Metrics Validation for Automated Vehicle Operational Safety

Shujauddin Rahimi, Computer Science
Mentor: Dr. Jeffrey Wishart, Adjunct Faculty
Ira A. Fulton Schools of Engineering (Polytechnic)

Motivation

The world around us is rapidly changing and new technology presents us with the opportunity to make travelling a much safer experience. With the development and commercialization of automated driving system (ADS)-equipped vehicles (AVs), a question arises: “What level of operational safety performance is required compared to that of a human-driven vehicle (HDV)?” Operational safety of AVs is a key requirement before public road deployment can occur and thus, a methodology to quantitatively compare AVs and HDVs is needed.

Problem Statement

This project seeks to provide data from the CARLA simulator using various traffic scenarios and vehicle controllers to refine the safety metrics that comprise the comparison methodology.

Background

What is CARLA?
CARLA is an open-source simulator for AV research. It provides digital assets and a platform geared towards flexible specification to allow for the creation of valuable data.

Figure 1: CARLA Logo

Figure 2: Simulator viewport and information

Figure 3: Simulation created for PhD research

Work

One of the projects tasks was to create a scenario in CARLA that is as similar as possible to one in the HVE Simulator to support a PhD student’s research. HVE is used for sophisticated work in areas such as accident reconstruction and safety research, but it lacks the infrastructure to easily run numerous scenarios that CARLA has.

Figure 4: HVE scenario example

Using a scenario modifier I created during my SURI internship, we generated and simulated approximately 500 scenarios in CARLA. The data collected helped evaluate safety metric violations in the PhD research.

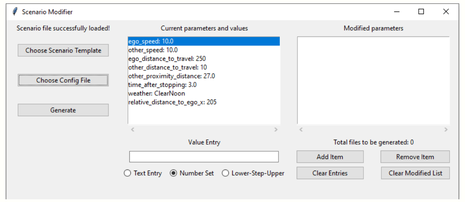

Figure 5: Scenario Modifier GUI application

Figure 6: Scenario output for one of the iterations

Additional work began on developing new vehicle controllers in CARLA that ensure that the subject vehicle adheres to a particular safety metrics, starting with TTC (time-to-collision).

The vehicle controller in use uses RSS (Responsibility-Sensitive Safety), a safety model developed by Intel/ Mobileye.

$$TTC = \frac{X_L - X_F}{v_F - v_L}$$

X_L: Leading vehicle position
X_F: Following vehicle position
v_L: Leading vehicle speed
v_F: Following vehicle speed

Figure 7: TTC Formula

Future Research

Further Scenario Development:
Currently 4 out of 37 NTHSA pre-crash scenarios are modeled in CARLA. Additionally, a scenario database needs to be developed that includes challenging scenarios, known as “edge cases”.

Vehicle Controllers:
New vehicle controllers developed to test and collect data on safety metrics.

Conclusion

In order for AVs to serve their purpose and make our roads safer, it must be ensured that they perform at standards that can be quantitatively measured. This research is a crucial step in understanding the effectiveness of AVs in comparison to HDVs, and will be in important component of a safety case-based assessment methodology that will include evidence to corroborate safety claims of AVs that are to be deployed on public roads. This work gives public and private sectors new tools to push the AV world forward.

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Ira A. Fulton Schools of Engineering
Arizona State University