Drive Right: A Simulator Approach for Safe Autonomous Vehicle Demonstration and Education

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INTRODUCTION

Autonomous vehicles (AVs) have the potential to improve road safety, reduce traffic congestion, save energy, and increase productivity. Yet, in order for society to fully enjoy the benefits of AVs, the public must accept and actively use self-driving technology. Currently, there are two major factors hindering its effective adoption: **mistrust** and **misuse**.

In a survey conducted by PAVE of 1200 drivers, 48% said they "would never get into a taxi or ride-share vehicle that was driven autonomously", and 20% believed AVs would never be safe. Another survey conducted by AAA found that "71% of people are afraid to ride in a self-driving car". The other problem is that drivers in general do not understand how to interact with an autonomous system. According to the SAE 5 levels of vehicle automation, driver's input is required except at level 5. In the future, we will most likely see level 2 and level 3 automation for privately owned vehicles, and level 4 for shared taxis and shuttles in the local area. Although the vehicles are not fully automated at this stage, there is no doubt that with each increased level of automation, the driver's workload and mental pressure will be tremendously reduced. However, it is essential that drivers understand the capabilities and limitations of the AV at each level, instead of blindly trusting it or not trusting it at all. Consequently, this effort develops an immersive and interactive driving simulator that helps drivers gain trust and understanding of AVs.

METHODS

The method proposed in this work is a virtual reality (VR) driving simulator, which comes with its unique advantages. First, a simulator is perfectly safe, since any collision or accident has no impact on the real world. Consequently, it does not require the user to possess a driver's license, insurance information, nor does it require a safety expert behind the wheel. Second, a driving simulator is perfectly controllable, as the scenarios and the environments can be freely adjusted to create the desired traffic conditions, which is impossible in the real world. Third, a driving simulator is easy to set up, and can be moved around different places for education and demonstration purposes. By experiencing and interacting with an AV in the simulator that properly mimics the behavior of the AV in the real world, the user can gain a decent understanding of how the autonomous system works and what outcome should be expected. We hope that this enhanced understanding and mental modeling will evolve into confidence and trust which are necessary to the acceptance of the technology.

Our proposed simulation platform is based on CARLA, an open-source driving simulator introduced by Intel. Our customized implementation allows the user to drive in the CARLA world in the first person driver's seat view wearing an Oculus Quest 2 headset (or any other VR headset). The user can then interface with the vehicle using a Logitech G29 steering & wheel and pedal set. Three scenarios were designed: rural, city, highway, and in all scenarios, the vehicle supports manual and autonomous driving.

RESULTS

A pilot human study with 36 participants has shown that the simulator helped them build a better understanding of the autonomous system and changed their attitude to be more positive. A survey with 15 quantitative questions indicated that after the simulator experience, the participants showed a significant decrease in the perceived risk of AVs, and a significant increase in the perceived usefulness, perceived ease-of-use, trust, and behavioral intention towards AVs. Moreover, most participants endorsed the idea of using simulators at auto dealerships to complement the real vehicle test drive. They also supported the idea of using simulators at driving schools as additional education for drivers to get used to AV control. Driving simulators could also be used by novice drivers to practice basic driving skills before learning the AD features.

CONCLUSION

Our simulator method has been shown effective through the pilot human study. The plan of moving forward is to add more system interaction, better control fidelity, and a more intelligent AD system. Another important step is to take our current simulator and convert it into the mixed reality (MR) scope. With MR, the user will be able to sit in a real car surrounded by greenscreens, observe everything inside the car, and see the simulation through the windshield. Overall, we see a lot of potential for improvement, and are confident that our simulator serves as an effective tool for AV demonstration and education.

CONTRIBUTION

1. Our work is the first systematic approach to deploy CARLA into the VR framework while extending its driving algorithm for human factor consideration.

2. It is also the first attempt to take the AD system as a whole and focus entirely on user experience and interaction. We believe that users will be able to form a mental model on AVs and get a rational assessment of the technology as they actively engage in the driving task and make informed decisions.

3. We present the rationale for using a driving simulator and show why it could be such an effective tool for AV demonstration and training. The results from our study suggest that policy makers should use legislative processes to reduce the misuse of AVs and promote a safe AV environment, while a simulator can be an effective tool.

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