AUTONOMOUS DRIVING SIMULATOR FINAL REPORT

(Technical Paper)

ANALYZING THE DANGERS AND ETHICAL CONCERNS OF AUTONOMOUS VEHICLES

(STS Paper)

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Signature _____ Date _____

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Introduction

In recent years, the push for autonomous vehicles has been rising in popularity, and some of these vehicles are now starting to hit the roads. Self-driving vehicles aim to increase road safety, reduce accidents, decrease traffic congestion, and improve transportation efficiency. Two major components of driverless vehicles are computers and AI. Both of these components have become the backbone of numerous aspects of society including technology and transportation. Computers and AI can solve complex problems, analyze extensive amounts of data, and efficiently perform high level operations; however, neither component has the human judgement necessary for decision making. The judgement that AI and other technologies lack may lead to several dangers for vehicles and drivers on the road and may pose concerns about the reliability of autonomous vehicles in regard to ethical decision making. In order for self-driving vehicles to become the future of transportation, there are many safety and reliability factors that must be taken into consideration.

One method being utilized to better observe the decisions and scenarios that need to be considered for autonomous driving is driving simulators, more specifically, autonomous driving simulators. Driving simulators have many uses such as finding solutions to improve traffic flow, improve vehicle systems, and simulate races. However, more related to autonomous vehicles, driving simulators allow for the analysis of driver behavior and further enable users to identify different scenarios and circumstances where autonomy could be applied without endangering the driver or others on the road. Additionally, autonomous driving simulators allow humans to make ethical decisions in a given situation and apply their decision-making process and logic to how an autonomous vehicle would perform in the same situation through the use of AI, coding, and other technology. Identifying dangerous driving situations when quick or ethical decisions need

to be made is essential to the future implementation of autonomous vehicles and maximizing their safety on the road.

Technical Topic

Vehicles are machines that function through the performance of multiple systems working together. This includes the electrical, steering, braking, exhaust, powertrain, navigation, and entertainment/infotainment systems. Autonomous vehicles require even more systems and technology to operate simultaneously because they lack the human judgement required to make driving decisions. Determining the additional systems and technology that need to be utilized requires the cooperation and communication of multiple entities including the software developer, vehicle manufacturer, and vehicle owner. Furthermore, these entities working together must be honest and transparent with the public in regard to the vehicle's capabilities and limitations. Self-driving vehicles should not be advertised as safer than they really are, nor should their limitations be ignored. One current limitation for autonomous vehicles is the process for which ethical decisions are made. Since decision making in code programs and AI are logic based, they cannot account for ethical or moral principles. As a result, technology implemented in autonomous vehicles should provide safety for those both in and outside of the vehicle. It is imperative that different driving conditions are tested to analyze how an autonomous vehicle would react to ensure its safety.

The use of a driving simulator will allow my Capstone team to safely test these types of situations. The current technology installed includes the simulator itself, which consists of a real car cockpit, a projector display system, and a MOOG motion-based platform which is an electrohydraulic motions and control system. All of these systems help to create the driving experience; however, our team wants to implement other technology in order to make the

experience more realistic. One improvement we aim to make is the implementation of CARLA. CARLA is an open-source coding program used for autonomous driving research. This program provides digital assets such as different layouts and driving environments like urban layouts, buildings, and other vehicles to simulate various driving conditions. The integration of CARLA in addition to the projector display system will enable us to create situations, in particular merging onto a highway, and analyze how the car would respond to the given conditions. Furthermore, we can analyze how a human would typically react and behave in this situation and apply that to improving the vehicle response.

A second improvement our team would like to make in order to create a more realistic driving experience is the use of a haptic vest. Haptic technology generates an experience focused on the application of applied forces, motion, or vibrations. The use of a haptic vest with the driving simulator would allow the driver or passengers to better feel g-forces and other motions when the car is picking up speed, turning, decelerating, or stopping. The utilization of haptic technology will exhibit the existing dangers in certain driving situations by providing physical feelings of the vehicle's motion and further allowing passengers to determine the level of safety to which they feel. It is necessary to make the driving experience as realistic as possible, and "driving" in dangerous situations yet feeling safe is not useful in helping to identify areas of needed improvement or attention.

The last improvement our team aims to make is the addition of a rearview display. The driving simulator currently has a rearview mirror; however, there is nothing behind the simulator. Adding a projector display behind the simulator will allow us to analyze vehicle behavior for objects and other cars either behind the vehicle or in its blind spot. In realistic driving conditions, there will be cars, objects, and people surrounding the car, not just directly in front of it.

Especially for highway merging, it is crucial for a vehicle to be aware of other cars coming up from behind in order to safely merge.

The technical project will take place over two semesters. My Capstone team has already started working on the driving simulator, meeting twice a week with assistance from Professor Furukawa. Our biggest goals are to utilize the driving simulator to identify how autonomous technology can be implemented to create safe highway merging capabilities with sensor compatibility and to create a realistic driving experience with vehicle decision making abilities while providing overall safety.

STS Topic

The goal of this research is to analyze the safety and reliability concerns associated with autonomous vehicles in order for self-driving vehicles to perform at the highest level of safety. I would like to explore factors such as driver behavior, traffic patterns, and road obstacles or conditions in order to analyze how an autonomous vehicle would "react" to different situations. With a potential increase in the use of autonomous vehicles, communication among these vehicles with traffic infrastructure and other autonomous vehicles, such as the case of highway merging, also needs to be considered. This will make certain the vehicles can properly function in an environment composed of human drivers and computer systems. Another situation I want to consider is how a vehicle would choose to prioritize the safety of pedestrians or its passengers given dangerous circumstances. For example, if a pedestrian suddenly jumped into the street, should the vehicle swerve off the road to save the pedestrian but injure its passengers or save the passengers and risk the life of the pedestrian? I aim to evaluate common safety concerns with autonomous vehicles and what the current approaches are to resolving these issues along with new approaches.

Hopefully with the implementation of CARLA, my Capstone team can analyze driving behavior and reactions to numerous different driving conditions. Driving tests can be performed in busy environments such as cities and highways or less crowded areas such as rural regions. Furthermore, different weather conditions and terrains can be applied to analyze how the vehicle systems would operate and ensure the vehicle would provide a safe response. It is essential to consider these conditions and how the vehicle systems perform for the purpose of determining liability in the event of an accident. For example, if an autonomous vehicle malfunctions or crashes, should the responsibility be placed on the vehicle manufacturer, software developer, or driver? The liability of autonomous vehicles is a large area of concern for many people.

Although some autonomous vehicles have already been implemented, these are typically for delivery services, agriculture purposes, and mining and construction industries. Moreover, the current uses do not typically involve a human in the vehicle. However, this does not minimize safety concerns for people around these vehicles. The safety of these vehicles must be ensured in order to implement them in industries such as ride sharing and public transportation, which potentially involves putting many peoples' lives at risk. Autonomous vehicles will be extremely beneficial for people who are unable to drive, perhaps due to disabilities, or for those who do not own vehicles. Additionally, they can improve efficiency in certain industries, reduce traffic congestion, and may even improve road safety by consistently reacting safely to situations and reducing human error such as distracted driving. However, autonomous vehicles should not be implemented until their safety is approved and their full limitations are known.

Research Question and Methods

In order to implement autonomous vehicles, we must define what is considered safe. Since safety is one of the largest concerns, we must establish a threshold for safety that most

people would agree to in order to feel confident using these vehicles. One way to measure safety is by analyzing errors made by the vehicle compared to human error. By examining typical human behavior for stressful driving conditions when an accident is more likely to occur, we can determine the best reactions to avoid the accident. Once this data is collected, we can establish a threshold of safety as vehicle error being less than human error. Furthermore, autonomous vehicles can be considered safe when they are less likely to make common driving errors than a human.

Secondly, for a vehicle to be considered safe, it needs to have consistency in its reactions to a given scenario. Not only should the vehicle react quickly to a dangerous situation, but it should react the same way every time for that given scenario. This can be done by repeatedly driving in specific conditions and ensuring the autonomous features of the simulator operate the same way each time. There is no quantitative measure for a decision-making vehicle to be considered safe; however, there still need to be standards and criteria to demonstrate the safety of the vehicles and gain trust from the public.

Conclusion

Successfully identifying safety and reliability concerns associated with autonomous vehicles will further assist in developing the proper technology that will allow these vehicles to hit the roads. Testing different driving situation with a driving simulator and implementing technology software such as CARLA, the use of haptic technology, and more complex display systems will allow us to determine the current safety needs of autonomous vehicles and the technology necessary for their improvement. Furthermore, the use of this technology will allow us to recognize scenarios when ethical and moral decisions need to be made and how a vehicle should handle these situations. The deployment of autonomous vehicles has the potential to lead

to improved road safety, decreased traffic congestion, and increased accessibility. The research from this project may help autonomous vehicles hit the roads sooner; however, safety and trust cannot be surged. There must be transparency in the capabilities and limitations of autonomous vehicles along with a commitment to safety in order to establish the public's trust and acceptance.

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