Autonomous Vehicle Education Using a Virtual Reality Driving Simulator

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ABSTRACT

Autonomous vehicles are increasingly popular in our lives, whereas people's misunderstanding and mistrust towards autonomous vehicles have become the main obstacles to the use of these technologies. In response to this problem, proper work must be done to increase the public's understanding and help drivers rationally evaluate the system. In this abstract, we propose a virtual reality driving simulator serving as a low-cost platform for autonomous vehicle demonstration and education. The results show that our simulator successfully increased participants' understanding while favorably changing their attitude towards the autonomous system.

Figure 1: Carla simulator first person driver's view with VR headset in the city scenario.

1 INTRODUCTION

Autonomous vehicles (AVs) are gaining increased attention as it has the potential to improve road safety, reduce traffic congestion, save energy, and increase productivity. However, it has been shown that the public has a natural tendency to resist AVs as it expects them to be much safer than human driven vehicles before considering their use [2]. In order for society to fully enjoy the benefits of AVs, the public must accept and actively using the autonomous 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.

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To solve the above problems, we propose a driving simulator which stands up as a cost-effective, time-efficient, and completely safe platform to help drivers get familiarized with the capabilities of AVs. In this abstract, we develop a virtual reality (VR) driving simulator based on the open source simulator CARLA [1], which allows the user to sit in the simulator chair and interact with the vehicle as if it was a real one. Our study shows that our simulator has successfully improved participants' understanding and trust towards autonomous vehicles.

2 METHODOLOGY

The method proposed in this work is a 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.

Figure 2: Simulator demonstration: left monitor shows CARLA server first person driver's view which is also displayed in the VR headset; right monitor shows the CARLA client third-person tracking view which is provided by the CARLA client by default.

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 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. In addition, they were designed so as to guide users to gradually get used to the interaction with the AV, understand its capabilities, and start building confidence in it.

During the experiment, participants first watched a three-minute video introduction to the five levels of automation which was an explanation of the vehicle's capabilities [3]. The video was carefully selected so that it did not affect the participants' attitude towards AV neither positively nor negatively. With this background information, the researcher then explained that the simulator AV was set at level 4. Participants then took a seat in the simulator setup as shown in Fig. 2 and tried all three scenarios. In each scenario, they were asked to drive along a predefined route, but with the freedom to switch between the manual and autonomous mode at any time. After the participants finished all three scenarios, we administered the second part of the survey, which carried the same fifteen quantitative questions plus the qualitative part.

3 RESULTS

36 participants were recruited via email and social media. Participant group consisted of 18 males, 18 females and had a mean age of 25.5 years. The effectiveness of our simulator was measured through a survey instrument with 15 quantitative and qualitative questions. Specifically, questions were developed with regard to five categories: Trust (TR), Perceived Risk (PR), Perceived Usefulness (PU), Perceived Ease-of-Use (PE), and Behavioral Intention (BI). In addition, Cronbach's α coefficient was computed to validate the internal consistency of each category.

Table 1: Mean, Standard Deviation, and Cronbach's α of the Five Categorical Measurements

	Pre Simulator			Post Simulator		
	M	SD	α	M	SD	α
TR	3.12	0.77	0.75	3.60	0.78	0.75
PR	3.44	0.75	0.69	2.95	0.84	0.82
PU	3.53	0.65	0.03	3.90	0.79	0.67
PE	3.35	0.73	0.57	3.72	0.71	0.52
BI	3.63	0.84	0.78	3.98	0.76	0.82

The results are shown in Table 1. The study showed that the simulator helped participants build a better understanding of the autonomous system. 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. These significant improvements confirmed our hypothesis on the effectiveness of the simulator. 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 AV features.

4 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 AV 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.

There are also some limitations in this work and we hope to improve them in the future. First, our small number of participants cannot represent all age, gender, and population groups. Future study will require a greater number of participants with varying backgrounds to achieve more comprehensive and objective analysis. Also, the simulation environment needs to be enhanced to support higher fidelity and user interactivity. Third, our customized AV stack may not be a faithful representation of a real vehicle and will require further development.

REFERENCES

[1] Alexey Dosovitskiy, German Ros, Felipe Codevilla, Antonio Lopez, and Vladlen Koltun. 2017. CARLA: An open urban driving simulator. In *Conference on robot learning*. PMLR, 1–16.

[2] Peng Liu, Lin Wang, and Charles Vincent. 2020. Self-driving vehicles against human drivers: Equal safety is far from enough. *Journal of experimental psychology: applied* 26, 4 (2020), 692.

[3] Geospatial World. 2018. What are the different levels of Autonomous Vehicle? https://www.youtube.com/watch?v=6592pKyQfyE