Campus Vehicle Platoon

Engineers' Responsibility to Mitigate Sociopolitical Effects of Autonomous Vehicles

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Mechanical Engineering

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October 22, 2022

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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

Transit for citizens with physical disabilities is incredibly challenging. Not only do they experience difficulty with public transportation, but often personal cars are not an option. For example, individuals with impaired sight would need to walk to a public transit stop. Then they have to ride the train to the correct stop and walk again to their final destination.

In a study completed by the Buruea of Transportation in 2022, they found that “an estimated 25.5 million Americans have disabilities that make traveling outside the home difficult.” The article goes on to discuss the difference in travel habits for people with and without disabilities. Based on the statistics found in the study, 70.6 percent of disabled people reduce day to day travel and 21.6 percent give up driving. While public transport could be a solution, 14.4 percent of individuals with physical disabilities use public transport less often.

Regardless of the reasons behind these statistics, it is clear that physical disabilities severely limit citizens’ mobility. Sandra Rosenbloom summarizes many of these studies done by the Burueau of Transportation Statistics within her abstract covering the book “The Future of Disability in America.” She wrote that “roughly one-third of people with disabilities have no public transportation or other transportation available to them, so the accessibility of those services is beside the point” (Rosenbloom, 2007).

While the data above presents a more severe problem, transportation to UVA classes is an immediate challenge many students face. Even though UVA offers a bus system, students with disabilities face problems stated above like walking to the bus stop and walking to their final destination. More importantly, bus transportation is not reliable between classes because there are many buildings with no road access. As a result, students with physical disabilities or temporary injuries have a difficult time arriving to class on time.

In light of these issues, I am working with my Capstone team to develop a self-driving platoon of golf carts that provide quick transportation for students directly to classroom buildings, while exploring the sociopolitical affects of that self-driving technology through Langdon Winner's techno-political framework.

Autonomous Platooning Capstone

Currently fully autonomous vehicles are not available for personal use on the road for a number of reasons. Most importantly, the technology is still being developed and engineers have not been able to establish enough successful tests to guarantee autonomous vehicle user's safety. Regardless, multiple companies have developed semi-autonomous systems. The most well known company is Tesla, which provides full self-driving capabilities for attentive drivers in its newest Tesla vehicles. However, OVIS by ForwardX created a follower suitcase which works to predict the owner's motion and uses similar autonomous vehicle technology for collision avoidance. Another company, Scania, synthesized the technologies mentioned above by creating an autonomous fleet of semitrailers with the goal of increasing the efficiency of the transportation industry. Scania utilizes self-driving capabilities for the lead tractor trailers. Then, all other tractor trailers in the fleet follow the leader with platooning technology similar to the follower suitcase.

My technical project consists of a self-driven leader golf cart and platooning followers carts. The platooning follower carts determine their motion by the direction and speed of the lead golf cart. This technology is incredibly similar to Scania' fleet of semitrailers. However, the primary goal will be to provide more efficient and convenient transportation for disabled students at UVA. Even though UVA has a bus transit system, the golf carts would be a better

solution for physically disabled students because they would be able to reach the specific buildings where their class was located. The platooning capability of the golf carts also means that the carrying capacity of the entire fleet is easily adjustable based on the demand for transportation. If eight seats are not enough, it is simple to copy and paste the technology onto a new golf cart and add that cart to the fleet. As a result, a self-driven golf-cart platoon would be more convenient for transporting students much closer to their respective classrooms. At the same time, the platoon remains versatile and would not become overcrowded like the UVA bus system.

To develop this student transportation solution for UVA, the Capstone team is working underneath professor Furukawa, in MAE 4610. The first task is specifically working on developing and initiating the mechanical systems which control the braking, acceleration, steering and control signals between the lead cart and follower carts. The braking, acceleration and steering systems will require a motor and computer chip to control the motor speed and timing. At the same time, the control signals will be relayed from a computer program to the necessary computer chips. To illustrate these details, a wiring schematic of these components of the cart is shown in Figure 1 below.

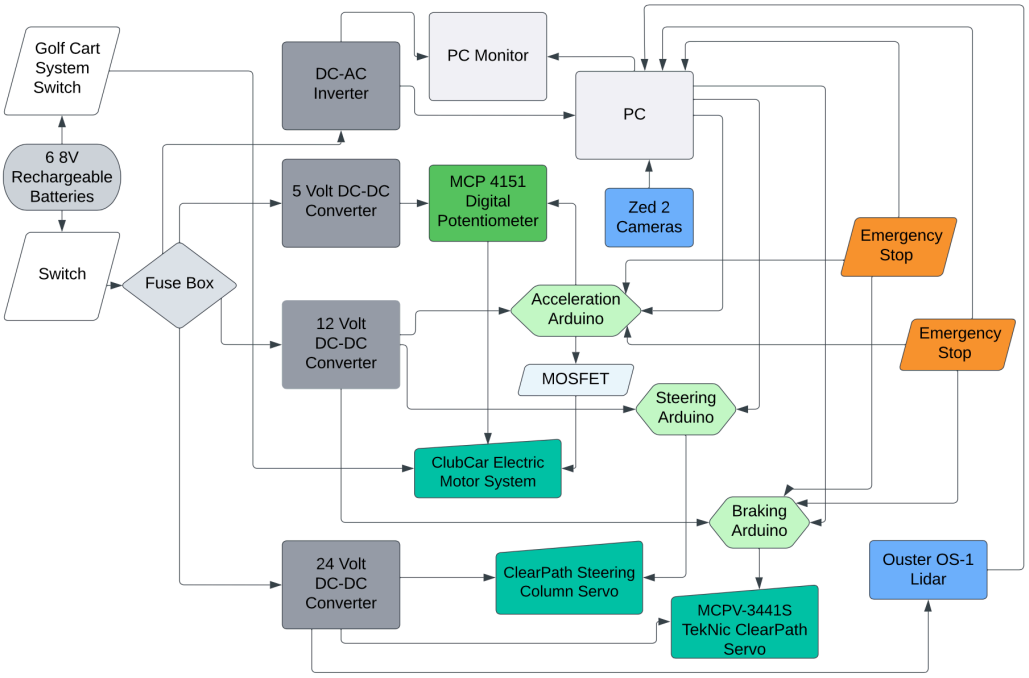

Figure 1: Detailed Campus Vehicle System Wiring Diagram

After that is completed, the team will also install platooning technology on the follower golf cart using cameras and sensors to relay information to an open source robotics program. Upon the completion of the project, the team will have two carts with similar designs to the image in Figure 2 which will be showcased to UVA Engineering faculty at the end of the spring semester.

Figure 2: 2018 Campus Vehicle Design

Technopolictical Framework

While the campus vehicles hopefully resolve transportation issues on grounds at UVA, it is important to consider the broader impacts of self-driving vehicles. In the article "Autonomous automobilities: The social impacts of driverless vehicles," the authors highlight that autonomous vehicles will have layered complex affects on the culture (Bissell et al., 2020**)**. Another article titled "Humanizing autonomous vehicle driving: Understanding, modeling and impact assessment" also emphasizes the value of exploring autonomous vehicle's relationship to many actors including pedastrians on the road (Orfanou et al., 2022). While both articles do not expand on detailed effects of autonomous vehicles, they emphasize the need to account for expansive sociopolitical affects. At the same time, other authors explore autonomous vehicle's

sociopolitical implications. For instance, Kamil Mamak and Jadwiga Glanc co-author a piece of writing in 2022 which discusses how autonomous vehicle users would experience consequences for traffic accidents. Since the users of the autonomous vehicle are not technically at fault, they would experience freedom from the law. Citizens in lower socio-economic classes who could not afford autonomous vehicles would then be adversely affected by traffic regulations. As a result, autonomous vehicles may enforce socioeconomic disparity. McCarroll and colleagues (2022) claim that autonomous vehicle users may experience more time to complete work and increase their productivity. Then, citizens who cannot afford autonomous vehicles may be left behind in the workplace generating a class divide between autonomous vehicle users and nonusers.

On the other hand, many people are optimistic about the solution autonomous vehicles could provide for disabled individuals. Specifically, William Riggs and Anurag Pande (2022) wrote about the current issue of paratransit for a wide range of disabilities. The second half of their paper even goes through a variety of autonomous vehicle designs that could solve transportation issues for the physically disabled. Another journal article, "Persons with physical disabilities and autonomous vehicles: The perspective of the driving status," explores disabled community members' view of autonomous vehicles. Although some people are very apprenhesive, the authors collect data from a variety of disabled individuals. As a result, people's specific fears and technological designs to resolve those fears can be attained from the article. The author's also emphasize the value that autonomous vehicles can provide transportation solutions for the physically disabled, if designed well (Petrovic et al., 2022).

Langdon Winner (1980) provides a techno-political framework to critically consider autonomous vehicle's relationship with all of the environmental factors mentioned above. Within his article, "Do Artifacts Have Politics?" he writes that the theory of technopolitics "draws

attention to the momentum of large-scale sociotechnical systems" and how the culture interacts with technologies (p. 123). Through Winner's article, it is clear that technology can have great positive and negative impacts on culture. Artifacts may decrease civil liberties or economic opportunity for social groups, while increasing accessibility and freedom for others. Applying this framework to the campus vehicle Capstone and general self-driving car development requires the consideration of unintended affects. For instance, how will real laws be adapted in light of the adoption of self-driving cars. Specific examples, such as altering traffic infrastructure and redefining data privacy for cybersecurity, are provided in "Understanding autonomous vehicles: A systematic literature review on capability, impact, planning and policy" which uses literature review to determine legislation that should be put in place (Faisal et al., 2019). The case studies Winner (1980) explores later in his article in light of the techno-political framework, also provide examples of how engineers can impact the sociopolitical affects of technological systems. By extrapolating this idea to the development of autonomous vehicles, the framework illuminates engineers' agency regarding the consquences of this new technology.

Research Question and Methods

I plan to research the question: What can mechanical engineers, electrical engineers and computer scientists can do to enhance positive and mitigate negative sociopolitical affects of autonomous driving technology? By critically exploring predicted and observed social effects of autonomous vehicles it is possible to understand many problems that this artifact will cause. However, engineers are still developing this technology. So, recognizing its issues could provide practical physical innovation, sensor implementation and software design that maximizes this artifact's benefits as it is adopted.

I will draw my primary source of information from three interviews and a survey of the student body. First, I would like to discuss self-driving car and human interaction with Professor Lu Feng who researches cyber-physical systems interacting with human operators. Next, I hope to interview Professor Laura Barnes about current concerns with unmanned control systems. Then, I will conduct an interview with the University of Virginia Disability Resource Center, to give insight into key features which self-driving vehicles could have. Finally, the survey will focus on whether autonomous driving is viewed positively or negatively by students. After understanding personal student's opinions the survey will follow with categorical questions about the reasoning behind each opinion. Each category will hold comments related to fear of the technology itself, fear of the affects of the technology and excitement about the new technology. This will help quantify UVA students' hopes and fears surrounding autonomous vehicles and may highlight specific systems engineers should focus on while developing self-driving cars.

Secondary sources will involve an interview with Maite Brandt-Pearce who has experience in DOD vehicle to vehicle communication to determine the benefits and dangers of platooning communication technology. Finally, articles included in the description of the techno-politcal framework above will be used to consider general positive and negative affects of self-driving cars. These research methods should clarify, the interaction between autonomous platooning vehicles and human actors as well as specific positive technologies engineers can develop.

Conclusion

Currently, disabled citizens everywhere are often unwilling to travel because of the challenges it presents. Reaching public transit or utilizing a taxi becomes difficult or even uncomfortable. As a result, physically disabled individuals would rather remain at home. Many students have a similar difficulty getting to class on their own. The current bus system is helpful. However, it is inefficient, so the campus vehicle Capstone project is meant to resolve that transportation issue for physically injured or disabled students at UVA. At the same time, self-driving cars could provide a large-scale solution. Despite the optimistic view of autonomous vehicles, it is important to also consider their negative sociopolitical impacts. Since this technology is early in the development stage, many of the impacts considered are hypothetical. Nevertheless, surveys and previous research articles can shed light on potential affects self-driving cars may have. Then engineers can intelligently design autonomous vehicles in light of their sociopolitical affects.

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