Autonomous Shuttle Bus Navigation on Public and Private Roads

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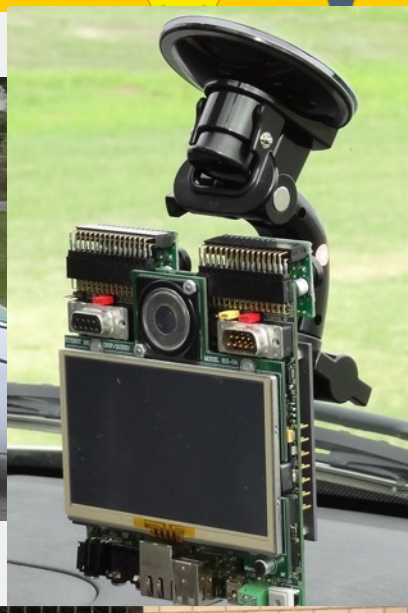
The University of Western Australia
http://RobLab.org/ http://REVproject.com

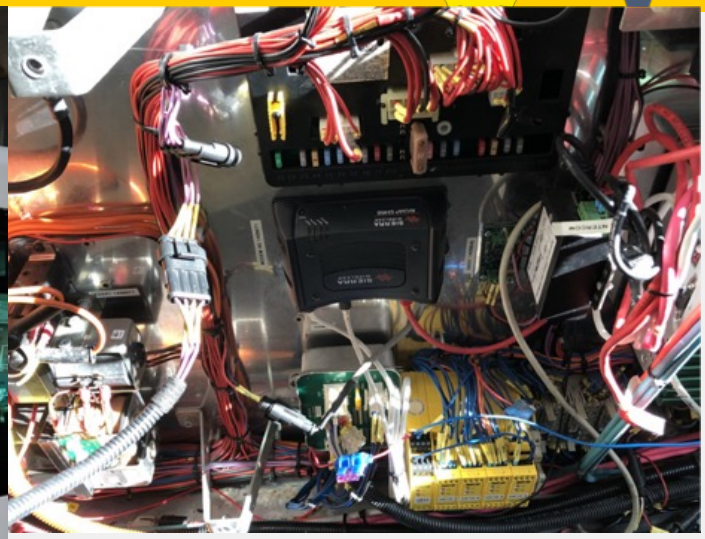
ACRA 2025

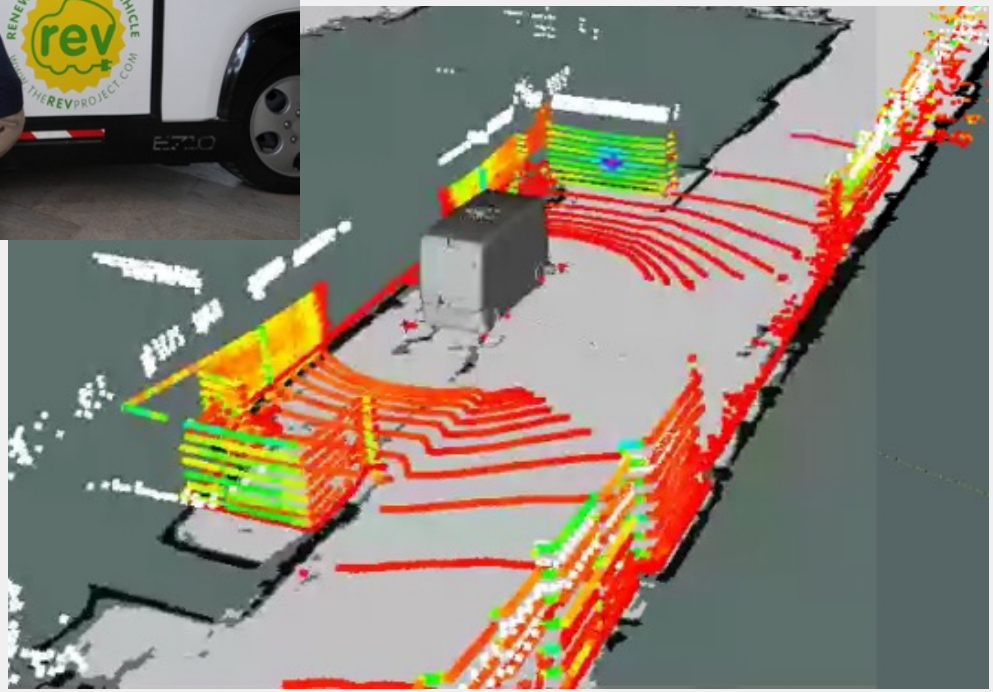
Driver Assistance 2009-2011



Autonomous Formula-SAE 2014-2018

Autonomous Shuttle Buses 2020





The REV Team

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Zhihui Lai

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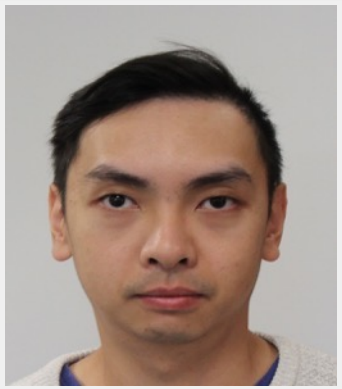

Lee Le

RobLab.org
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EasyMile EZ10 Sensors

Point Grey GS3-PGE

Velodyne - VLP-16

SICK LMS-151

SICK LD-MRS

Nuvo-5006P

Nvidia Orin

SBG Ellipse-D RTK-GPS

Xsens IMU

EZ10 Wheel Odometry

Autonomous Driving Methods

	Campus	Road
1. GPS-RTK	✗	✓
2. Lidar-SLAM	✓	✗
3. Image Processing (trad.).	...	...
4. Vision-based Deep NN ..	✓	✓
5. Large Language Model .	...	✓

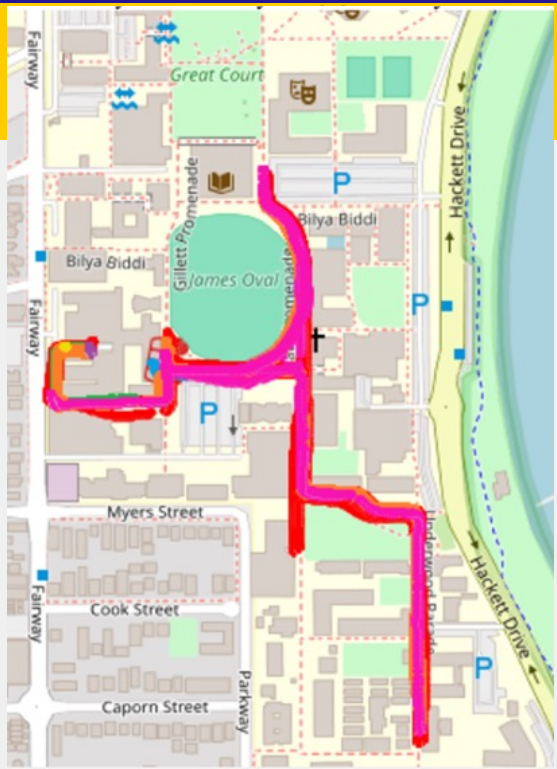
Combined Methods

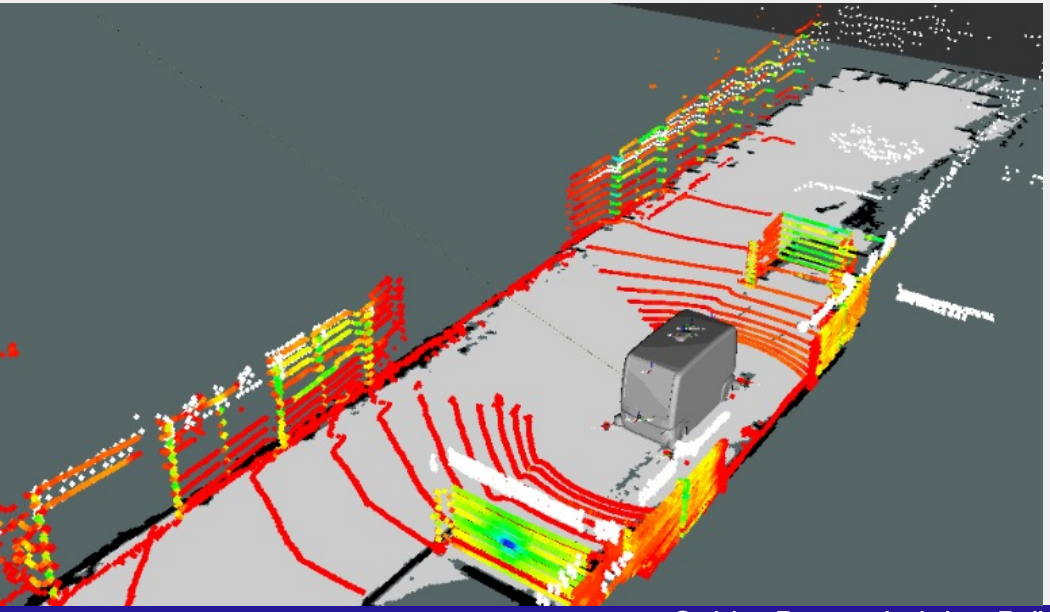
Autonomous Driving on Campus

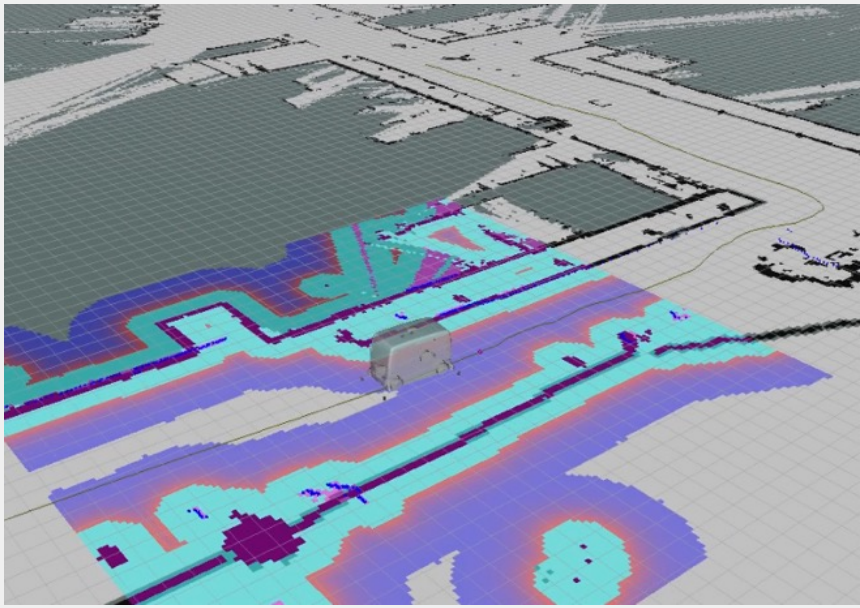
Campus Driving

2D Lidar SLAM

- 4 x Sick Lidar, single-layer
- 2 x Ibeo Lux Lidar, 8-layers
- 2 x Velodyne Lidar, 16 layers
- Full university campus Lidar map
- Path planning and navigation based on map with sensor fusion





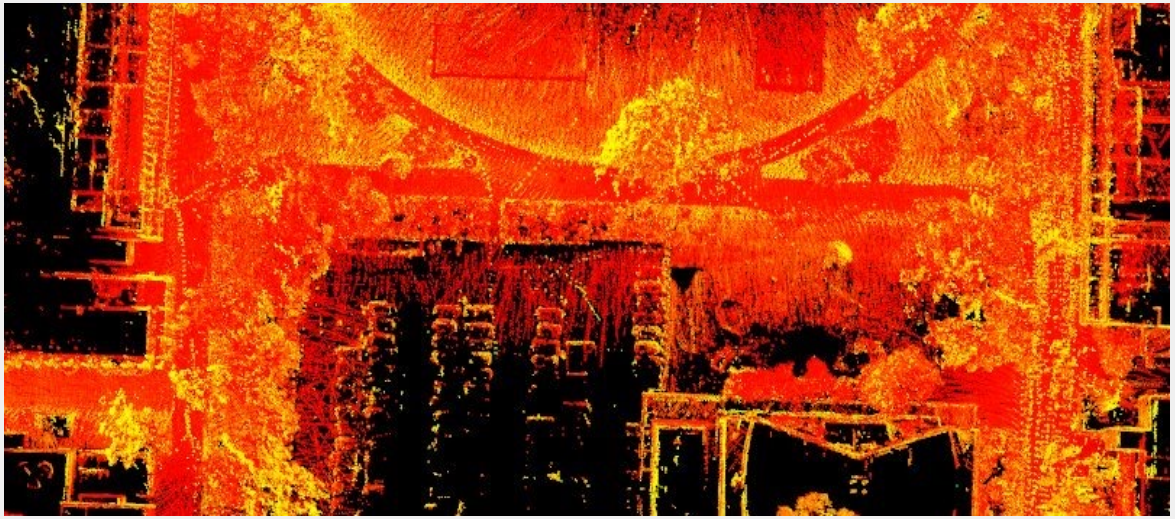


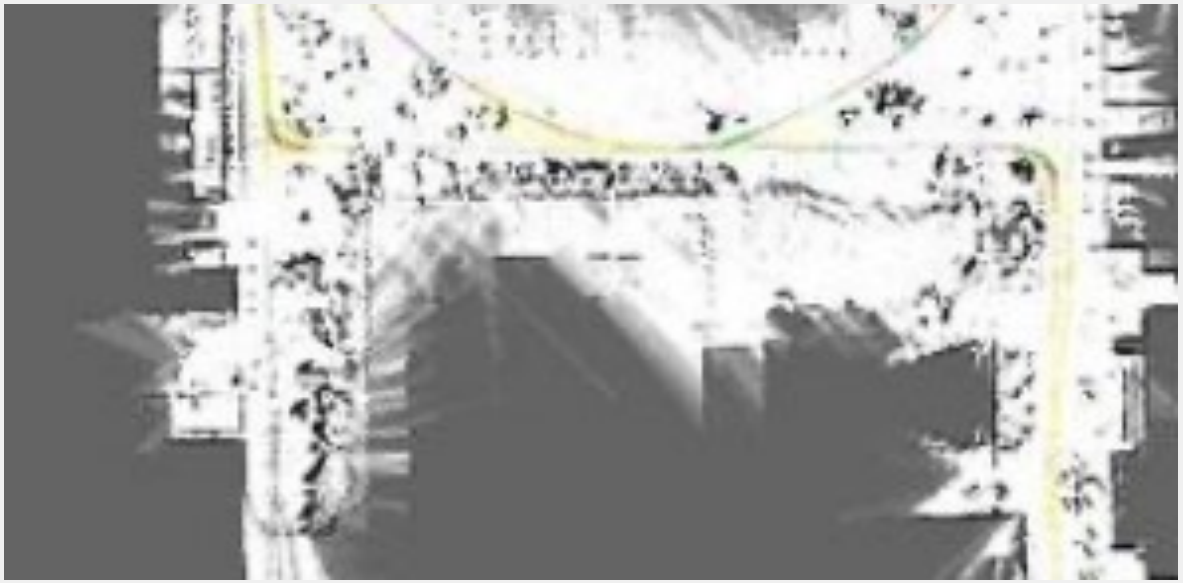
Campus-wide Lidar Map

Lidar only:
incorrect angles

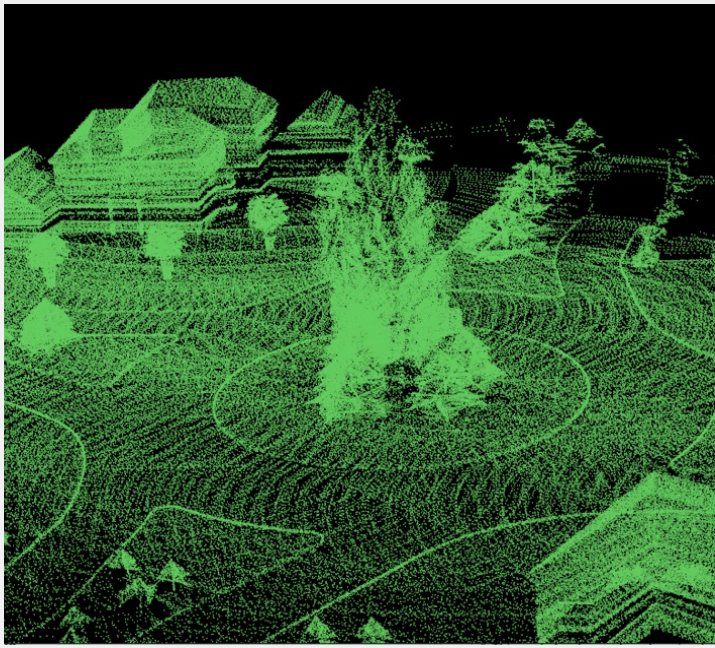
Lidar + IMU:
Corrected full map

Outlook: 3D SLAM





- Creates more complex maps, capturing full 3D structure
- Important for trees etc.
- Object detection (pedestrians + cars)
- More robust than vision



Autonomous Driving on Public Road

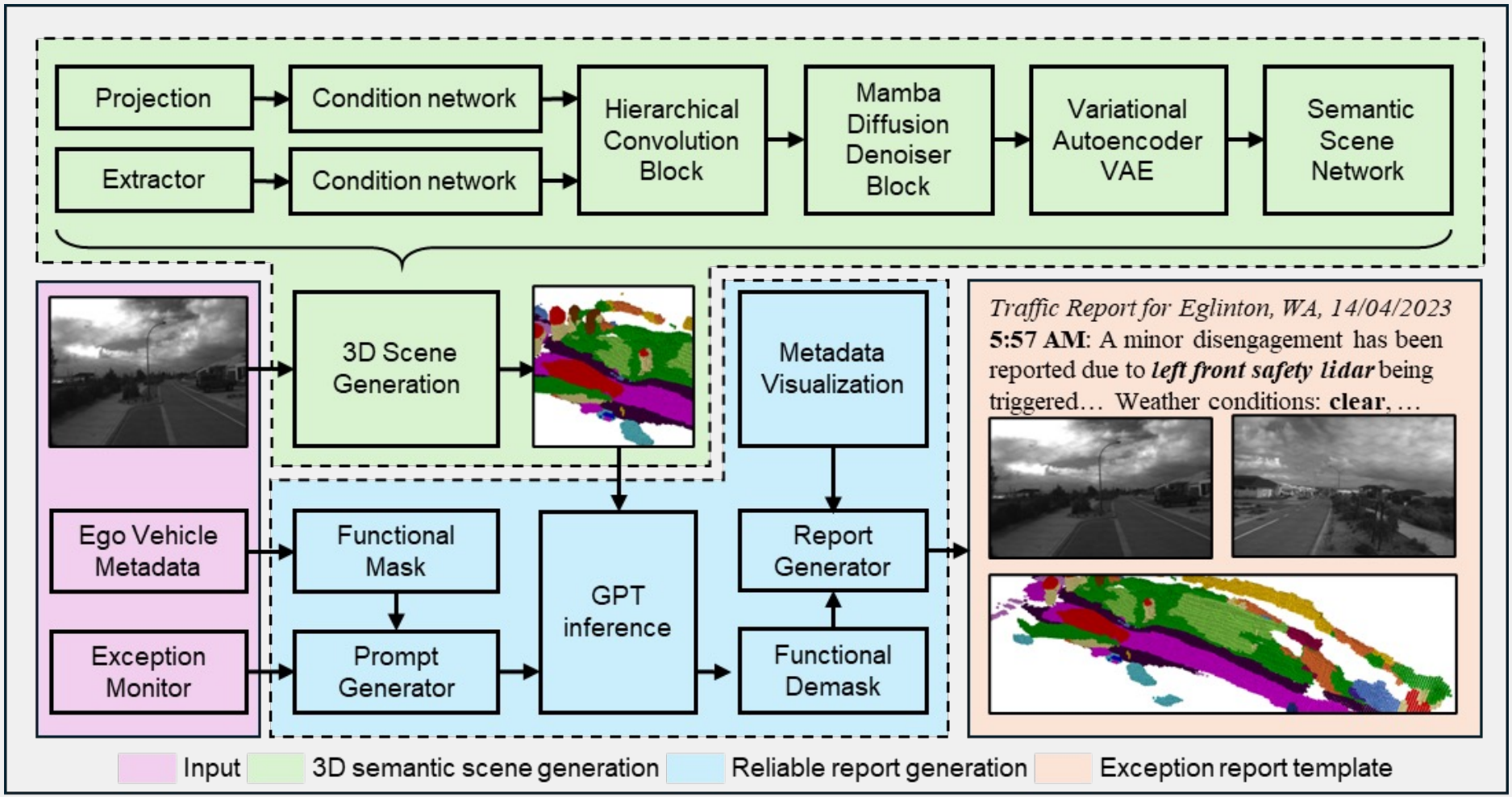
Public Road – Amberton Beach

Input from:

- Department of Transport
- Public Transport Authority
- Police Department
- Fire Department
- Emergency Services
- …

- Traffic Analysis
- Traffic Management Plan
- External Consultants
- $$$ + 3 years negotiating

Disengagement Reporting with LLM

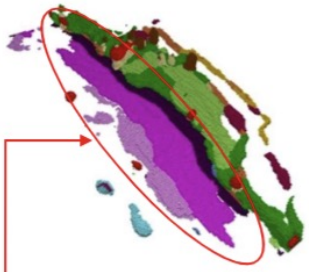


Disengagement Reporting with LLM

Date and Time: `get_incident_datetime()`

Location: `get_location()`

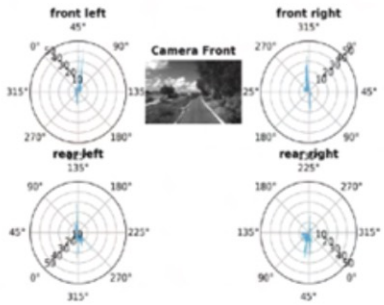
Detailed Incident Description: The incident took place on a suburban residential street during clear weather conditions. The autonomous shuttle was traveling down a road lined with residential houses on both sides.

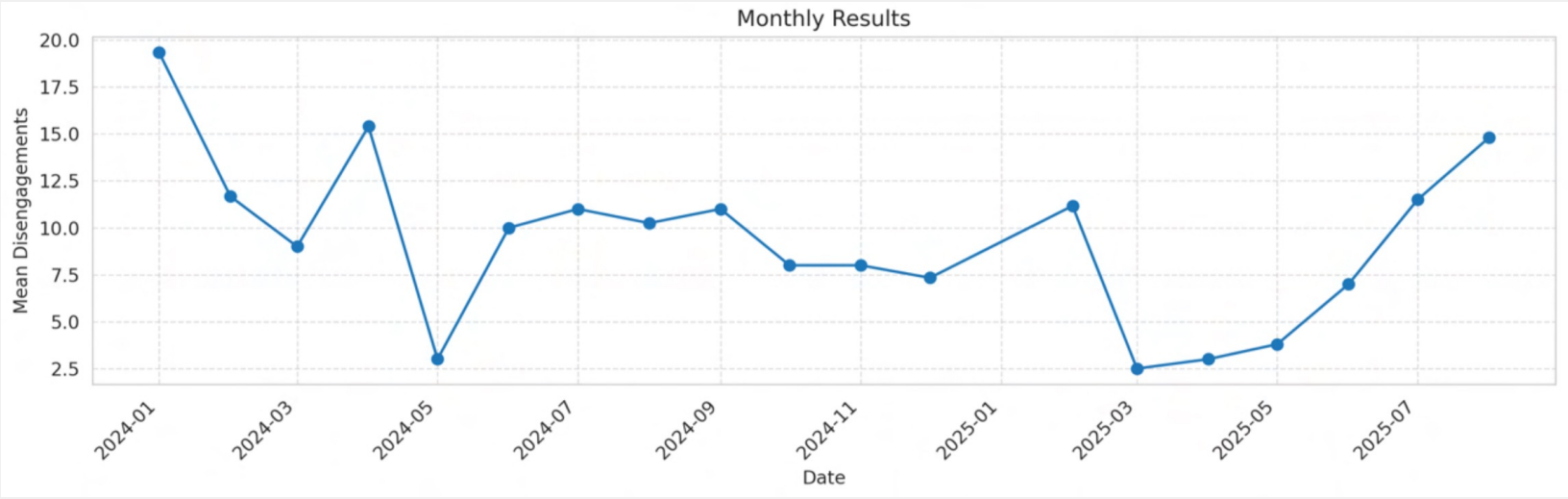


In the front camera image, a white sedan is parked on the side of the road, partially on the pedestrian walkway, with another utility vehicle parked further ahead on the left side, possibly involved in nearby construction work. The road is slightly curved, leading into a straight section with no immediate obstacles or oncoming traffic.

Disengagements

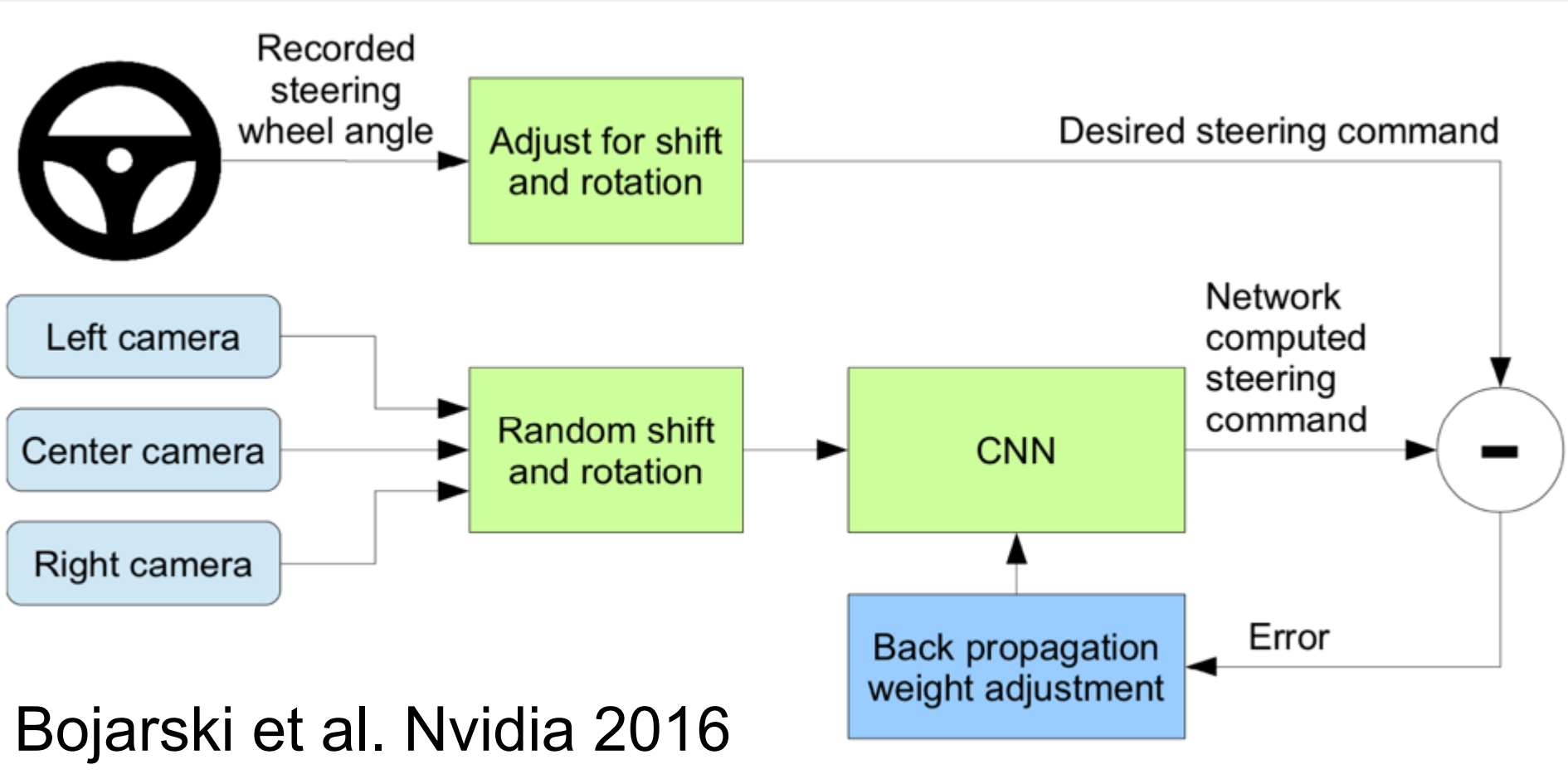
- A non-serious incident happened at **14:28 28/07/2023** which caused no damage.
- Description: An EZ10 Autonomous Bus broke down on 52 Cinnabar Drive, Eglinton, (location: **-31.596191, 115.668724**). The incident didn't cause any damage to property or injuries to anyone involved.
- Details: After the vehicle left the roundabout, it was running at a speed of **about 20 km/h**. At this point, the safety lidar system triggered an emergency braking due to the curb. This breakdown resulted in the rear left shaft of the vehicle being broken, which caused the vehicle to come to an immediate stop.





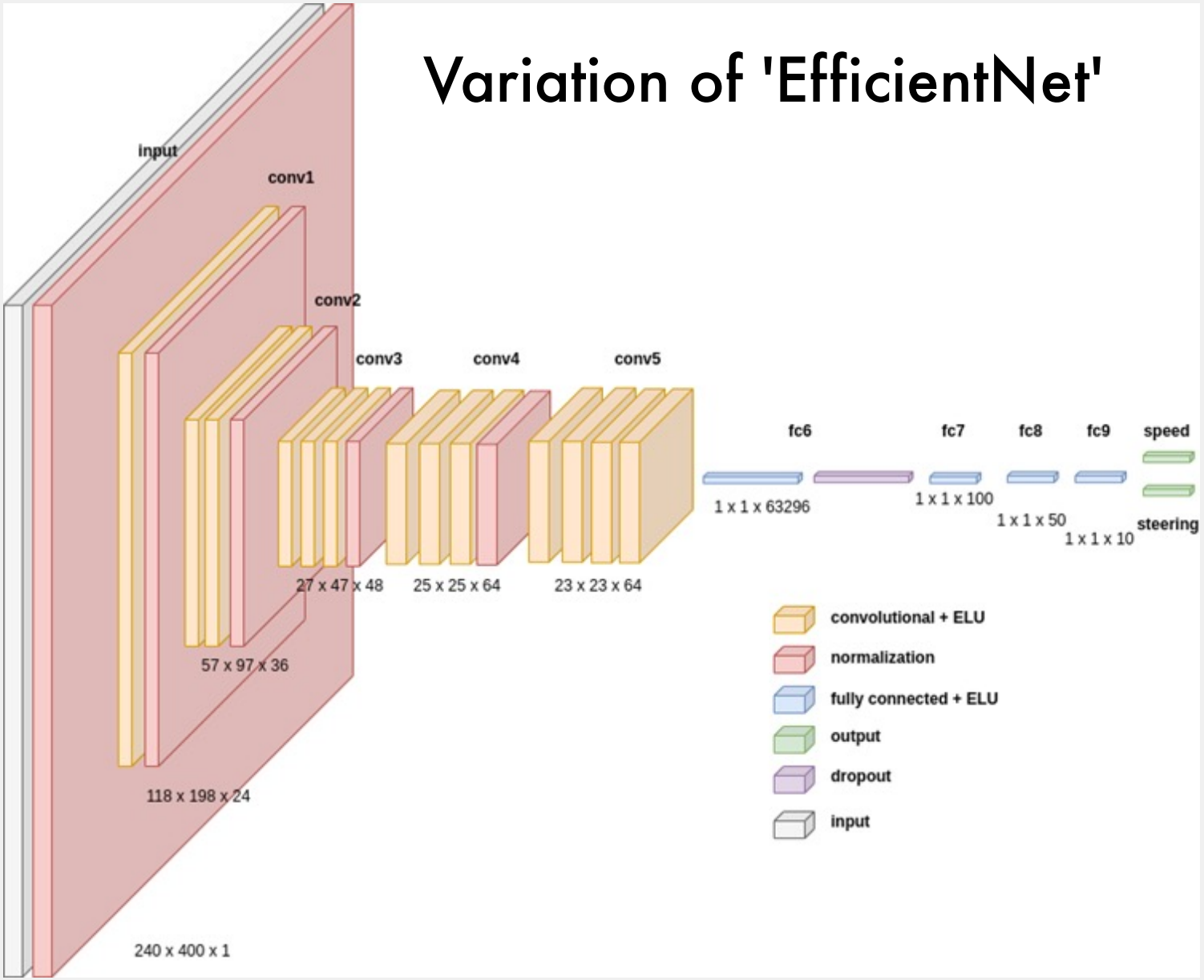
End-to-End Learning

End-to-End Deep Learning for AV



Bojarski et al. Nvidia 2016

End-to-End Learning



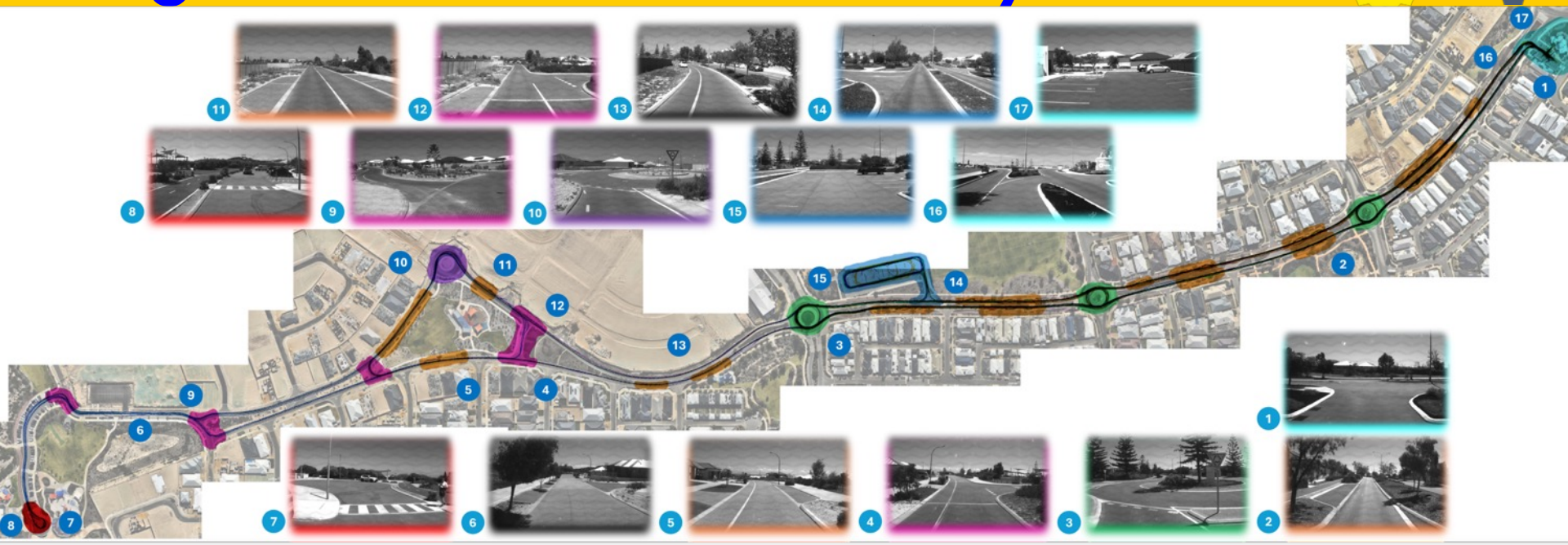
Amberton Beach Trial

Deep NN Training

- Mono camera (front + rear)
- Lidar Velodyne (front + rear)
- GNSS
- IMU

→ Drive commands at 20Hz

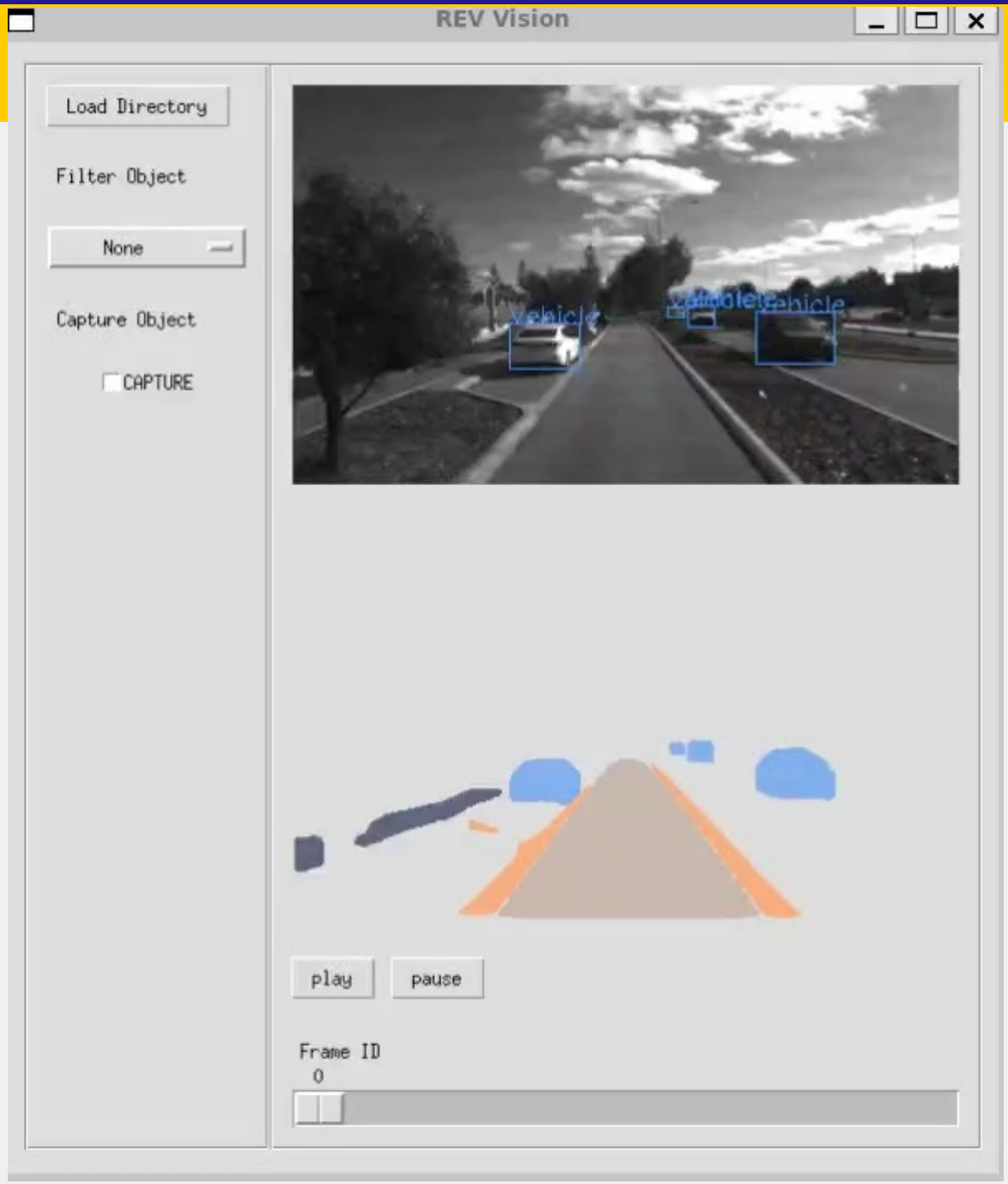
Eglinton Shuttle nUWAy2



Identified 7 driving scenes along path

Merged into 3 different NN models:

- M0: Lane following + pull-out + straight
  at roundabouts and intersections
- M1: Lane following + pull-in + East-turns
- M2: Lane following + reverse + West-turns


REV Vision
Load Directory
Filter Object
None
Capture Object
CAPTURE
play
pause
Frame ID
0

Autonomous Driving Simulation

Vehicle Simulation

Simulation Systems

- **CARLA** (Unreal Engine)
- **AWSIM** (Unity 3D, Autoware)
- Maps created with Roadrunner and Nearmap

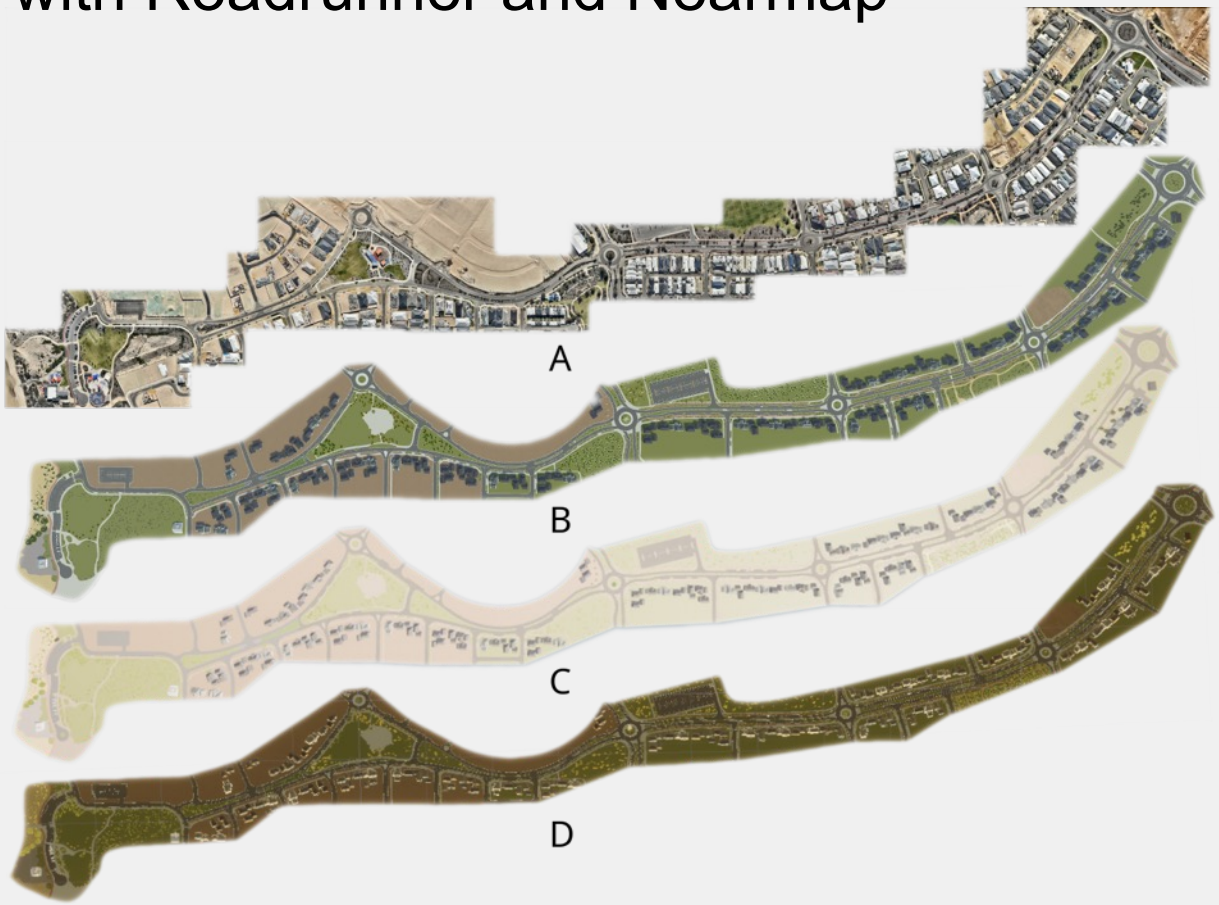
Legend:

A: Nearmap

B: Roadrunner

C: CARLA

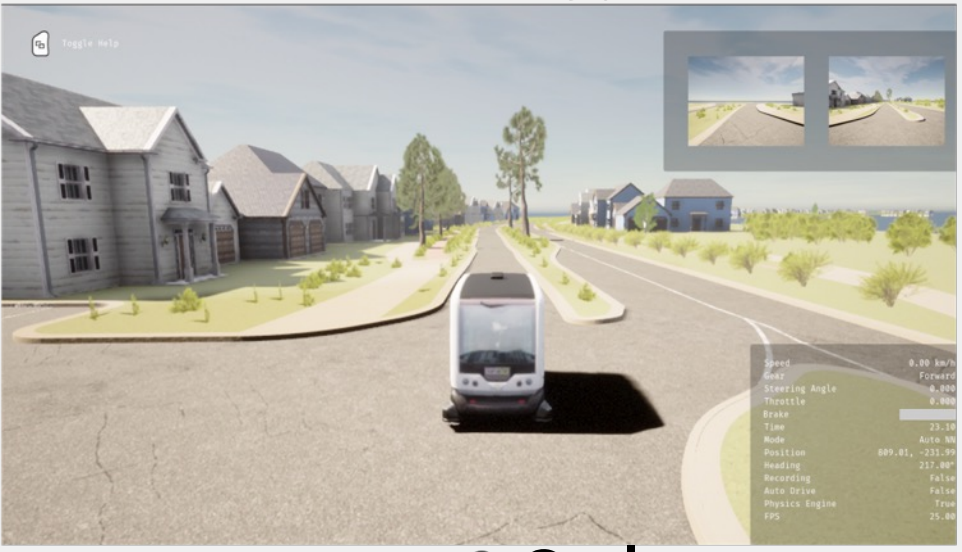
D: AWSIM



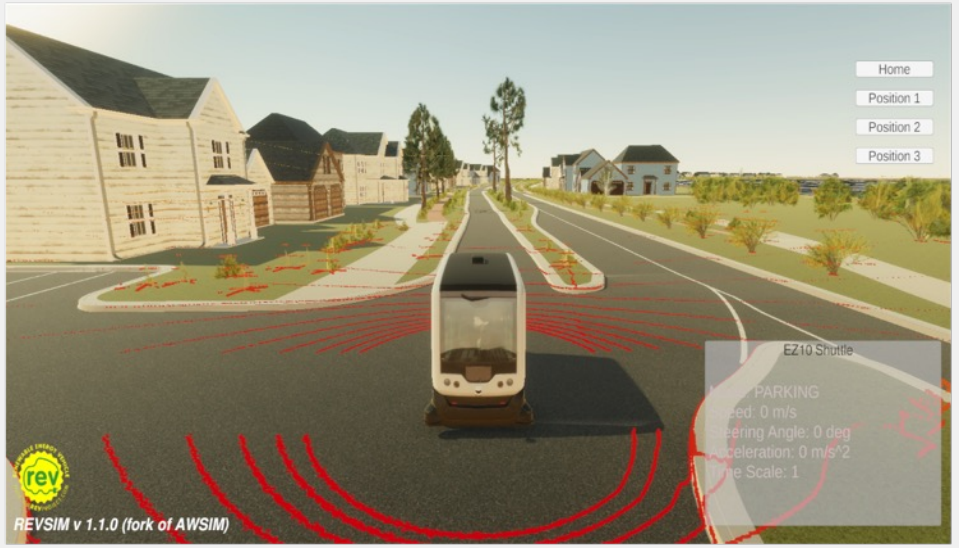
Simulation Systems

A Real

B Roadrunner

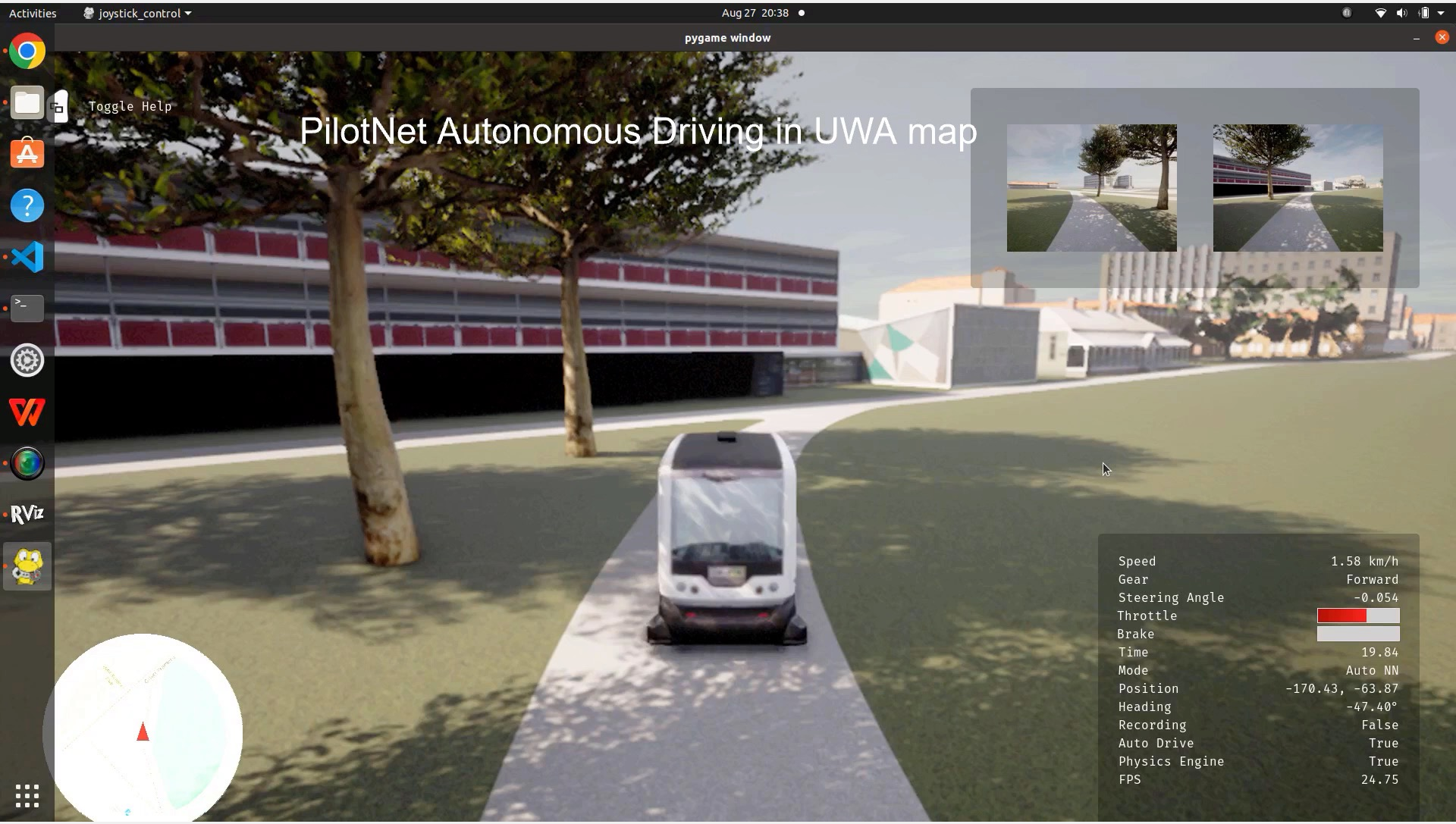


C Carla

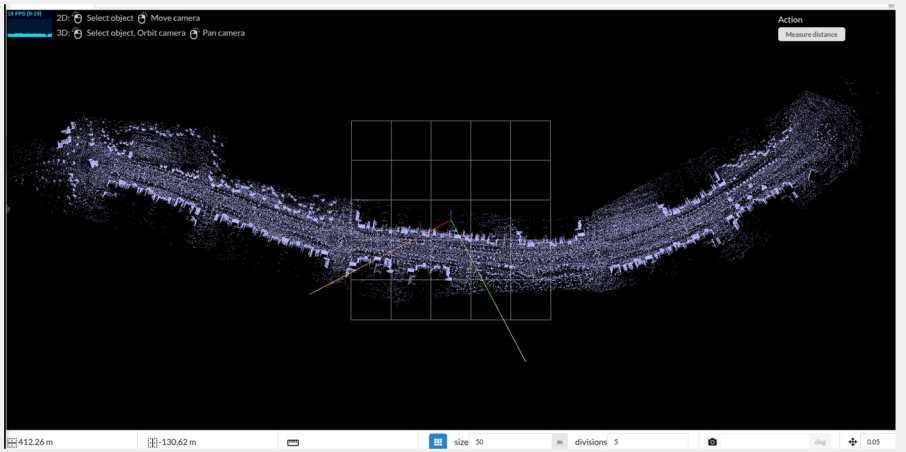


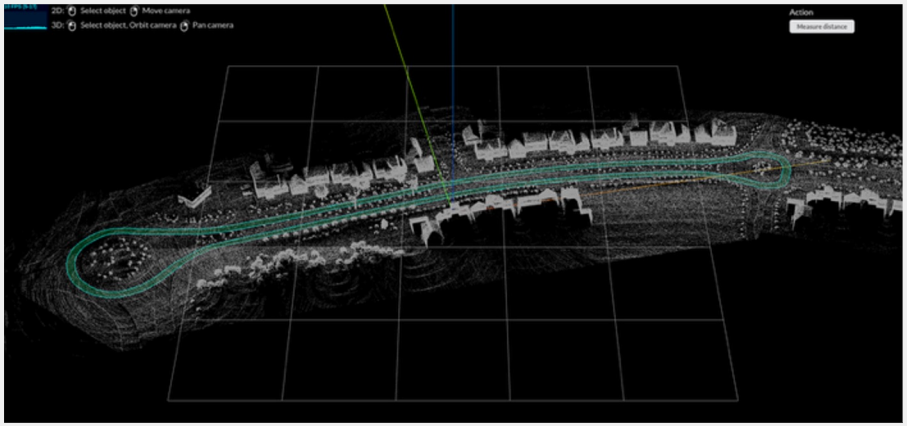
D AWSim

Vehicle Simulation in Carla



Vehicle Simulation in Autoware





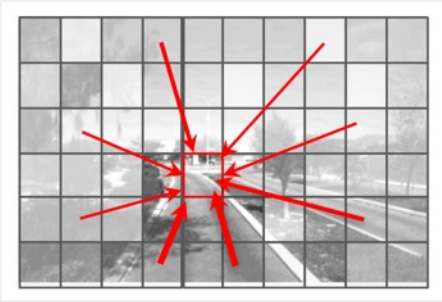
Hardware:

- Jetson AGX Orin 32GB (ARM)
- PC with RTX 2070 GPU

Software

- Point-Cloud Mapping (LIO-SAM Alg.) with loop-closure
- Validate generated Lanelet2 map against real data

Alternative Autonomous Driving Methods



- Transformers
- State Space Models
- Reinforcement Learning

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