Multi-Sensor Fusion and V2V Collaboration in Autonomous Vehicles: A Comprehensive Framework for Self-Driving

Myra Cropper
Advised by: Dr. Sidi Lu
Committee Members: Dr. Robert Lewis, Dr. Yi He

Background

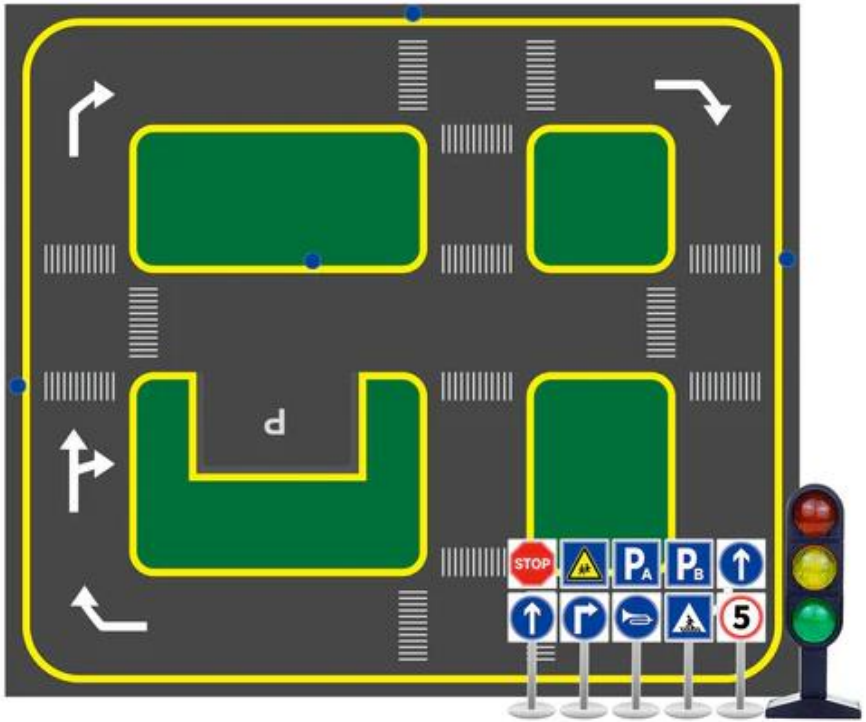
- Tesla, Waymo, OpenPilot
- We use a robotic vehicle for testing/research purposes.

Motivation

- Semi-autonomous driving
  1) Lane Detection
  2) Vehicle Detection and Tracking
  3) Traffic Sign Detection
  4) Vehicle-to-Vehicle Collaboration
  5) 3D Virtualization

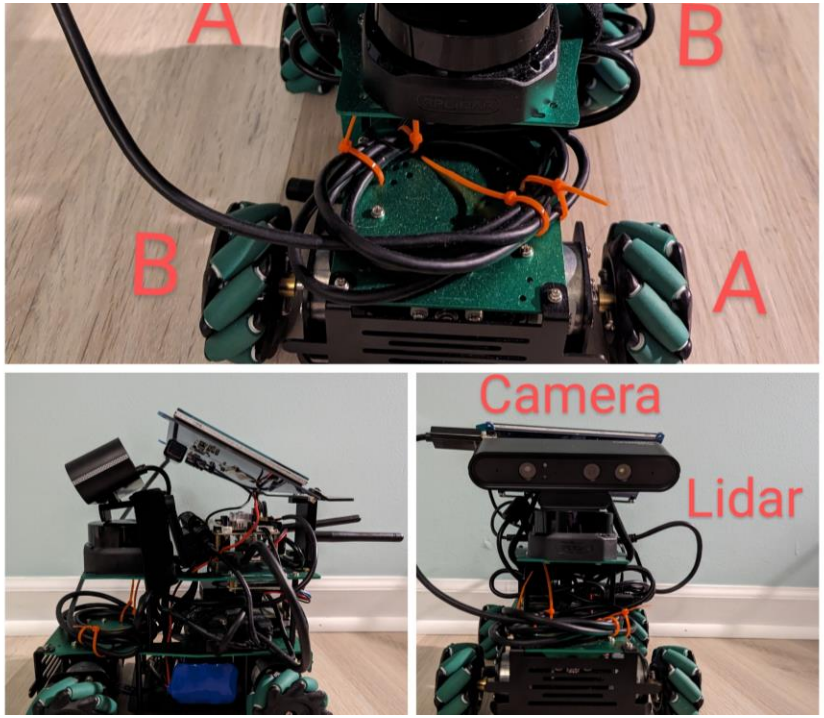
Map

Robotic Map Used
2.8m x 3.2m



Robot

- Robot Used
- Wheels are labeled according to their direction



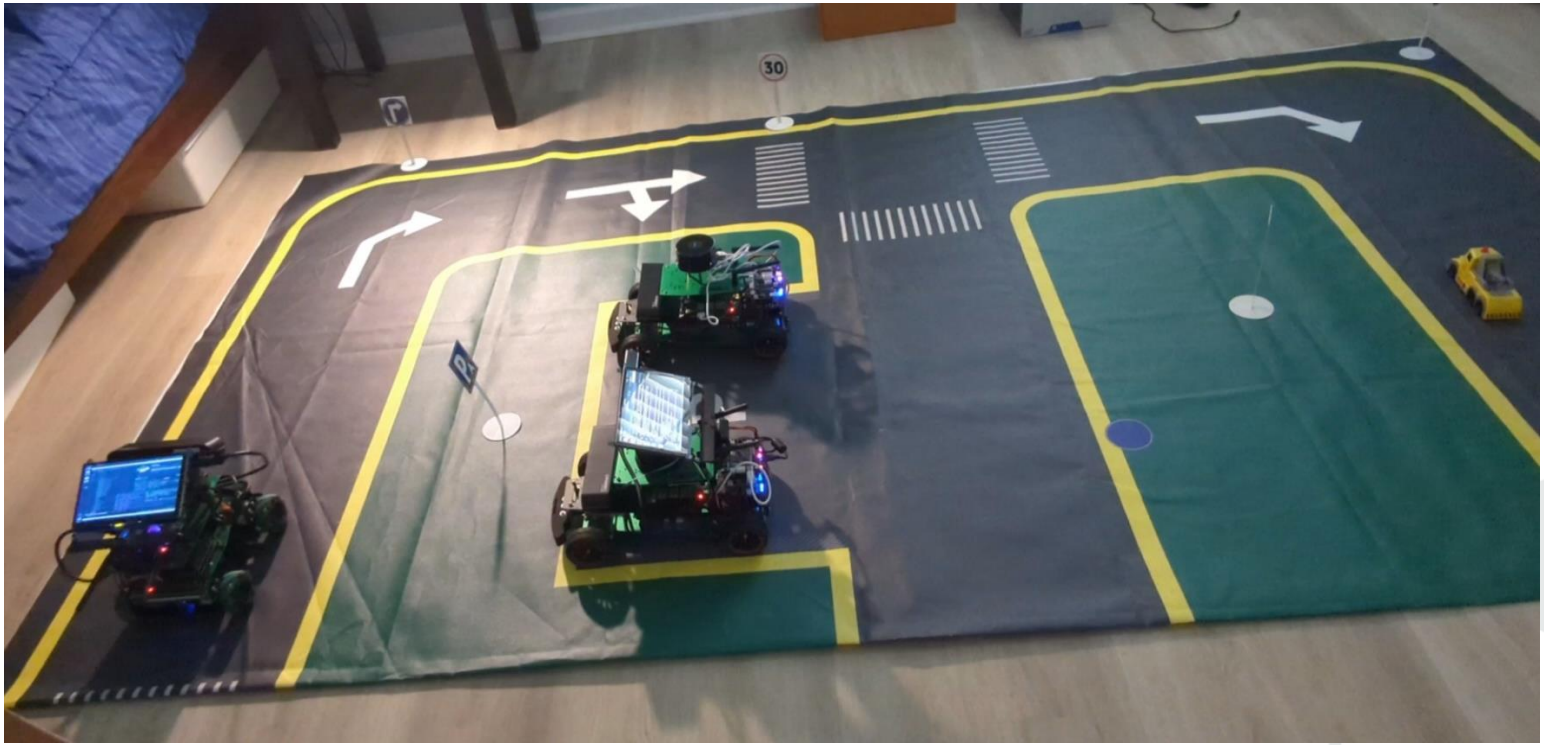
Experiment and Framework Overview

- Lane Detection
- Vehicle Detection and Tracking
- Traffic Sign Detection
- Vehicle-to-Vehicle Collaboration
- 3D Visualization

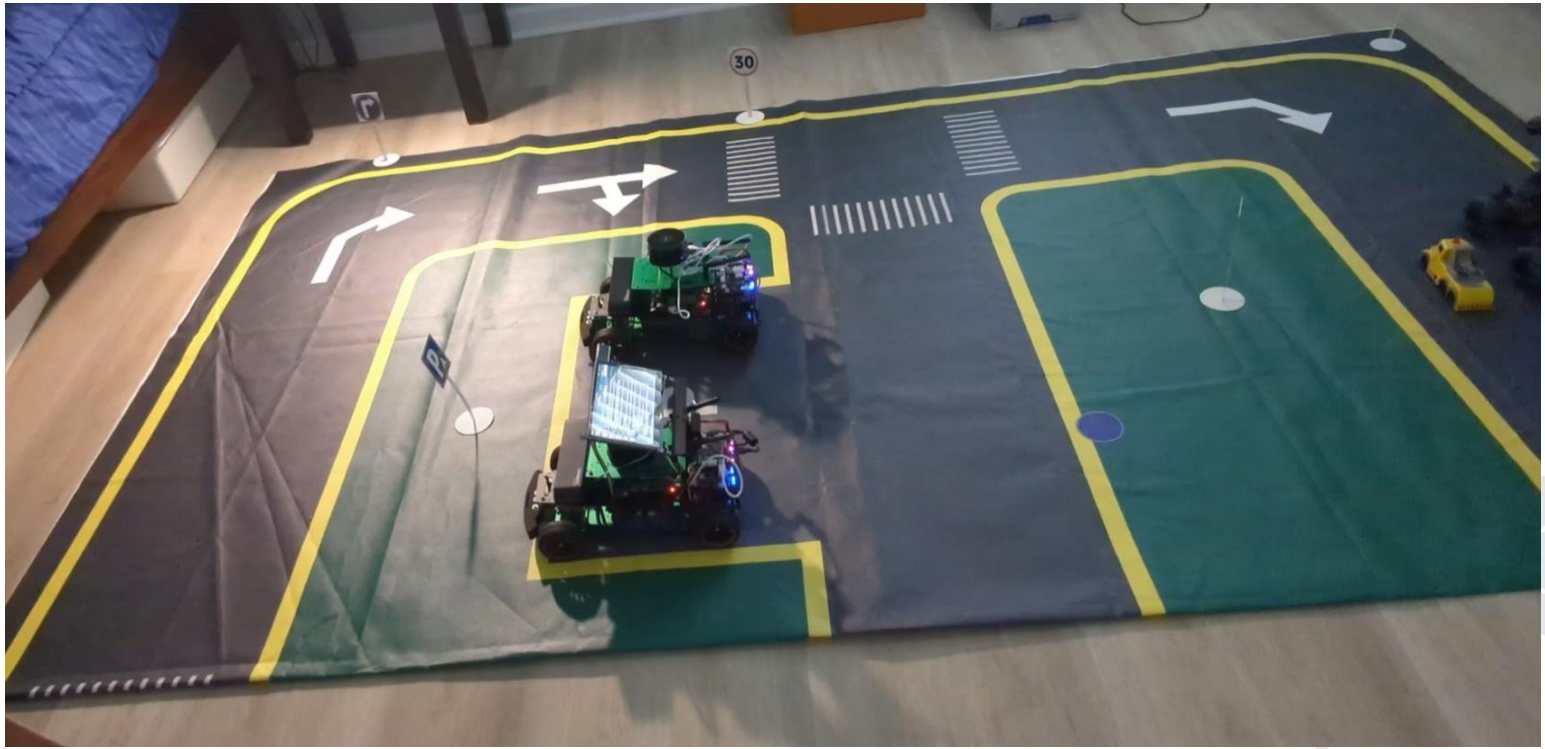
Lane Detection

- Recorded vehicle movement around map
- EfficientNet CNN + Long Short-Term Memory (LSTM)
- Trained model is saved to robot, inference is performed on live video

Lane Detection Demo Video



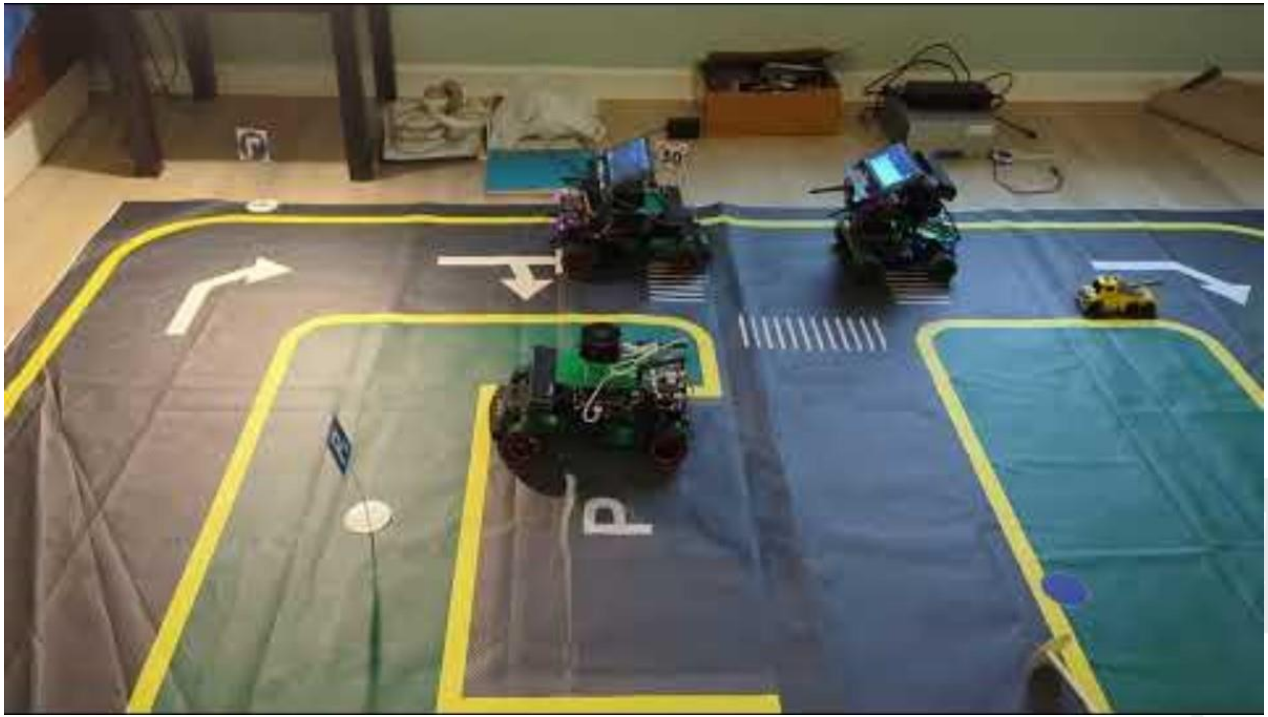
Lane Detection Demo Video



Vehicle Detection and Tracking

- LiDAR sensor for distance calculations/object detection
- Robot identifies and follows the other robot/vehicle

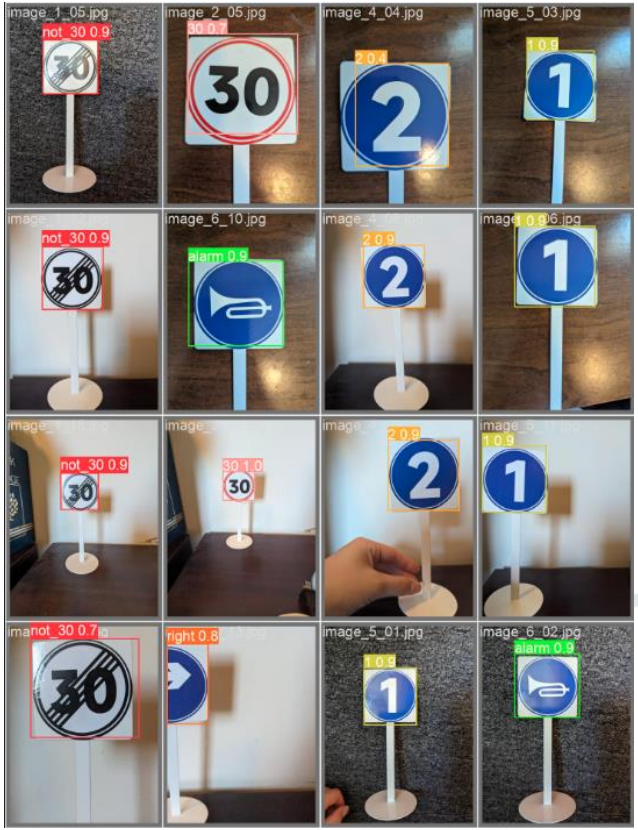
Vehicle Tracking Demo Video



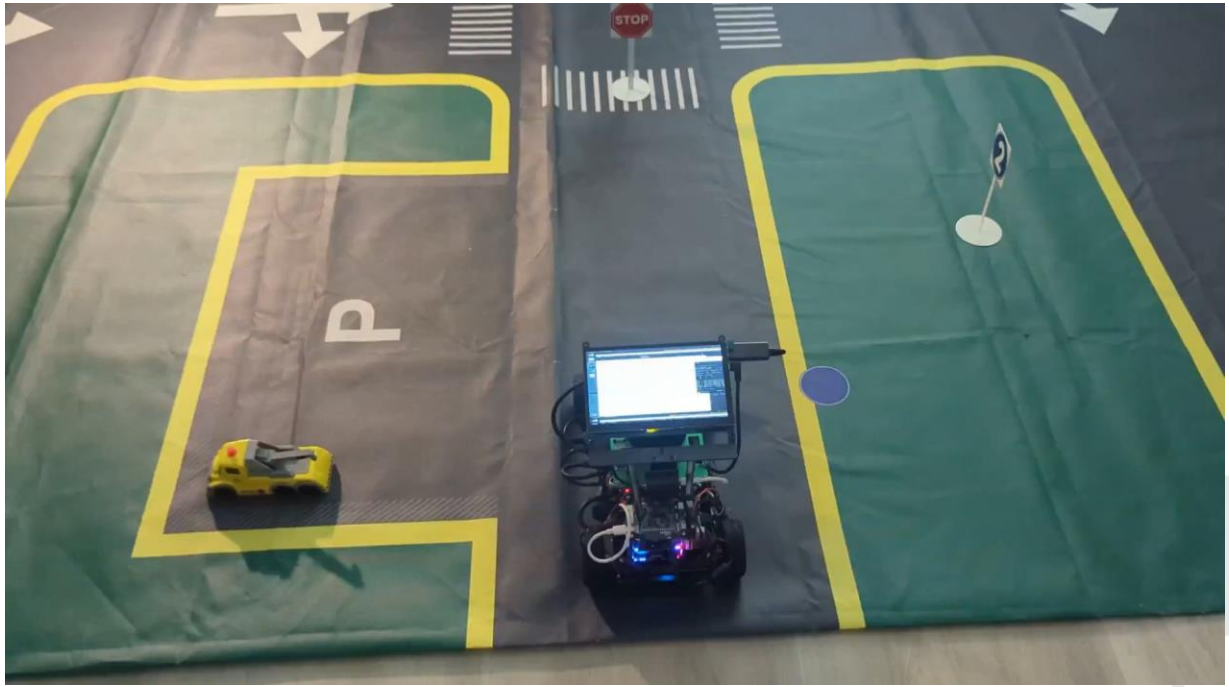
Traffic Sign Detection

- You Only Look Once (YOLO)
- Augmented images for training
- Robot checks if object is detected, if so open perform call the model

Traffic Sign Detection



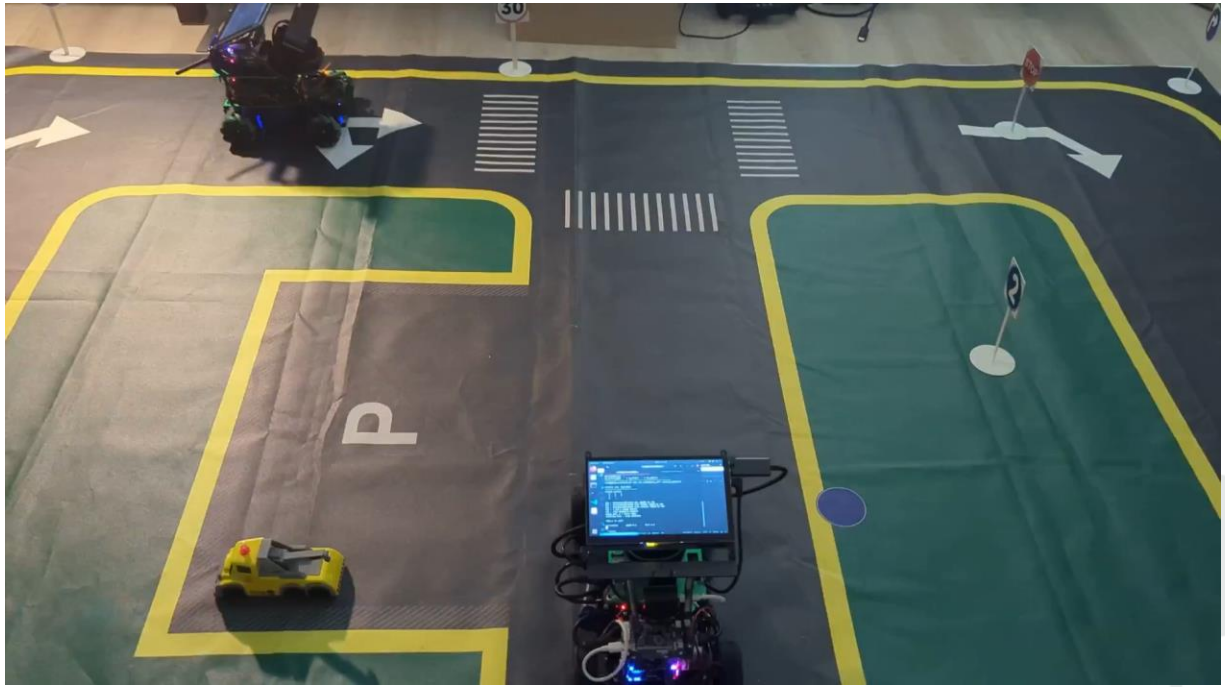
Traffic Sign Demo Video



Vehicle-to-Vehicle Collaboration

- Data Distributed Services (DDS) used
- Robot 1 creates a publisher
- Robot 2 creates a subscriber
- Send each other position and velocity data

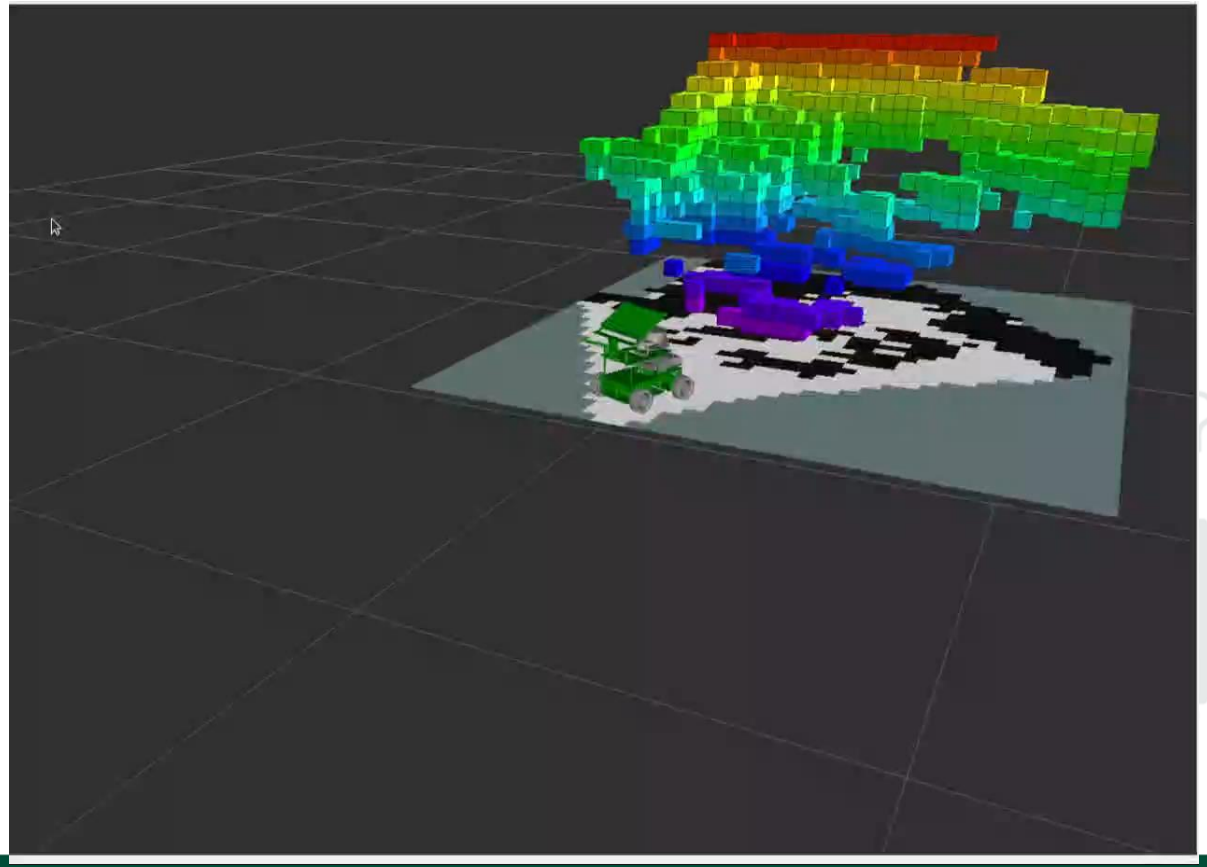
Vehicle-to-Vehicle Collaboration Demo Video



3D Virtualization

- LiDAR sensor + camera
- Display objects in RVIZ
- Uses Octomapping

3D Virtualization Demo Video



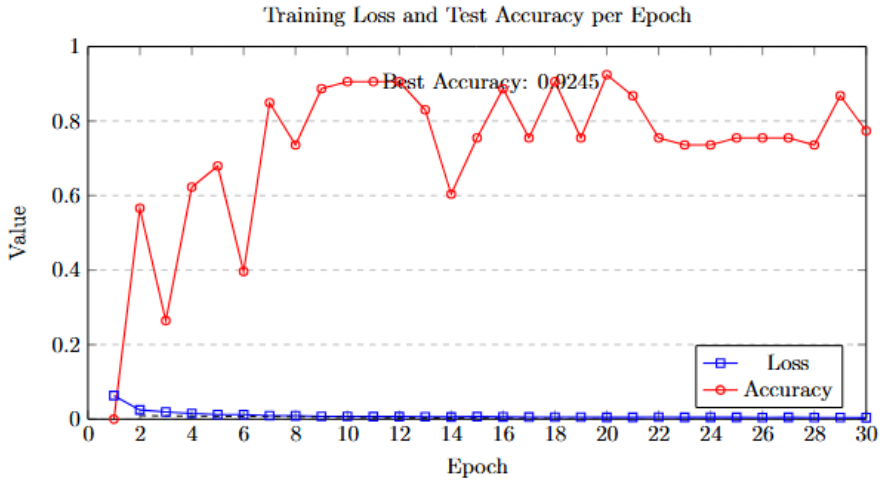
Traffic Sign Detection Results

- YOLO model validation results
- Overall mAP of 94%

Class	Images	Instances	P	R	mAP@50	mAP@50-95
all	50	57	0.982	0.833	0.945	0.766
not_30	50	9	1.000	0.982	0.995	0.803
30	50	8	0.985	1.000	0.995	0.819
right	50	9	0.965	0.667	0.870	0.685
2	50	8	1.000	0.531	0.900	0.682
1	50	7	0.951	1.000	0.995	0.788
alarm	50	8	1.000	0.774	0.949	0.807
left	50	8	0.971	0.875	0.913	0.778

Lane Detection Results

- Best test accuracy was reached at Epoch 20
- 92.45%
- Early stopped called at Epoch 30

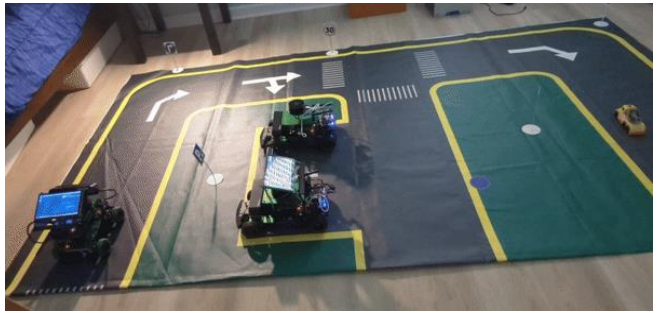


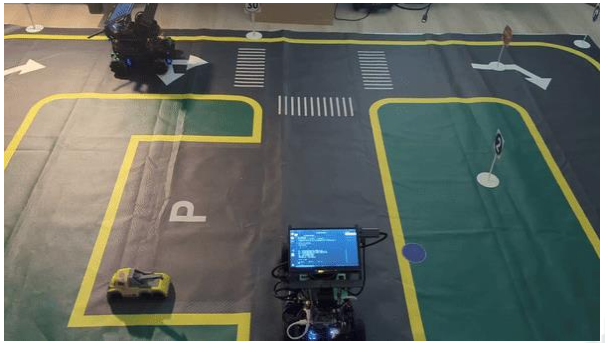
Challenges - Solutions

- OpenCV Incorrect Lane Detection
- Limitations of OpenPilot's Model
- Robot Turning Issue
- Optimizing Code for Lightweight device

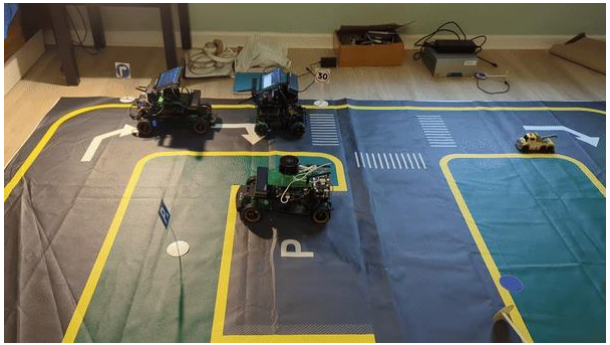
Overview/Summary

Lane Detection

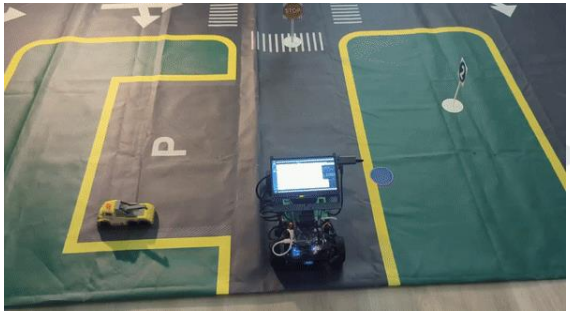




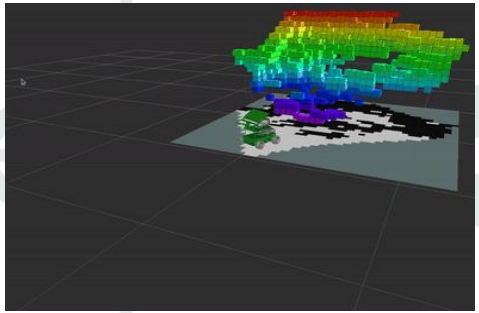
Multi-Robot communication



Vehicle Tracking

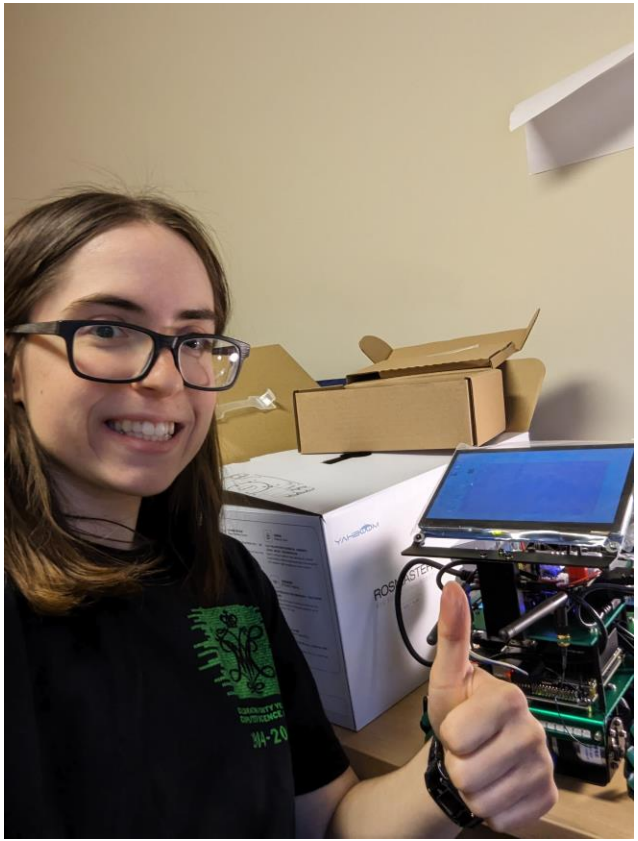


Sign Detection



3D Virtualization

Thank You!



GitHub

GitHub