TECHSUMMARY April 2018
State Project No. DOTLT1000088 / LTRC Project No. 15-2SA

Development of a Simulation Test Bed for Connected Vehicles using the LSU Driving Simulator

INTRODUCTION

Connected vehicles (CV) technology has been acknowledged to have operational benefits in terms of reducing travel times and delays for the traveling public, as well as lessening the environmental impact in terms of reducing vehicle emissions and air pollution. To fully assess reliability and potential benefits of CV technology, the use of test beds is required for unforeseen and potential issues associated with the development and deployment of the technology. Simulation-based test beds, harnessing a driving simulator platform, can be utilized to achieve the benefits of a physical test bed and, if successful, will provide a cheaper alternative that can be easier controlled for desired effects. This project provides an insight into the use of driving simulators in studying the impact of CV safety applications on driving behavior. Three applications include blind spot warnings (BSW), forward collision warnings (FCW), and do not pass warnings (DNPW) were tested in the LSU driving simulator.

OBJECTIVE

The main focus of this study was to develop a driving simulator-based test bed for CV technology research in the areas of operation and safety. The specific objectives are to create three CV safety applications in the driving simulator environment including BSW, FCW, and DNPW, and to test the impacts and benefits of each specific application on driving behavior.

SCOPE

This study explored the effect of the aforementioned CV safety applications on driving behavior at different market penetration (MP) rates. The study was conducted in the LSU driving simulator.

METHODOLOGY

The LSU driving simulator was utilized to develop a CV test bed consisting of randomly generated vehicles within an urban environment. Three CV safety applications were implemented in the simulator including BSW, FCW, and DNPW. To test the impact of MP on the effectiveness of the BSW application, four simulation scenarios were developed with zero, 25%, 50%, and 75% MP rates. Eighty-one participants were recruited to participate in a 15-minute experiment within the driving simulator. Drivers were instructed to perform lane change maneuvers whenever they felt comfortable. For each lane change, both the simulator vehicle and blind spot vehicle's speeds as well as gaps were collected. Two non-parametric statistical tests, along with a post-hoc pairwise test, were used to compare the significance each MP had on the minimum time-to-collision (TTC) and the speed variance of the

LTRC Report 586

Read online summary or final report:
www.ltrc.lsu.edu/publications.html

PRINCIPAL INVESTIGATOR:
Osama A. Osman, Ph.D.

LTRC CONTACT:
Kirk M. Zeringue, P.E.
225.767.9169

FUNDING:
SPR: TT-Fed/TT-Reg

Louisiana Transportation Research Center

4101 Gourrier Ave
Baton Rouge, LA 70808-4443

www.ltrc.lsu.edu

subject vehicle and blind spot vehicle. The FCW application was designed by enabling a lead vehicle to communicate alert messages to the subject vehicle when certain time-to-collision thresholds were reached. Thirty participants, grouped into aggressive and non-aggressive drivers, were allowed to drive the simulator twice; once with the alert messages, and another without the alert messages. In the third application, DNPW, an 8-sec TTC threshold was designed to warn drivers of oncoming vehicles on a two-lane two-way rural roadway. A pilot study consisting of 24 experiments was conducted at varying MPs. Participants performed five overtaking maneuvers within each experiment, totaling to 30 maneuvers for each MP level. The safety of each maneuver was evaluated by the TTC between the subject vehicle and oncoming vehicles at the beginning and end of the maneuver, the time spent in the opposing lane, the headway between the simulator vehicle and the vehicle in the right lane before the maneuver, and the tailway between the two vehicles following the maneuver.

CONCLUSIONS

The results showed that the MP has a significant impact on the effectiveness of BSW application. Although BSW application in environments with low MP had no significant safety improvements to the driver, medium and high levels of MP resulted in significant safety improvements due to the additional information available to drivers in the network. The safety warnings helped to significantly increase the subject vehicle's minimum TTC during the presence of the blind spot vehicle. The results indicated that an MP around 50% is needed to affect a significant impact on this particular type of crash risk. For the FCW application, the results showed that non-aggressive drivers did not significantly change their driving behavior when exposed to the alert messages. On the other hand, aggressive drivers significantly changed their driving performance by slowing down more at intersections and increasing their time-to-collision. Additionally, aggressive drivers activated more alerts than non-aggressive drivers, implying that the alert message system was successful in altering their driving style. Finally, the DNPW application results did not indicate any significant differences in TTC at the beginning and end of the maneuver between each MP. This implies that a DNPW system is limited by the abilities of CV technology and does not operate according to the MP as an effective means for increasing gap acceptance and avoiding dangerous overtaking maneuvers. It was also determined that there were no significant changes in a tailway after the maneuver across all MP levels. The warning system, however, did significantly increase the headway between the driver and the slow-moving vehicle before the maneuver. As the MP increased, the headway increased, which suggests that drivers were able to remain more conscious of their driving behavior with the assistance of the warning system. These results give an indication that this CV application is capable of improving safety during the decision making the process at medium and high penetration rates.

RECOMMENDATIONS

This research provides evidence that CV applications will only become an effective means towards improving safety when medium MP rates are met. To further assess this theory, more CV applications can be developed within the simulator environment to test their effectiveness on safety and driving behavior. More so, the impact of other factors on the safety aspect of the CV technology can be investigated using the developed test bed.