Realistic Human Driving Simulated Environment for V2X Infrastructure Development and Testing

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Overview

As autonomous vehicles (AVs) become commonplace on roads, developing further infrastructure to communicate with and aid driverless cars could:

- increase safety
- alleviate traffic
- reduce fuel consumption [1]

Simulated human driving environment as a research tool to study infrastructure-based systems coordinating AVs with surrounding agents. Simulation benefits:

- Human drivers and AVs can interact safely
- Ground truth useful for prediction and planning algorithms
- Lower develop, test time of intersection manager designs

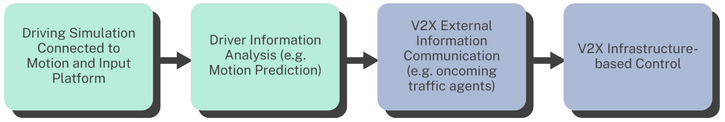

Figure 1: V2X Development Flowchart (2 of 4 steps completed)

Introduction

Future traffic will comprise both AVs and human agents. Vehicle-to-Everything (V2X) infrastructure will need to:

- Predict human behavior
- Calculate agent trajectories
- Coordinate autonomous vehicles accordingly [1]

Why intersection managers:

- System using lane reservations decrease traffic delay by 30% when 40% of vehicles were connected and autonomous (CAV). [2]
- Different intersections and merges make predicting behavior more difficult - training for predictions locally at intersection improved performance from 68% to 95%. [4]

Software so humans drive realistically within different scenarios reduce development and testing time for future intersection manager designs.

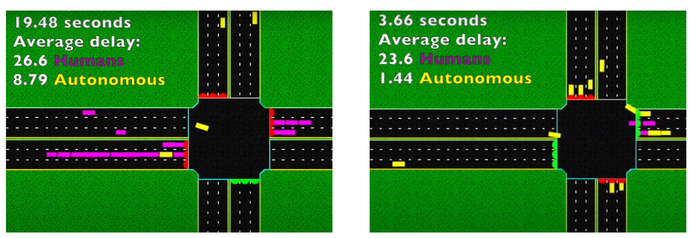

Figure 2: Intersection Protocol [4]
Average delay at 1:4 CAV to human (left), at 4:1 CAV to human (right)

Materials and Methods

Driving Simulation - Carla

- Support dev, training, validation of autonomous driving systems [3]
- Unreal Engine used to handle physics-based interactions

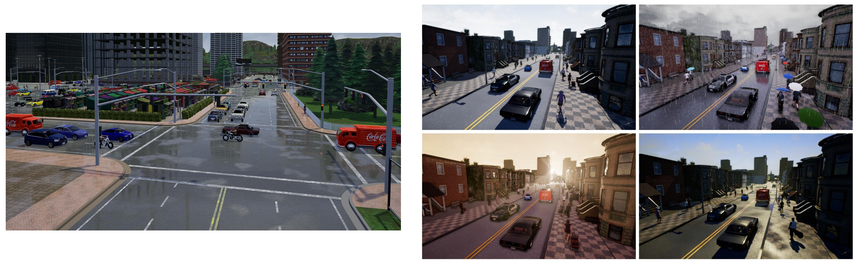

Figure 3: Carla Simulation; Intersection (left), Multiple Weather Modes (right) [3]

Motion Platforms - Eleetus and Simcraft

- Both platforms provide steering wheel and pedal input
- Both platforms have pitch-roll rotational motion

Figure 4: Simulated Human Driving Platform; Eleetus Blue Tiger (left), Simcraft Apex (right)

Platform Connection - Python script and Executable

- Connect and interpret input for manual vehicle control
- Send API calls to move motion platforms according to physical properties of the vehicle, e.g. linear, angular velocity and acceleration

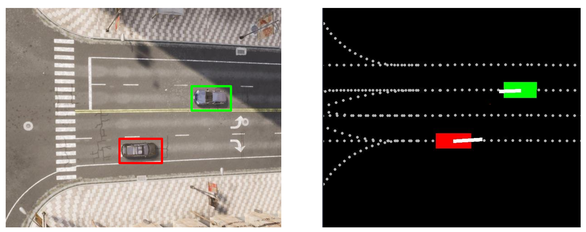

Figure 5: Motion Prediction; Visualization (right), Unreal Engine view (left)

Driver Information Analysis - Motion Prediction

- Uses positional information and velocity of the vehicle along with road geometry for physics-based prediction of driver in simulation
- Visualized trajectory predictions with view of sensor data

UNLV Map

- OpenStreetMap to get road geometries
- RoadRunner to clean map lane markings, add traffic control
- Map to export and build in Unreal Engine for use in simulation

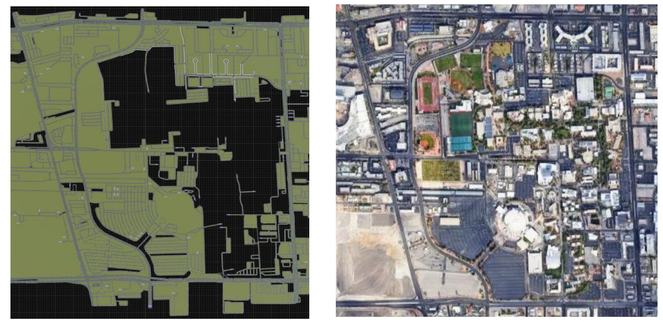

Figure 6: UNLV Map; RoadRunner (right), Satellite (left)

Discussion and Future Work

This project demonstrated a realistic human driving platform connected to a driving simulation developed for research, using a local map of the university and implementing motion prediction. This platform will enable development of V2X infrastructure that impacts traffic and intersection management.

Future work

- V2X external information communication about surrounding agents occluded to the autonomous vehicle
- Infrastructure-based control of intersections, merges, lane switches
- More robust motion prediction algorithm

References

[1] M. Čičić et al. "A Systematic Solution of Human Driving Behavior Modeling and Simulation for Automated Vehicle Studies." *2018 21st International Conference on Intelligent Transportation Systems (ITSC).* (2018).
[2] G. Sharon et al. "A Protocol for Mixed Autonomous and Human-Operated Vehicles at Intersections." *International Conference on Autonomous Agents and Multiagent Systems.* pg. 151-167 (2017).
[3] A. Dosovitskiy et al. "CARLA: An Open Urban Driving Simulator." *arXiv:1711.03938* (2017).
[4] C. -E. Framing et al. "Infrastructure-Based Vehicle Maneuver Estimation with Intersection-Specific Models." *2018 26th Mediterranean Conference on Control and Automation (MED).* (2018).

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