Introduction

- Automated Vehicles
  - Operation of the vehicle occurs without direct driver input to control the steering, acceleration, or braking and are designed so that the driver is not expected to constantly monitor the roadway while operating in self-driving mode.
  - Sensing → Fusion → Environment Understanding (Perception) → Planning → Control

- Connected Vehicles
  - Connected vehicles use wireless technology to "connect" vehicles to each other and/or to infrastructure (V2V, V2I, V2X).
  - Having significant amount of information can largely support the decision making of the connected vehicles.

- Connected and Automated Vehicles (CAVs) Technologies
  - Mobility and environmental impacts will NOT likely change much.
  - Increase in the driver's cognitive load, thus causing extra distraction and system disturbance

- Existing CAV Test Platform
  - Microscopic Traffic Simulators
    - Detailed Vehicle Dynamics
    - Autonomous Vehicles’ Behaviors
  - Vehicle Simulators
    - Interaction with other road users or roadway infrastructure
  - Real-world Testbed
    - Resource Intensive
    - Fixed Geographical Setup

Proposed Solution

- Fleet of miniature Autonomous Vehicles
  - Onboard Computer:
    - Raspberry Pi 4
  - Sensors:
    - 160° HD Camera
    - Infrared Encoder
    - 1-D TOF LiDAR
  - Communication:
    - WLAN
  - Platform:
    - ROS (Robot Operating System)

System Architecture

- Existing CAV Test Platform
  - Microscopic Traffic Simulators
    - Detailed Vehicle Dynamics
    - Autonomous Vehicles’ Behaviors
  - Vehicle Simulators
    - Interaction with other road users or roadway infrastructure
  - Real-world Testbed
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- Test Environment
  - Highway
    - Platooning
    - Car-following
    - Formation Control
  - Tran
    - Speed Limitation
    - Stop-and-go
    - Emergency Stop
  - Parking
    - Cooperative Parking

Key Modules

- Semantic Segmentation
- Orientation Error Estimation
- Lane Tracking and Platooning
  - Lateral: Desired Rotational Speed = PID Controller (Orientation Error)
  - Longitudinal:
    - Car Following: longitudinal speed = PID Controller(headway error)
    - Chasing – Waiting – Regular
    - Emergency Brake
- Parking
  - Pre-designed Trajectory Following
- Low-Level Control
  \[ v = \frac{\omega r + \omega L}{2} \]
  \[ \omega = \frac{\omega r - \omega L}{L} \]