Visual SLAM and Deep Learning-Based Localization in GPS-Denied Environments

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Problem Statement

Heavy GPS reliance for navigation.
GPS signal failures in:

- Urban canyons (signal blockage & reflections).
- Tunnels (no satellite visibility).
- Indoor environments (unreliable or unavailable).

Solution: Visual SLAM for robust localization in GPS-denied areas.

Objective of the Project

- Compare Visual SLAM vs. Traditional SLAM techniques.
- Implement & evaluate deep learning-based localization methods.
- Analyze & compare path planning algorithms for autonomous navigation.
- Enhance localization accuracy in GPS-denied environments.
- Improve overall reliability of autonomous navigation systems.

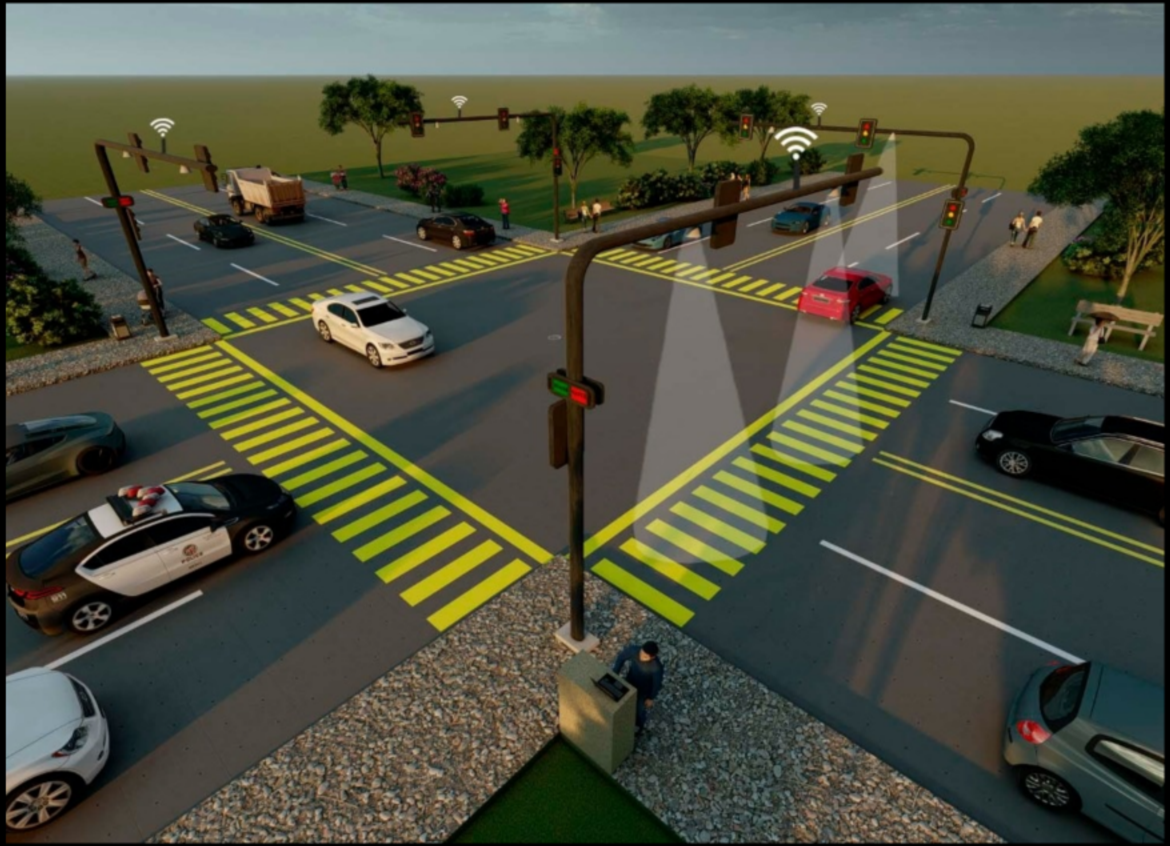
Tools & Programming Languages

- Python – Scripting & implementation.
- OpenCV – Image processing for Visual SLAM.
- PyTorch – Deep learning model training.
- CARLA – Simulation environment for testing and validation.

CARLA Sensor Utilization

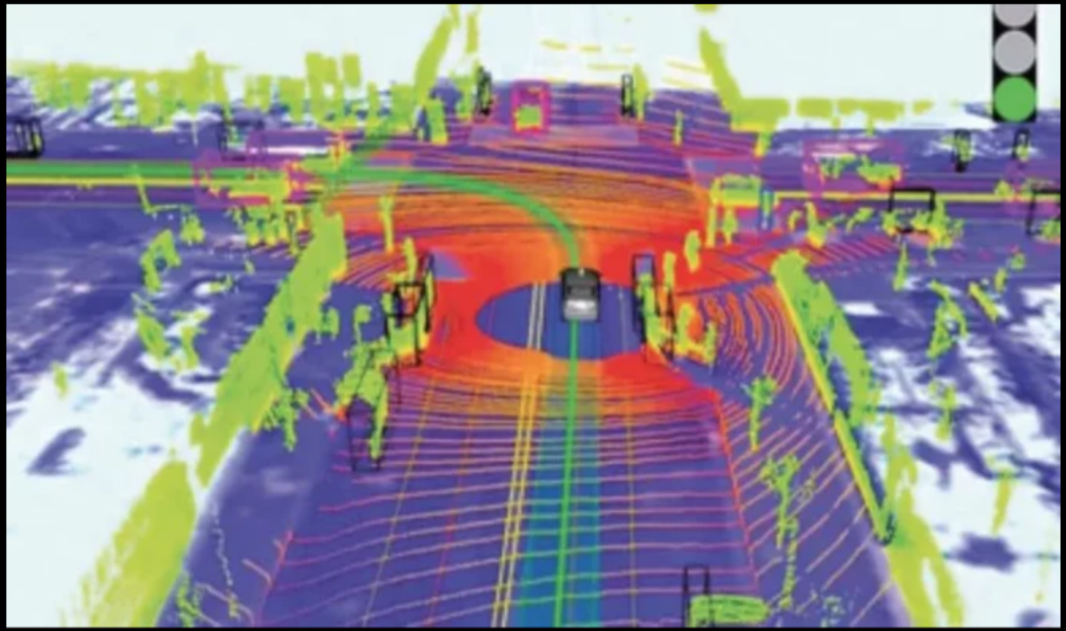
Sensors Used:

- RGB Cameras – Visual feature extraction.
- LiDAR – 3D mapping & depth estimation.
- IMU – Motion tracking & stability.
- Depth Sensors – Enhanced environmental perception.



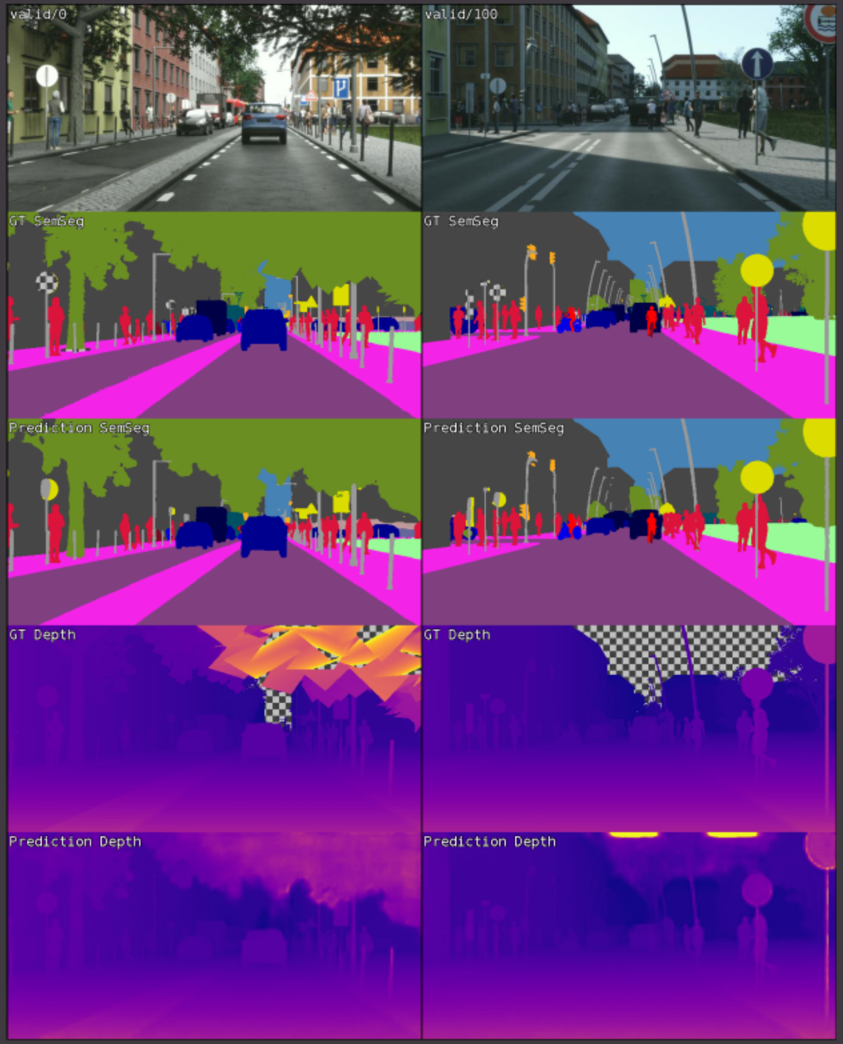
SLAM Techniques

- 3D SLAM – Uses LiDAR to create detailed spatial maps.
- Visual SLAM – Relies on cameras for localization and mapping.
- Comparison Focus:
  - Accuracy in different environments.
  - Handling of 3D structures & depth perception.
  - Computational efficiency & sensor requirements.



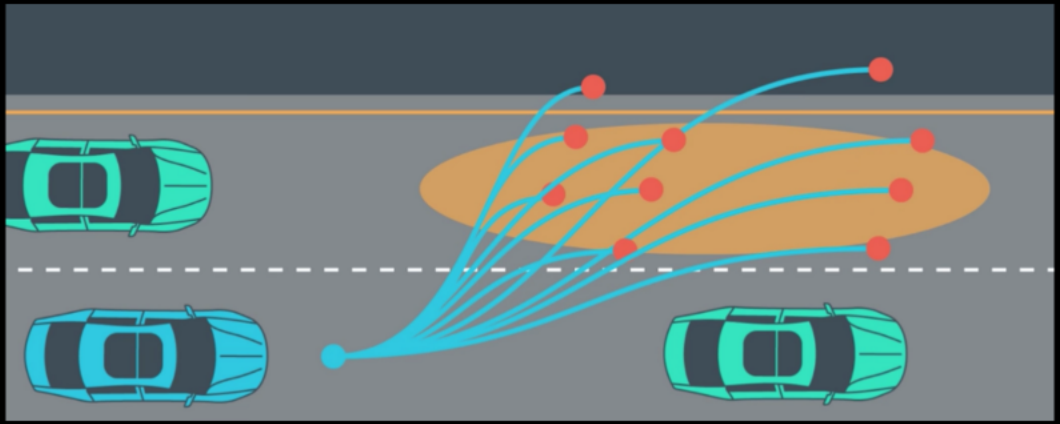
Deep Learning Integration

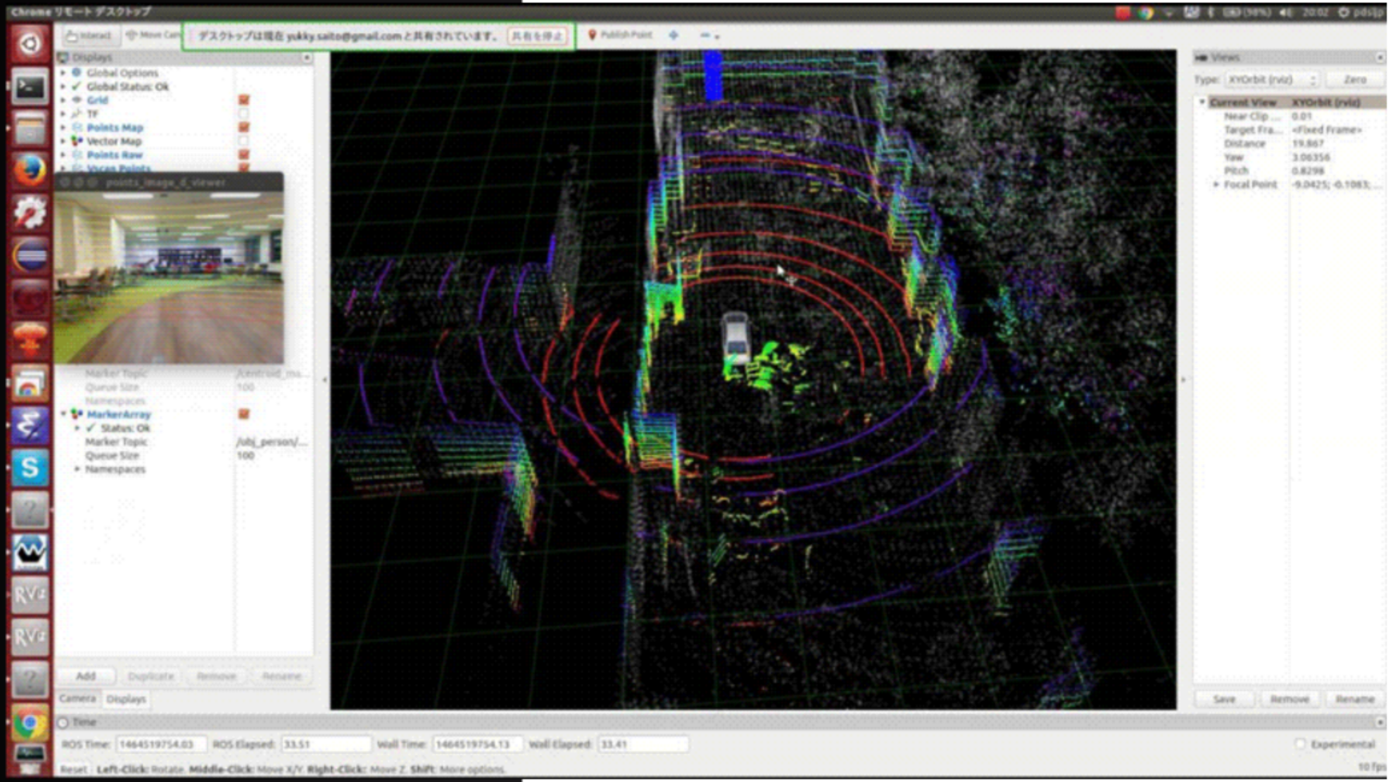
- CNN-based Feature Extraction – Extracts robust spatial features for precise localization.
- Sequential Frame Analysis – Uses deep networks (e.g., RNNs, LSTMs) to track motion and mitigate drift.
- Hybrid Models – Combines CNNs with traditional SLAM techniques for enhanced accuracy.



Path Planning

- Path Planning with A* – Efficient shortest path generation for autonomous navigation.
- RL & Optimization – Train models to adapt to obstacles for real-time decision-making.
- Testing & Validation – Assess performance in urban & off-road scenarios under realistic conditions.





Future Work and Improvements

- Implement SLAM and path planning within the ROS framework for modular development.
- Experiment with RRT, Dijkstra, and Reinforcement Learning for improved navigation.

Thank You