AUTONOMOUS PLATOONING GOLF CART FOR SHORT DISTANCE CAMPUS TRAVEL

(Technical Paper)

AN INVESTIGATION INTO THE SOCIETAL PERCEPTION AND ACCESSIBILITY 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.

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Introduction

In recent years, there has been a significant increase in the demand for commercial autonomous vehicles, especially cars for everyday usage. Some companies, such as Tesla, have contributed to this heightened awareness of such complex technology, but there are some "autonomous" features that have been developed and implemented in many modern cars. These features can include parking assistance, rear-view cameras/backup assistance, and cruise control. These are usually referred to as "safety features," by car manufacturers and society, since it is believed for the most part that these additions are used to keep people safe more than cause harm. However, the way these features are currently implemented in most modern cars makes it such that the driver of the car still has the opportunity to make their own decisions and override the system. Even in cars that are labeled as "self-driving", the person sitting in the drivers' seat is still expected to pay attention to their surroundings and be able to take control of the car at any time.

One of the multiple benefits to self-driving cars that people repeatedly cite is increased safety on the roads (Union of Concerned Scientists, 2017). However, the way safety is perceived can differ between individuals and between organizations. As cars are increasingly developed to reach higher levels of autonomy, a number of questions arise regarding the kinds of decisions an autonomous vehicle must make when it encounters an emergency situation (Bonnefon et al, 2016). Furthermore, it must also be asked if society trusts the autonomous car to make these important decisions in the event that the passengers cannot override the system in time.

Developing a fully autonomous vehicle is an extremely difficult task and has not been done yet successfully, but many companies are investing lots of time and resources into

strengthening the autonomous capabilities of important features that drive a car. The goal of this technical research project is to use various technologies to allow for autonomous control of a golf cart, which can then be applied to autonomous control of other types of vehicles. The STS research will investigate what exactly makes the general public nervous about autonomous technology and the ways in which self-driving vehicle manufacturers can utilize this feedback to influence the development and marketing of their products to increase people's confidence.

Technical Discussion

X-by-Wire Technology

All transportation vehicles, from standard cars to 18-wheelers to trains, use mechanical systems to control their movements. These mechanical systems involve a series of parts which are physically connected together such that an action performed by the driver allows another part of the vehicle to respond accordingly. For example, when a driver turns the steering wheel, the steering column attached to the wheel rotates and in turn moves a steering rack which allows the car wheels to pivot and change the car's direction of motion.

Many sensors are not needed in a vehicle driven by a human passenger since the driver is doing the work of observing the surroundings. However, in a self-driving car, many sensors must be used to collect data about its environment and appropriately influence the vehicle's responses. Part of the development of autonomous vehicles involves removing the mechanical connections between components and replacing them with sensors and code so that the system input and output are no longer physically linked. This type of technology is known as "X-by wire" or "drive-by-wire" (DBW) technology. The components of a DBW system include sensors

and actuators controlled by embedded software to optimize autonomous vehicle control and promote safe operation of the vehicle (Mushenski et al, 2003). The three main control systems within DBW are steering, throttle (acceleration), and braking (Mushenski et al, 2003). An advantage to DBW technology is the ability for automakers to remove heavy and bulky actuators (Choi et al, 2005).

Design Considerations

There are multiple electromechanical components and connections that can be implemented to drive and control an autonomous vehicle. However, different factors need to be considered that can influence the types of sensors and actuators eventually used in the DBW system. An important factor that needs to be considered is response time, which falls under safety. If any sudden change in surroundings is detected, the vehicle must be able to quickly recognize the situation and act accordingly. Other factors include usage of space within the vehicle and not including too many components to reduce the risk of too many parts of a system failing. For example, using a linear actuator for the braking system can have a good response time, but it can also take up too much room in the vehicle and leave less room for passengers.

Mapping the Environment

Beyond the physical operation of the vehicle being operated, the ability to navigate its environment is also required. Currently, humans and self-driving cars that already exist on the market use GPS technology to know what path(s) should be taken to get from one location to the next. If GPS technology is not available to be used, a set of special sensors can be used to generate a map of the vehicles' surroundings and allow the vehicle to navigate by itself. One such sensor that is commonly implemented in autonomous cars is Lidar, which stands for light

detection and ranging. Lidar sensors are recognized by the automotive industry for their ability to produce high-resolution 3D imaging of the surroundings even under various weather conditions (Yoo et al, 2018). However, just placing a Lidar on the vehicle is not enough to generate a map that could allow the self-driving vehicle to safely navigate its environment (Yoo et al, 2018). In order to enhance the accuracy of the navigation map, other external cameras can be placed on different sides of the vehicle which can generate their own maps that would then be fused with the Lidar map.

Technical Research Project

The purpose of this technical research project is to build upon the work done by previous teams at Virginia Polytechnic Institute and the University of Virginia to implement self-driving and self-navigation capabilities in two golf carts, one of which will autonomously follow the other. Lidar and stereo cameras will be attached to the leading golf cart and scan the surroundings to develop a map that will be used for navigation purposes and displayed to the user on a monitor. To autonomously control the vehicle steering, a potentiometer is connected to the steering column through a gear train and the reading from the sensor is used to appropriately power the wheel motors. For a braking system, a pulley connected to a continuously rotating motor is used to pull on or release the brake pedal, thus simulating the act of pressing on or releasing the brake pedal by a human driver. The environment map and all three x-by-wire systems will continue to be developed such that the carts can navigate their environment and perform multiple DBW operations successfully and simultaneously.

STS Discussion

As with any novel technology, there is plenty of excitement surrounding self-driving vehicles from ordinary people and major corporations alike. According to a survey conducted by Pew Research Center, about 40% of respondents were "at least somewhat excited" about the development of self-driving vehicles (Smith & Anderson, 2017). The company GM announced that they planned to invest $500 million into developing their first fully autonomous car to be used as a self-driving taxi (Krasniqi & Hajrizi, 2016). There are multiple positive impacts that self-driving cars can have on society that proponents of this technology cite. These can include increased accessibility for physically disabled people and the elderly, and it gives them the ability to live a more independent life. Passengers like the possibility of being able to use the time spent in the car doing other things that they might consider to be more productive or even have the ability to get rest during their commute (Cunningham et al, 2019). It is also believed that autonomous vehicles are safer overall since the vehicle's operation does not fully rely on human error from the user and thus have the ability to react faster to situations.

While accessibility and improved performance are significant improvements to the way cars currently work, it is equally important to ask what the unknowns and/or negative aspects of self-driving technology are and the general public's hesitations surrounding this new innovation. My STS research will investigate the different factors that might make consumers apprehensive to use a service that relies on autonomous vehicles or purchase a self-driving vehicle for themselves. To do this, I will explore the methods that car manufacturers are currently using to specifically target those who are not yet on board with self-driving cars and identify the potential effectiveness of these methods. Some of the reasons for hesitation that are brought up with

regards to autonomous vehicles are the lack of trust in a machine being completely in control (Smith & Anderson, 2017). In these systems, human decision-making based on moral principles is virtually eliminated and the car must be pre-programmed to make the choices on the road itself. To create a final product that appeals to as many users as possible, developers have to determine how to balance the many ethical perspectives that people hold and use this to influence how they develop their programs. I will look into the research that has been conducted regarding what the general public expects from the performance of self-driving cars and what features they want to be included that would increase their confidence in the technology.

I also plan to look into a few specific communities who can enjoy important benefits from self-driving technology, such as disabled people and the elderly, to see how car manufacturers can make their products accessible so that people in these communities can reap the projected benefits. Self-driving cars that integrate so many pieces of complex technology are bound to come with a hefty price tag that makes them inaccessible. Additionally, manual override systems may need to be rethought based on the fact that some passengers would not be physically able to operate these systems (Bradshaw-Martin & Easton, 2014). I hope to understand what these communities would need from their self-driving cars in order for them to have the ability to attain the independence manufacturers promise. The features in self-driving cars that satisfy the special needs of these communities could also be implemented in all self-driving cars and utilized by everyone.

Within our technical research project, my team is examining what features should be included on the golf cart to help the users feel more comfortable with utilizing the technology, such as displaying mapping data on a computer screen and keeping certain physical components, such as brake and accelerator pedals, on the cart.

Conclusion

The development of self-driving cars is a technology that many people have their eyes on and are curious to experience for themselves. Many advocates for the technology argue that increasing autonomy in vehicles can lead to safer roads and transit systems. However, the variety of ethical considerations and inputs from different people and groups must be looked into and balanced to achieve this goal of safety for passengers and pedestrians alike. Autonomous algorithm developers and car manufacturers should develop self-driving vehicles such that enough people will receive autonomous cars positively and encourage the thought of buying one for themselves. Additionally, enough transparency needs to be maintained by car developers in order for the public to have enough confidence in how self-driving vehicles operate and be able to feel comfortable sharing public roadways with them. Manufacturers must consider how much control over a vehicle the potential users are willing to relinquish and as a result whether full autonomy should be pursued.

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