Autonomous Driving and Platooning Robotic Testbed

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Real-Time & Embedded Computing Systems

Summary

- Introduction – Context and Objectives
- System Architecture – Hardware and Software
- Implementations – Racecar and Platoon
- Results
- Control Loss Warning (CLW) Mechanism
- Conclusion and Future work

Introduction

- Context
  - Developed at CISTER in connection with the European project SafeCOP – Safe Cooperative Cyber-Physical Systems;
  - Scenarios and implementations like Control Loss Warning and Platoon Simulation based on ROS/Gazebo – Omnet++ were tested and validated;
  - In addition, autonomous racing competitions are held every year, like the F1 Tenth, that follow a specific format of a robot, putting to test the algorithms developed by the competitors.

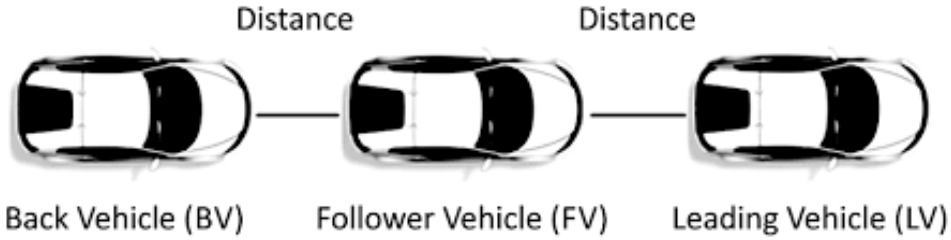
SafeCOP

gmv INNOVATING SOLUTIONS

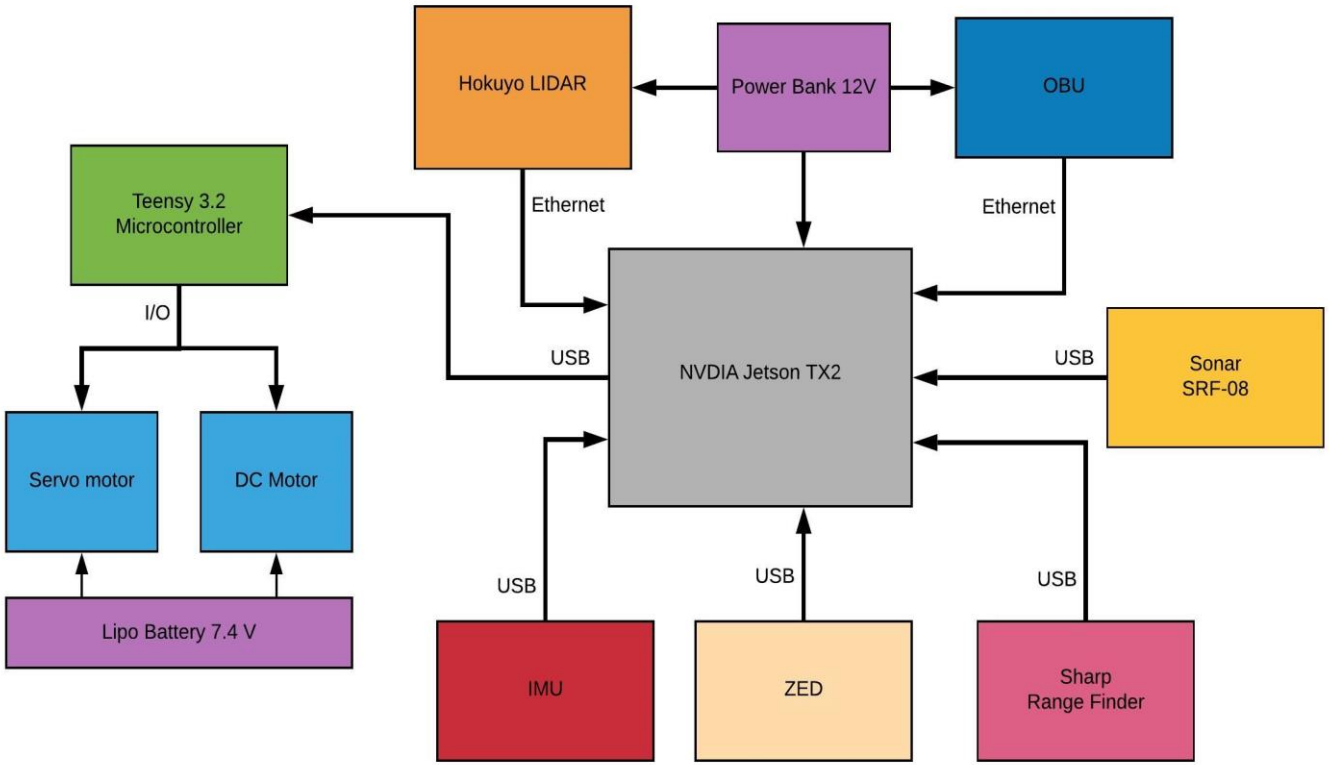
F1 TENTH

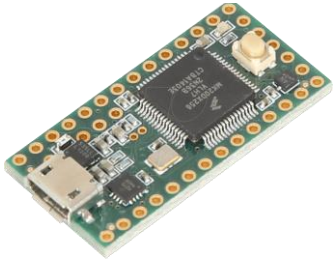
Introduction

- Objectives
  - Develop a baseline robotic testbed
  - Implement and test different algorithms for autonomous racing and platooning scenarios
  - Validate a CLW Safety Mechanism

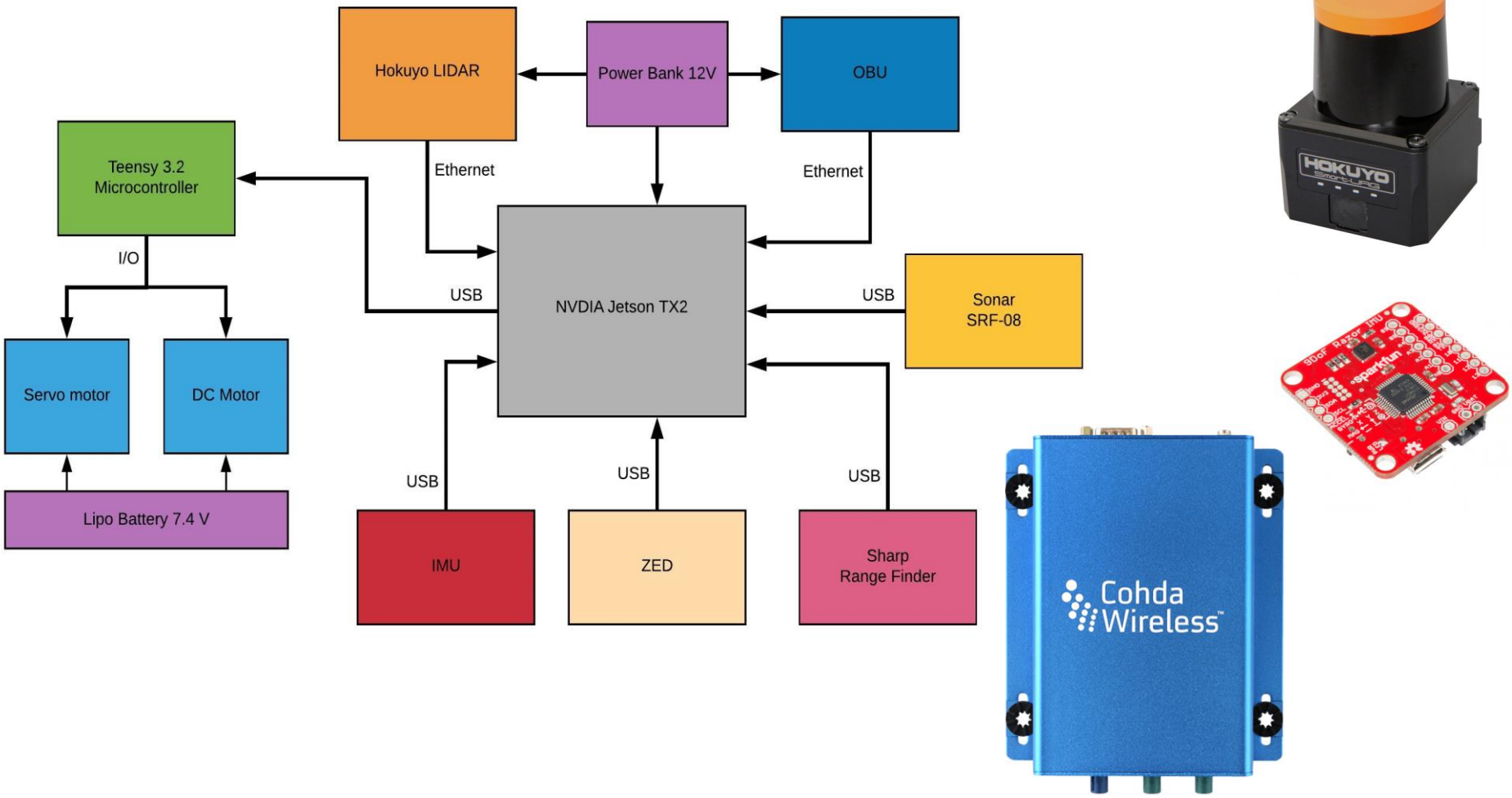


System Architecture
Hardware

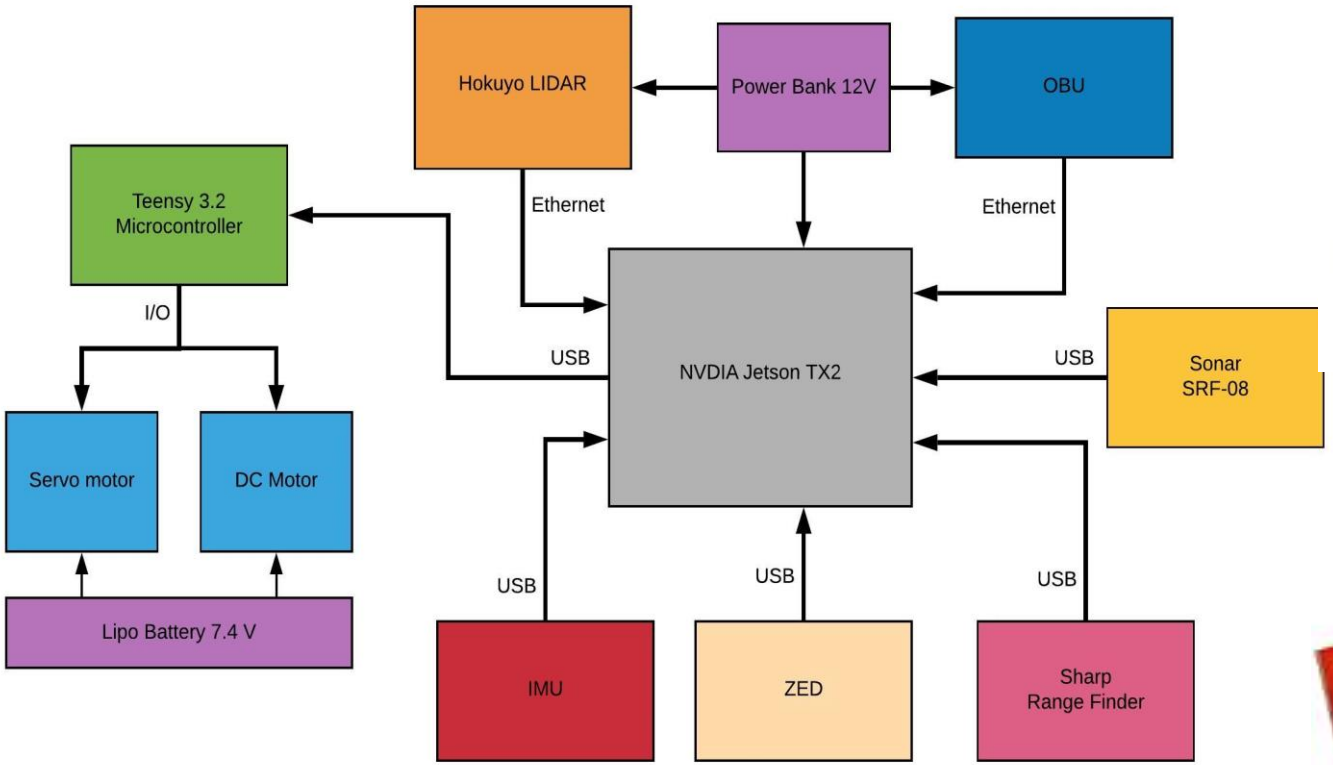




System Architecture
Hardware

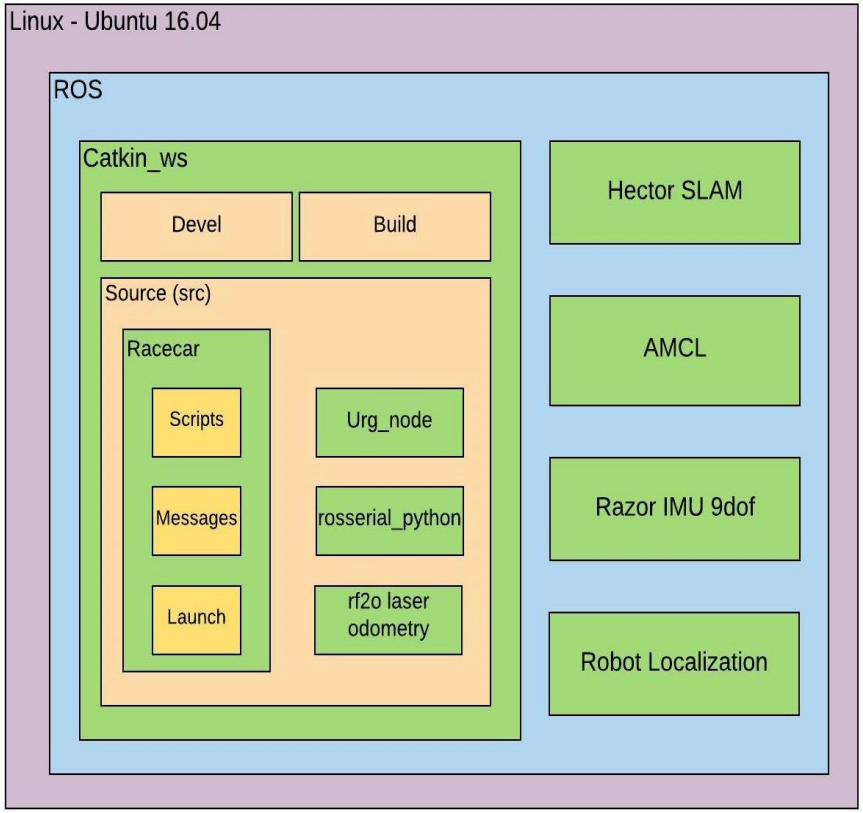


System Architecture
Hardware

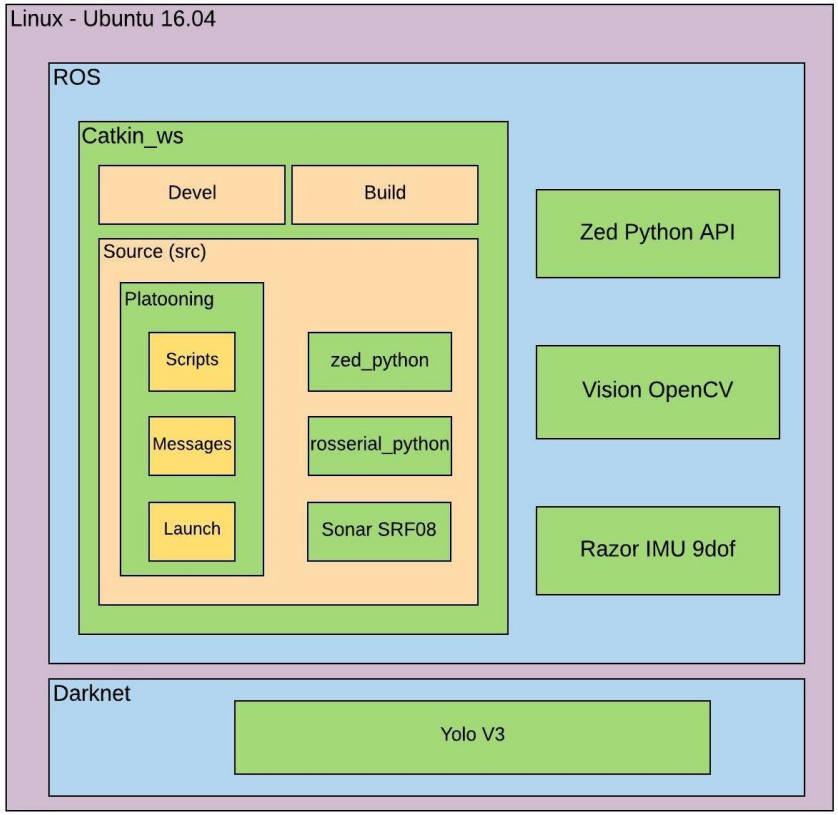


System Architecture
Software

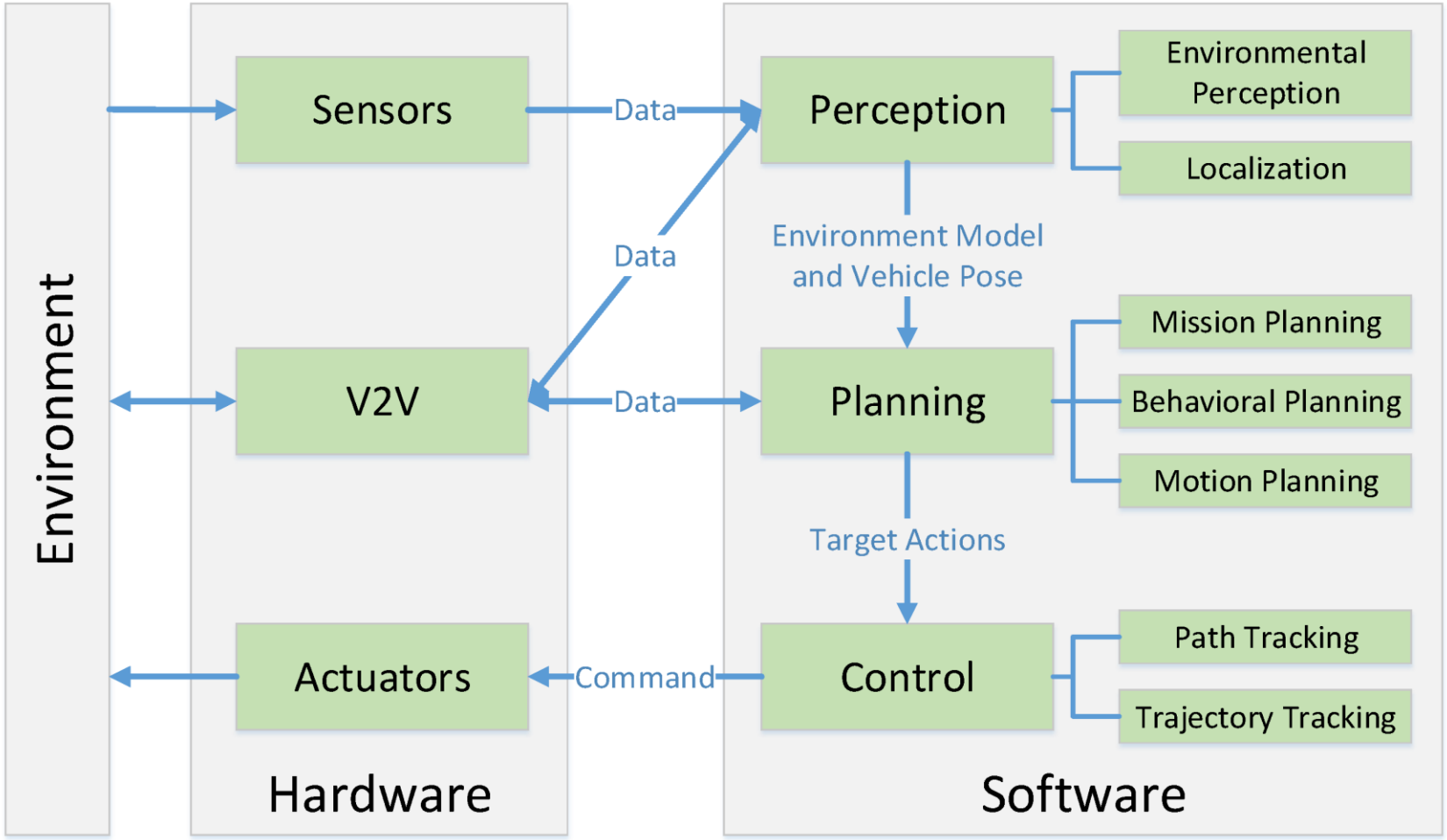
Racecar - Leader



Platoon - Followers

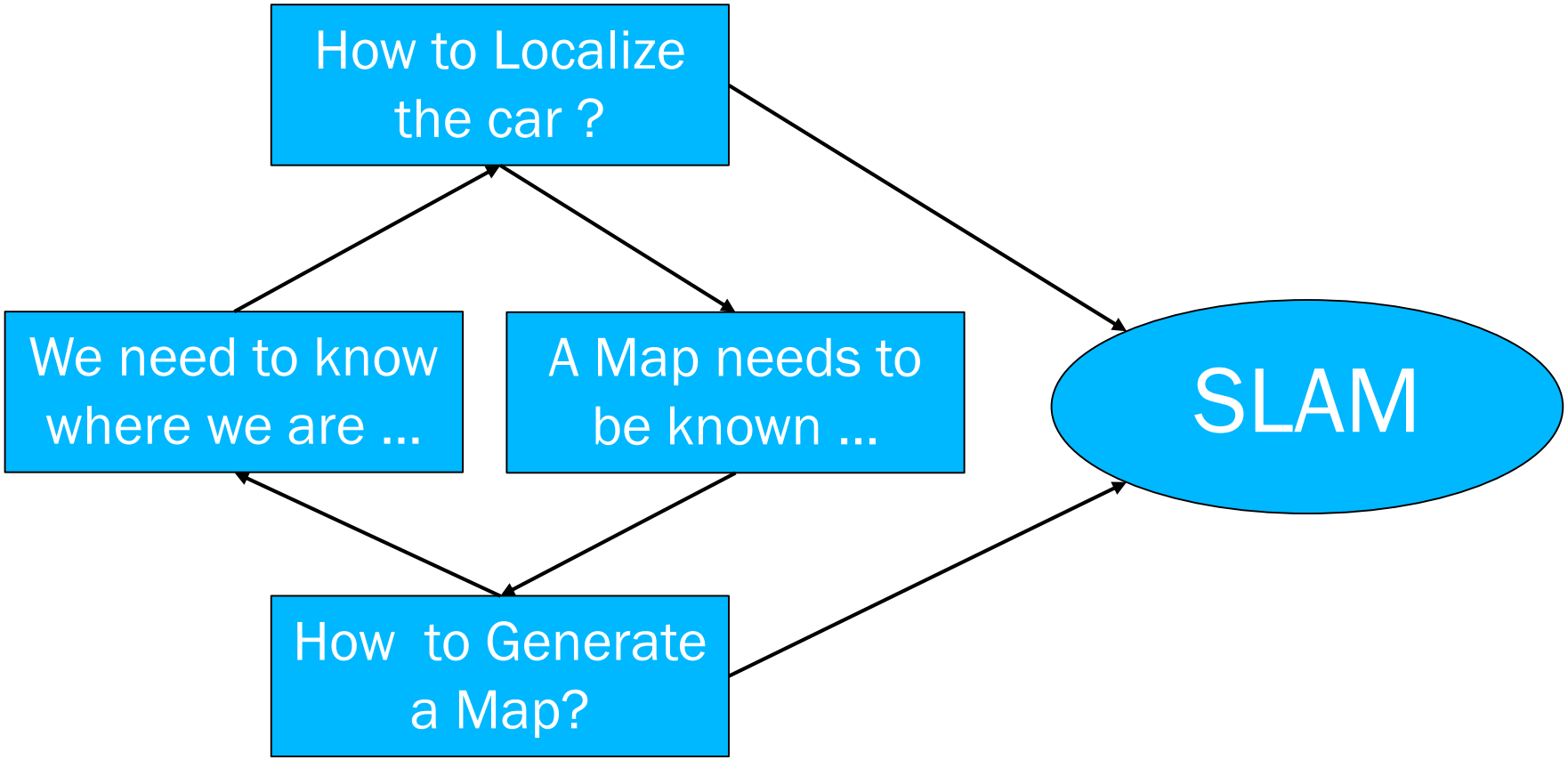


Implementation



Implementation

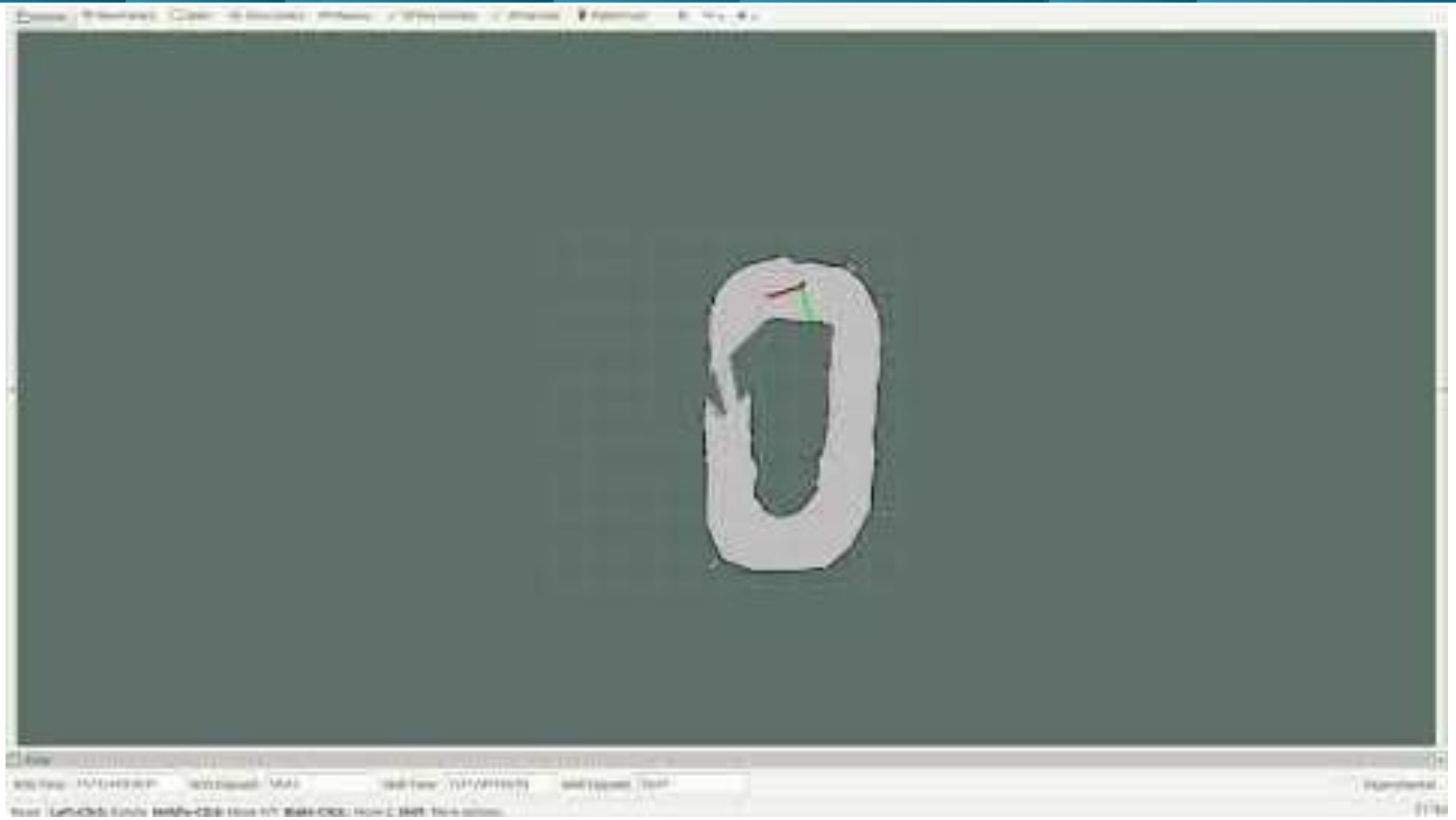
Perception – Mapping



Implementation
Perception – Mapping

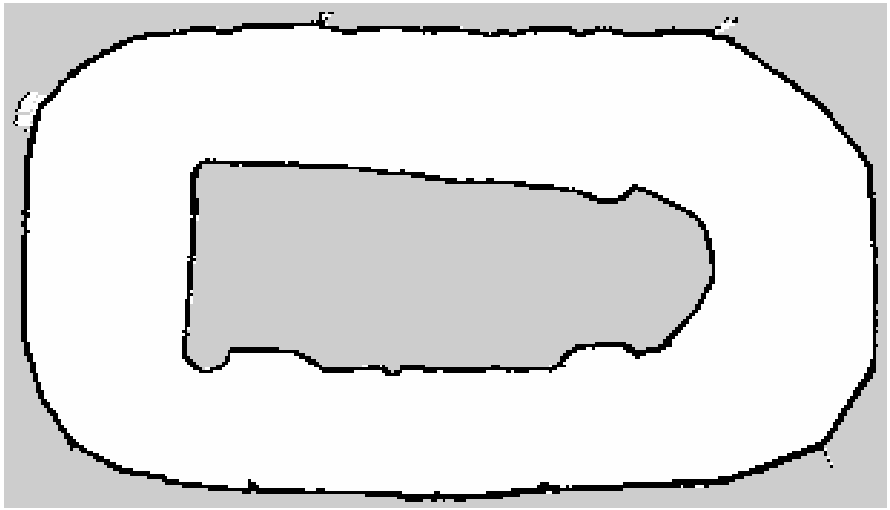
- SLAM – Simultaneous Localization and Mapping
- Requires LIDAR data as input
- Allows to Localize the car while Generating a Map
- Based on Scan Matching and Grid Mapping
- Hector SLAM used in ROS to generate the map

Results
Mapping



Video Link: https://youtu.be/t3QLWeSvhEs

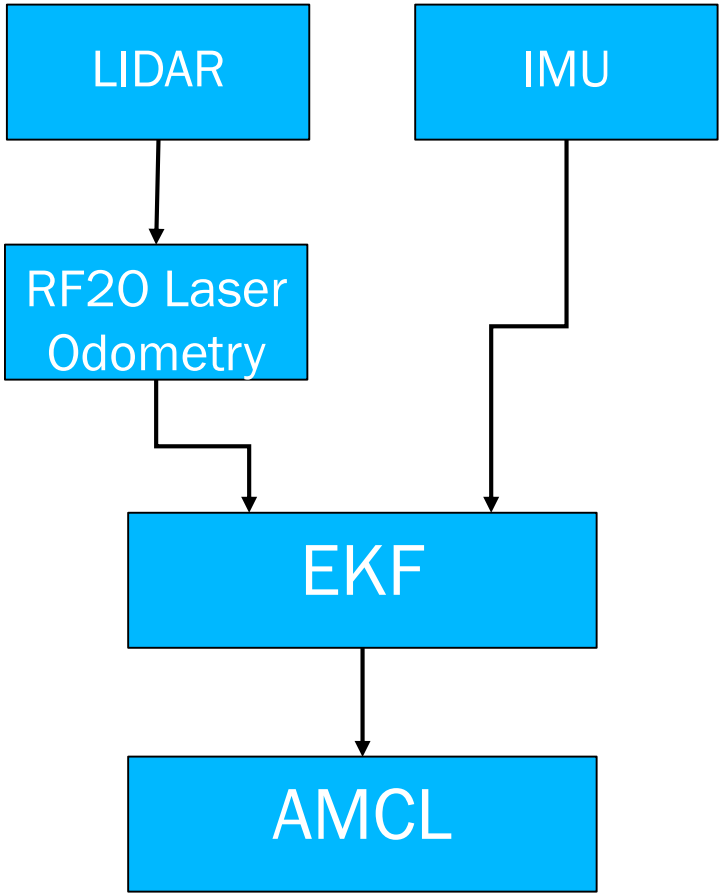
Implementation
Perception – Mapping



Map of Oval Race Track

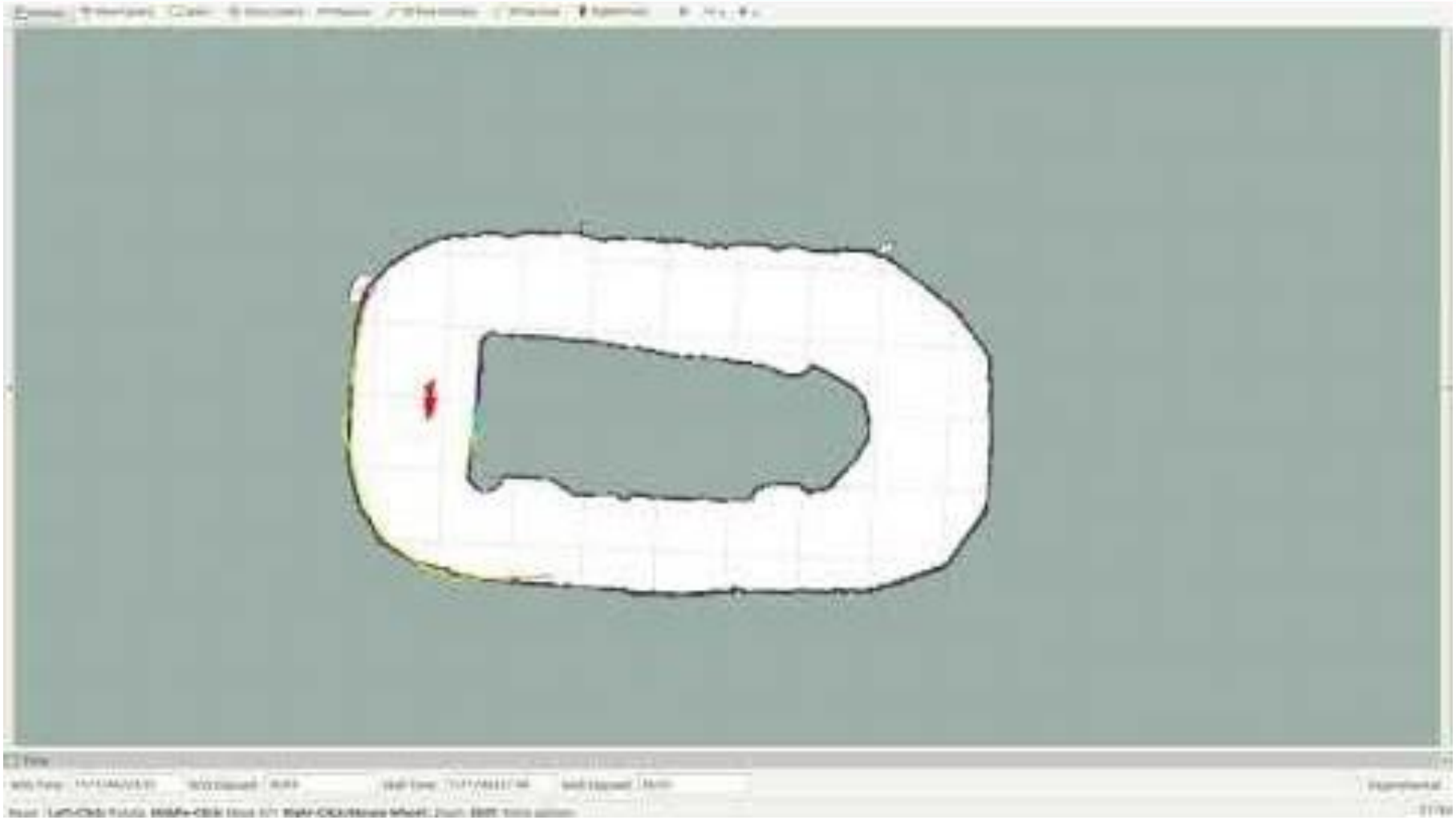
Map of CISTER Undergrad Lab

Implementation
Perception – Localization



- EKF – Extended Kalman Filter
  - Receives input data from various sources of odometry and fuses them to provide a stable positioning
- AMCL – Adaptive Monte Carlo Localization
  - By providing LIDAR and Odometry data, it is able to estimate the pose of the robot in a given map

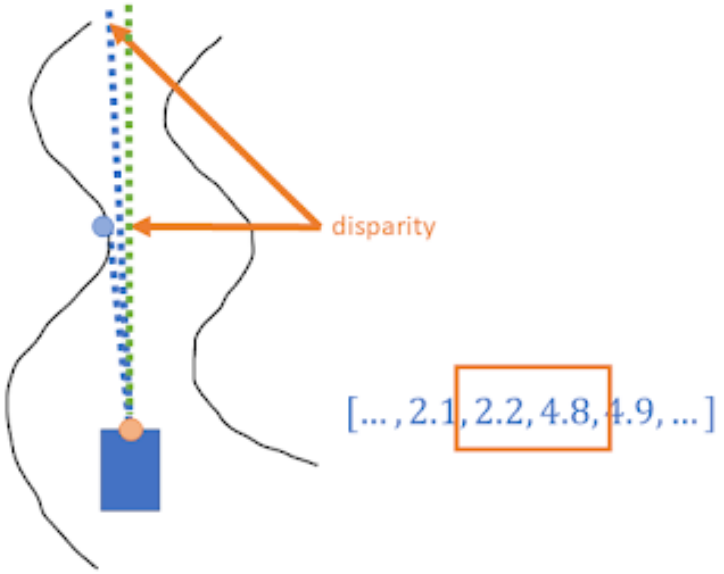
Results
Localization



Video Link: https://youtu.be/DZphmmLz-MY

Implementation
Planning and Control

- 5 algorithms were implemented and put to test:
  - Wall Follow (PID)
  - F1/10 approach (PD)
  - Curve and Line Detection (PID)
  - Disparity Extender
  - Disparity Upgraded



- Trajectory and Time were taken as measurements

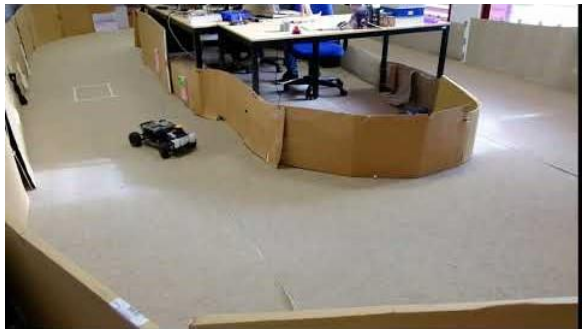
Results
Trajectories

Wall Follow

https://youtu.be/uX-Cc1Xp5tk

F1/10

https://youtu.be/X50_-NYrJmg



Curve & Line detection

https://youtu.be/al4tx2n6Ick

Disparity Extender

https://youtu.be/HoemRVNJARc

Disparity Upgrade

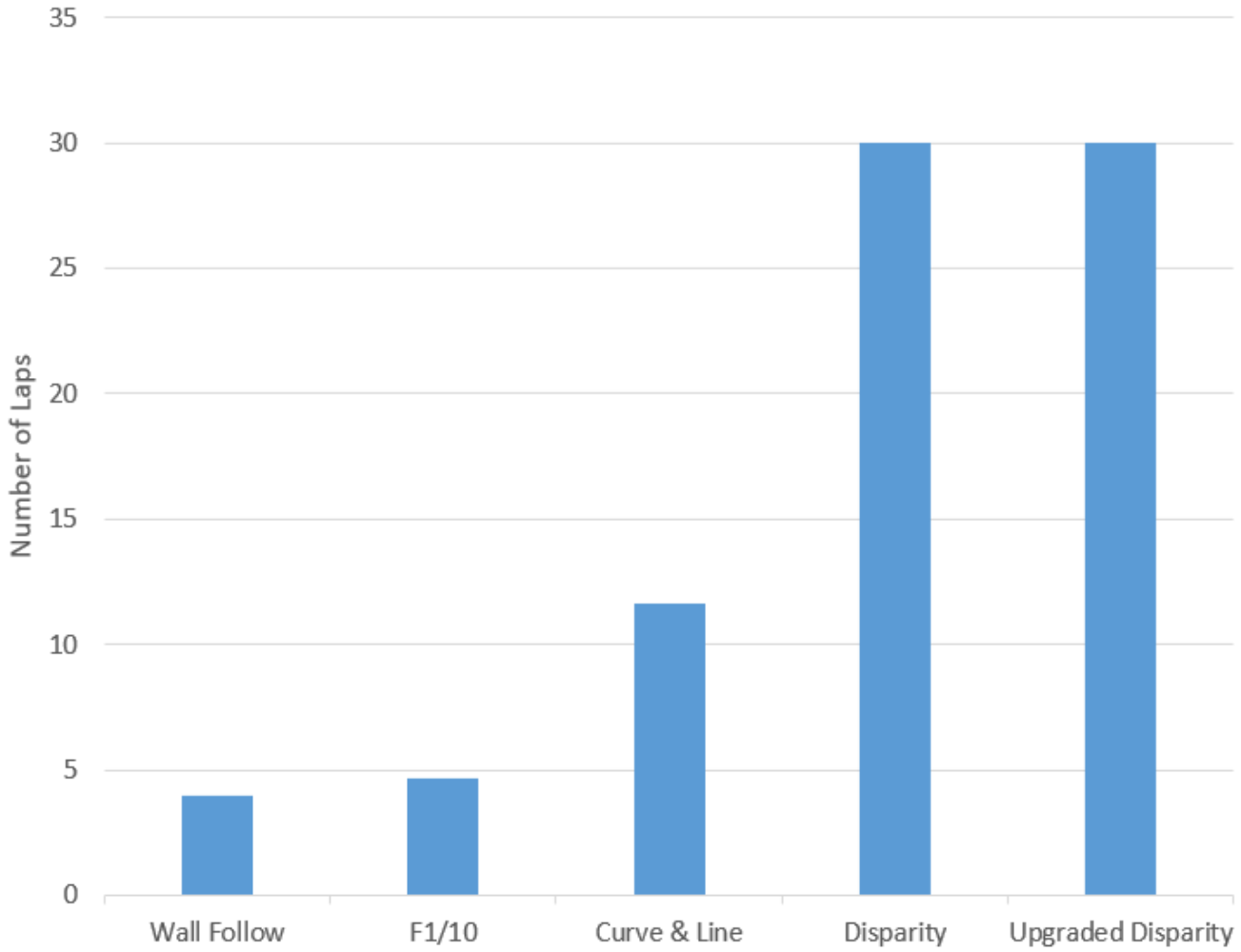
https://youtu.be/wLIxpcyy-uQ

Obstacle Avoidance (Disp. Upg)

https://youtu.be/TeNZUm9JpWY

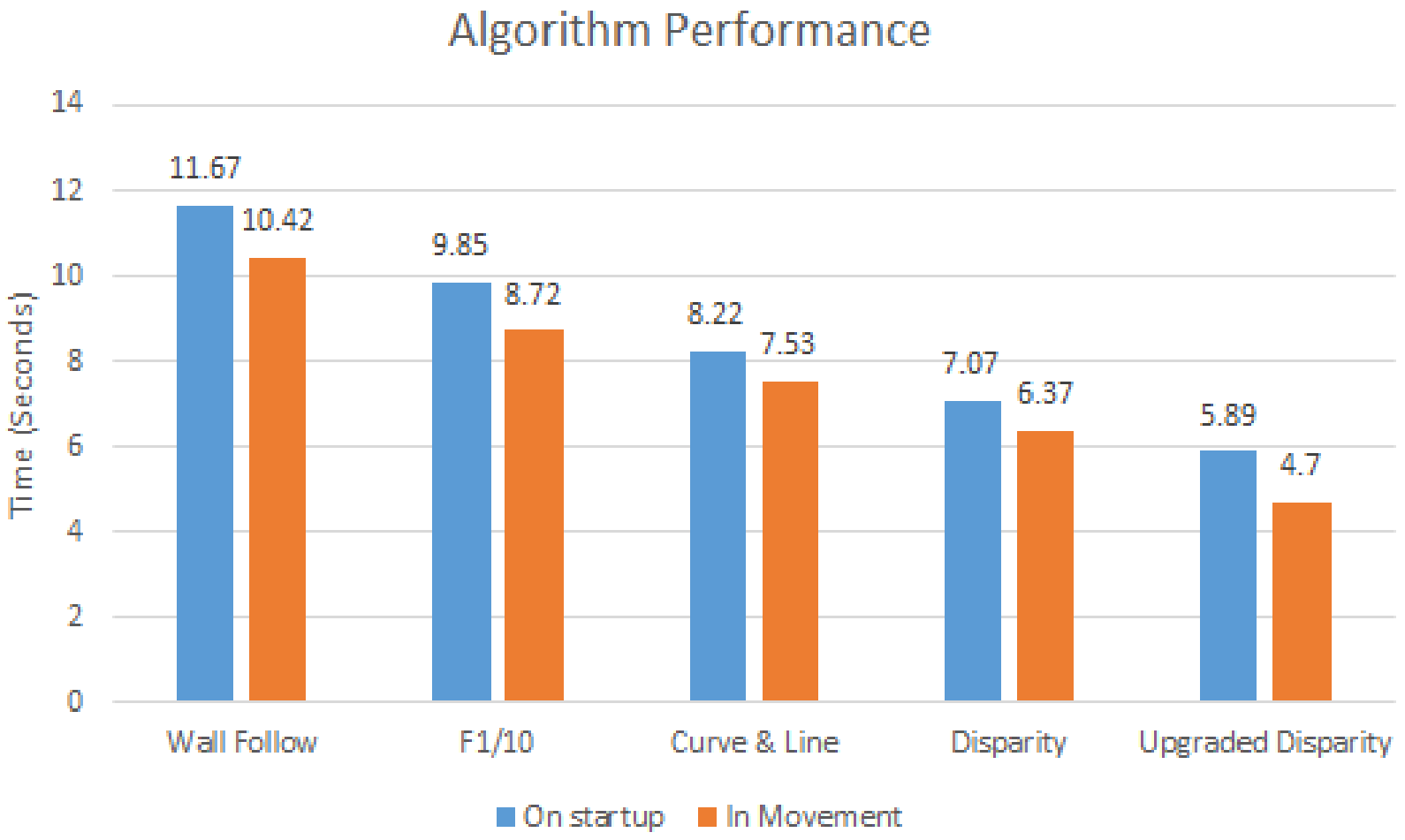
Results

Average Completed Laps



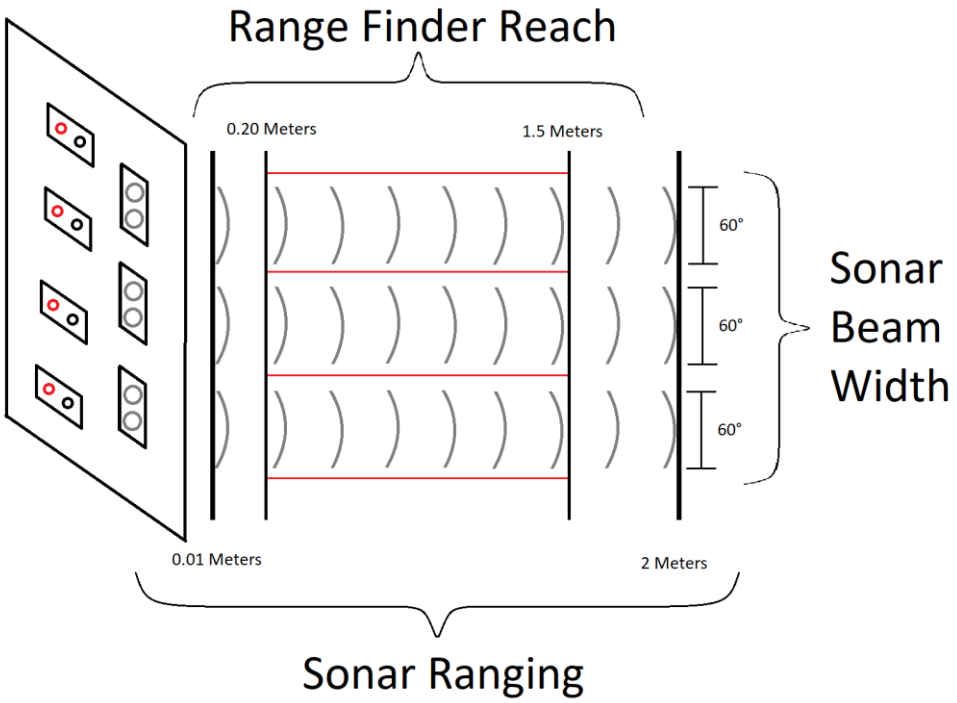
Results

Average time per Lap



Robotic Testbed

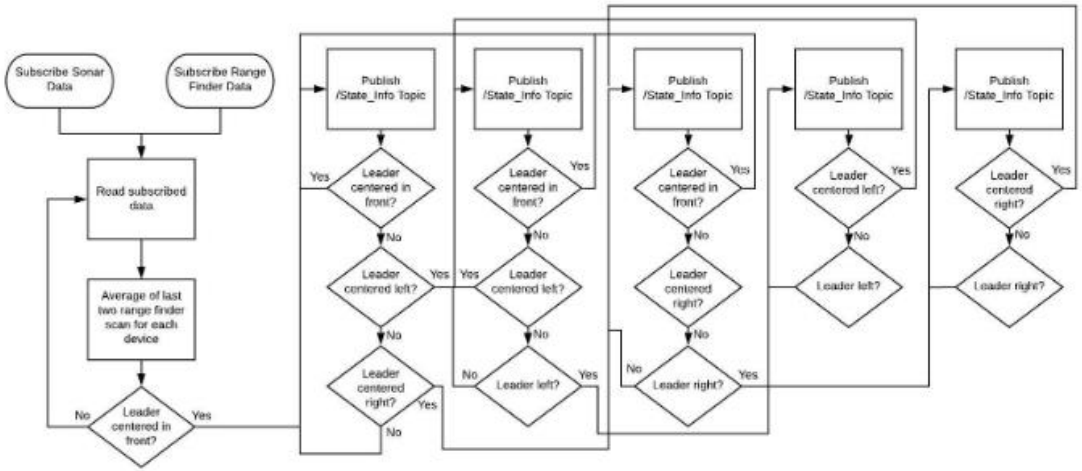
Sensor Board



Platooning Algorithm

Sensor Board based Platooning

- Lateral Control
- Longitudinal Control



Platooning Algorithm

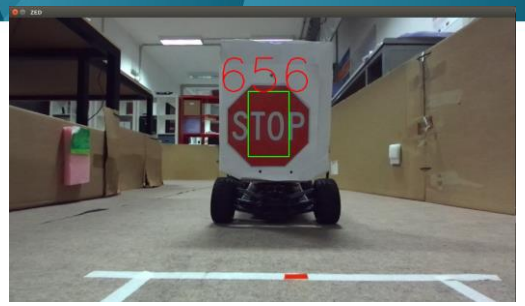
Sensor Board based Platooning

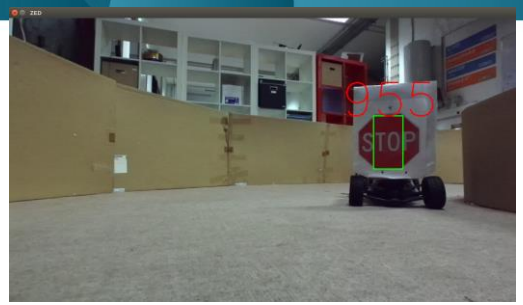
Video Link: https://youtu.be/YXVCwvI297g

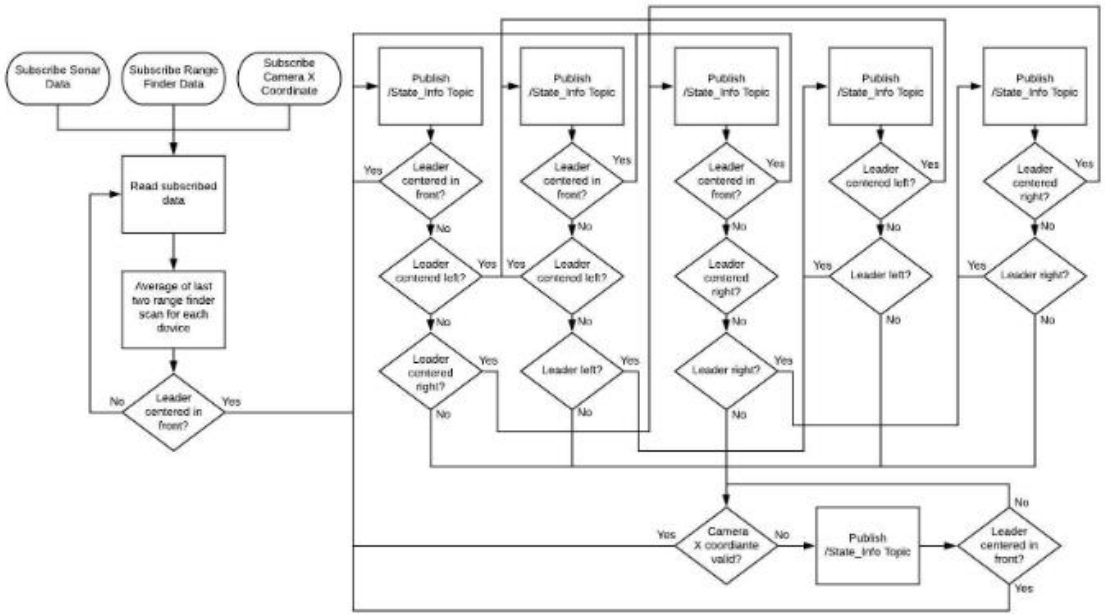
Platooning Algorithm

Camera based Platooning

- Lateral Control
- Longitudinal Control







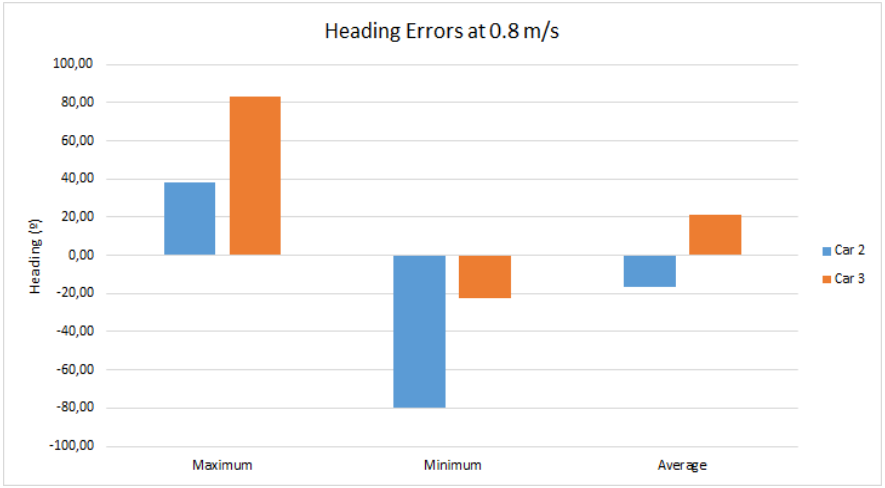
Platooning Algorithm

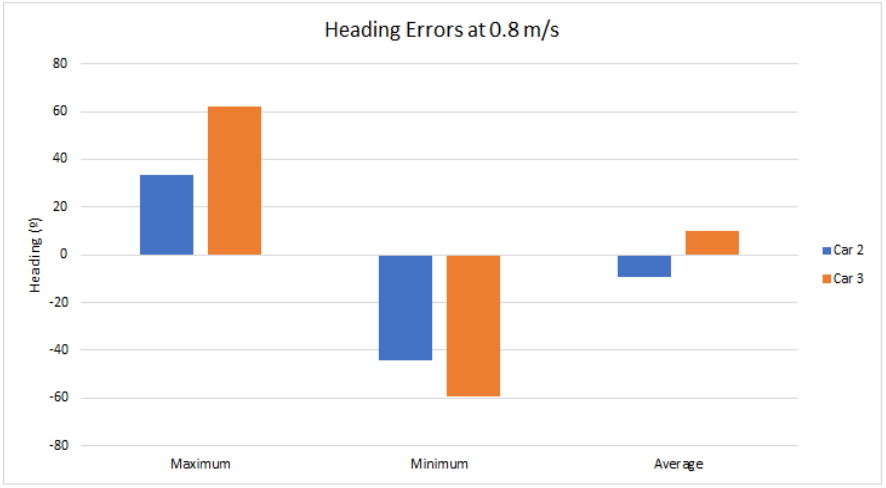
Camera based Platooning

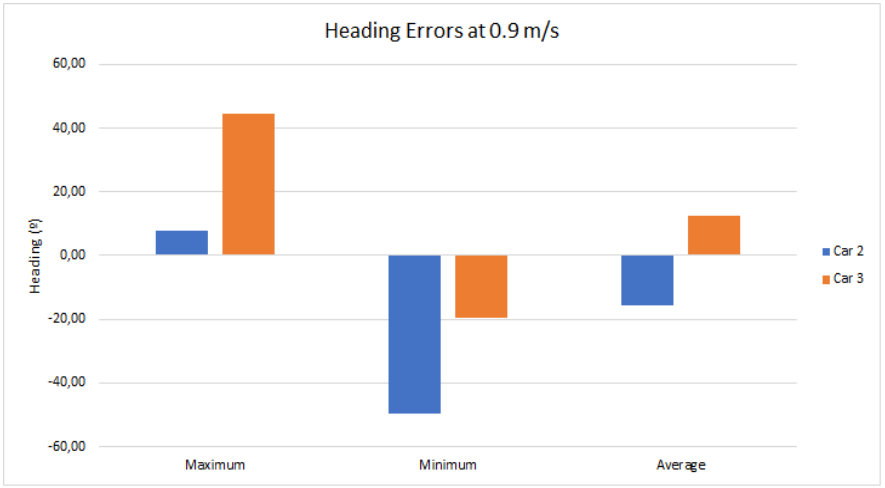
Video Link: https://youtu.be/STrbNJORiFw

Platooning Algorithm

Lateral Results

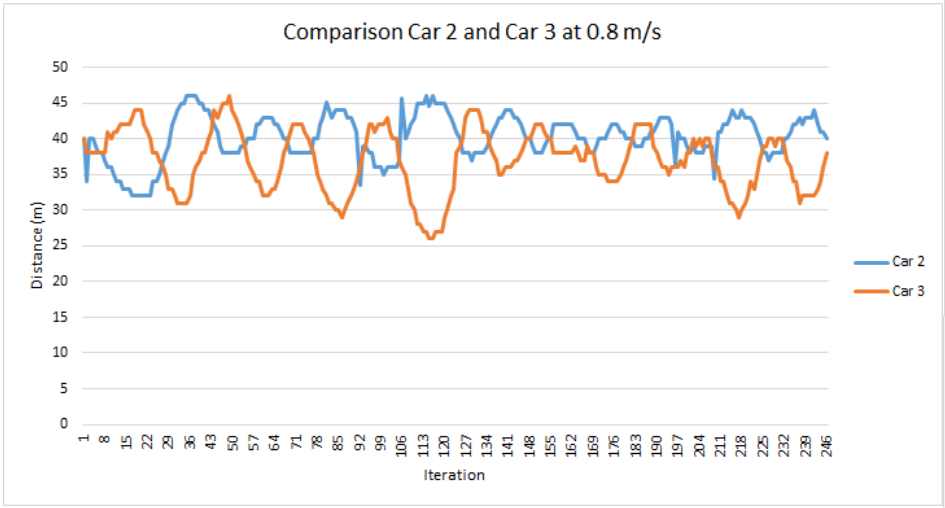


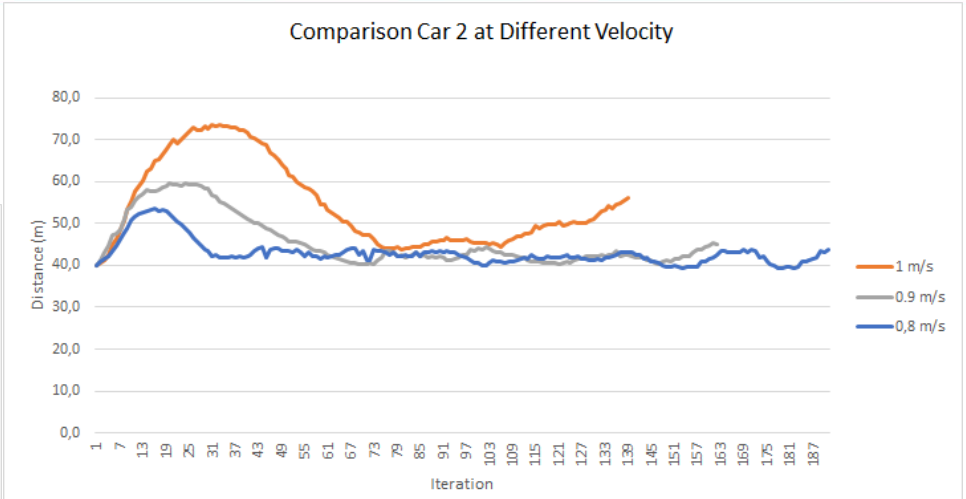


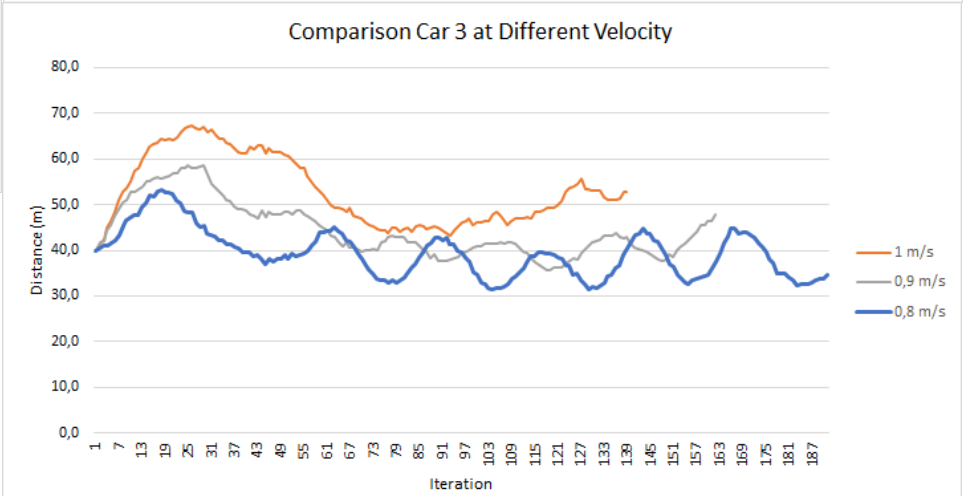


Platooning Algorithm

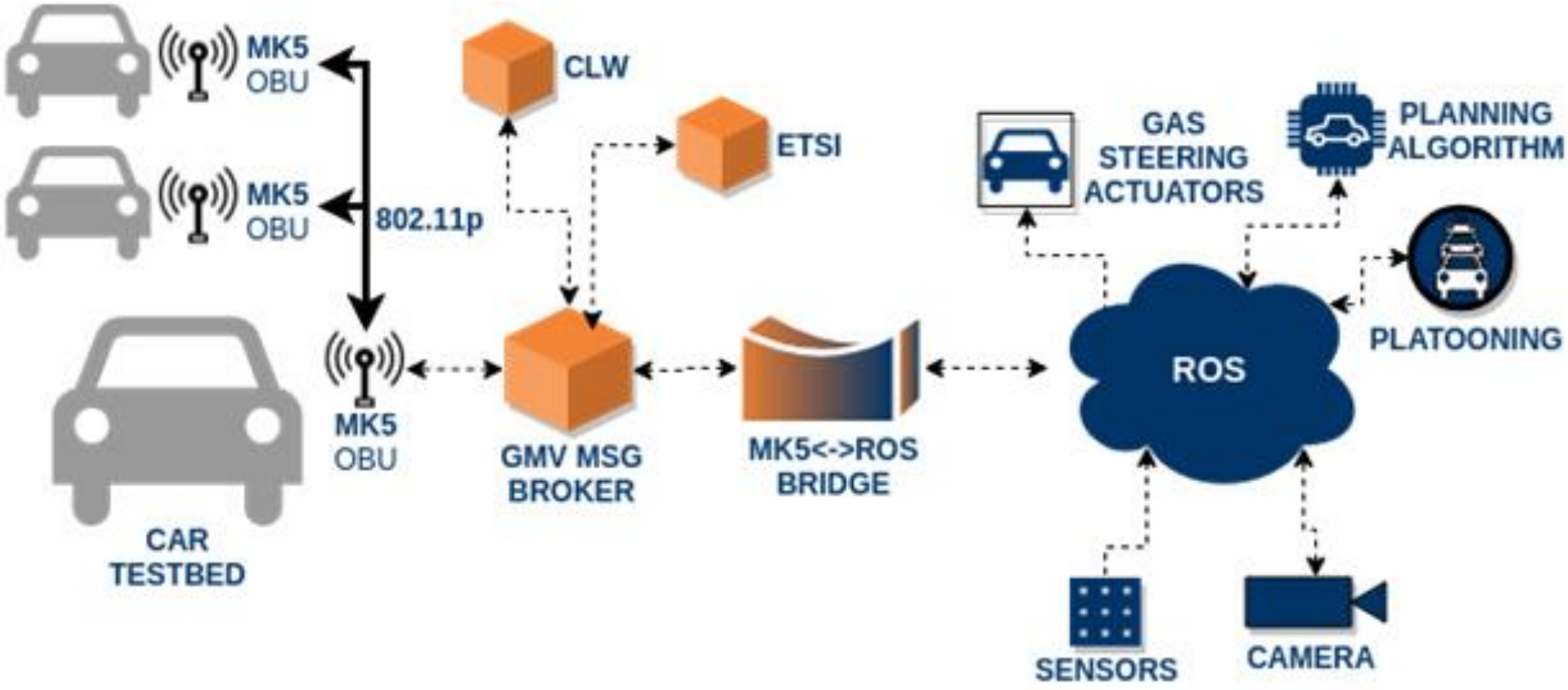
Longitudinal Results







CLW Mechanism



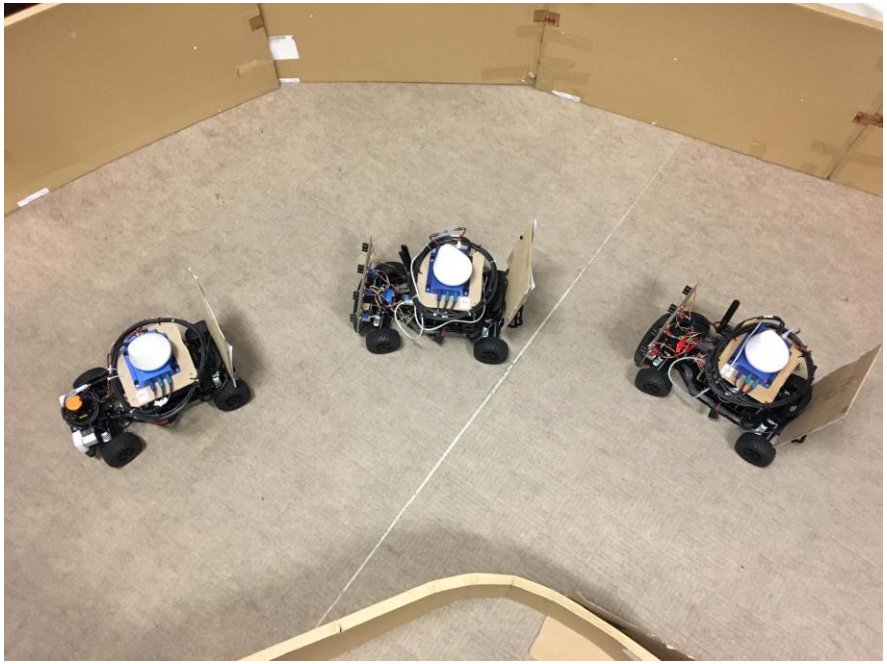
CLW Mechanism

Video Link: https://youtu.be/Ptgdleb1s1c

Conclusions & Future work

Conclusions:

- Robotic testbeds development
- Racecar and Platoon algorithms implementation
- CLW implementation and validation



Future Work:

- Odometry improvement
- Approach new control algorithms – MPC
- Cooperative Platoon
- Platooning with Drones

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