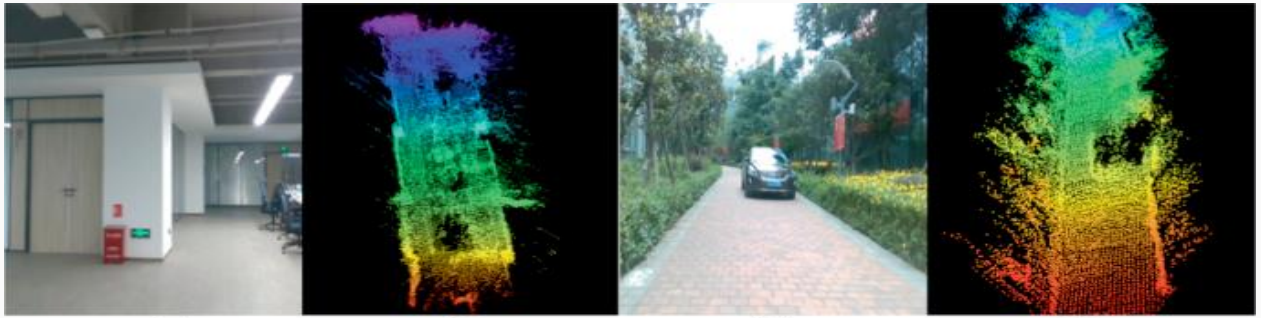


(a) First input image (b) Second input image (c) Warped second image (d) Difference image

# Real-Time Navigation

Dynamic navigation and positioning:

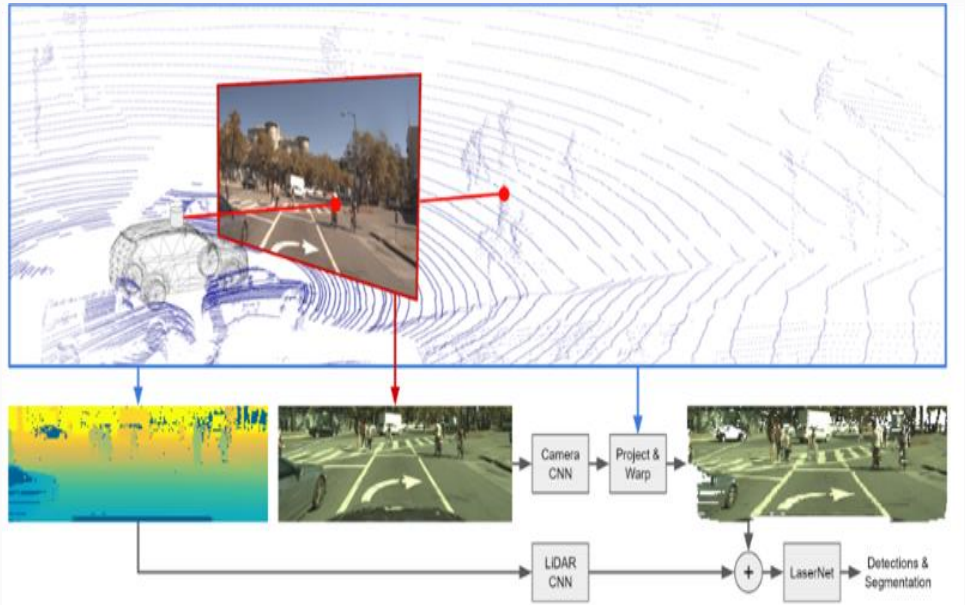
- Dynamic vehicle position and orientation updates via odometry
- Visual Odometry for vehicle navigation from Dense RGB-D Images



# Sensor Fusion

Exploring Advanced Sensor Integration Techniques:

- Multi-sensor Fusion (Early Fusion, Mid Fusion)
- Novel techniques, BEVFusion, LaserNet



# Conclusion

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- Generate data after running the CARLA simulator
- Export sensor data to disk
- Camera data goes to OpenCV to detect and match **keypoints** between frames
- Keypoint matches are used through odometry to estimate trajectory
- LiDAR data goes to Open3D to create a **3D point cloud** of environment
- 3D point cloud visualized to analyze the spatial layout
- Combine the estimated trajectory with generated point cloud to perform SLAM
- SLAM provides comprehensive view of the vehicle's path and environment

# Questions?