Undergraduate Thesis Prospectus

Autonomous Campus Vehicle

(technical research project in Mechanical Engineering)

The Road to Transport Equity: Automated Driving and the Pursuit of Inclusive Urban Mobility

(sociotechnical research project)

by

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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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General Research Problem

How can transportation be improved in terms of efficiency, sustainability, and health?

Transportation is an important aspect of society, affecting people's daily lives and the environment. Improving transportation in terms of efficiency, sustainability, and health is critical to ensuring better and more equitable mobility for everyone. In technical terms, this includes improving infrastructure, such as implementing better design for pedestrian safety, introducing bike-friendly design, and integrating public transit. Also, this can include optimizing vehicles to reduce greenhouse gas emissions and energy consumption. Socially, this includes seeking equitable mobility, which includes considering time, affordability, safety, accessibility, and health impacts for everyone. Transportation accounts for about 64% of global oil consumption, 27% of all energy use, and 23% of the world's CO2 emissions (Mead 2021). These negative effects of transportation further contribute to poor health, climate change, and inequality. Improving transportation to alleviate these issues is thus vital to daily life and the environment.

Autonomous Campus Vehicle (ACV)

How can autonomous vehicle (AV) technology, like platooning, be improved?

The technical advisor for this capstone project is Prof. Tomonari Furukawa in the Mechanical Engineering department. I will collaborate with other mechanical engineering students: Santiago Merida, Carolyn Pitorak, Ben Tharakan, Riley Tufts, and Victoria Vettoretti. The technical research project consists of improving the current autonomous campus vehicle, which is a modified golf cart system, and improving a working platooning system that groups multiple vehicles together.

Advancements in robotic car technology, like platooning, which involves a group of vehicles moving in sync, offer advantages such as improved safety and public health, increased travel and fuel efficiency, increased mobility and accessibility for the disabled and elderly, reduced congestion, and increased adoption of car sharing (Center for Sustainable Systems 2023). The CSS (2023) also states that platooning systems can improve traffic efficiency, reduce vehicle consumption, and even reduce energy consumption by 3-25%. However, there are challenges to ensuring the development and implementation of platooning. For instance, Bandapally, Vaidya, and Mouftah (2022) state that "cut-in or cut-through maneuvers by the non-platooning vehicles may be the major obstacle to maintaining platoon integrity." Other challenges could include inefficient sensor data, connectivity issues, and poor coordination. Without robust platooning systems and algorithms, the perceived benefits of safety and better traffic capacity cannot be met.

The project goals are to implement a functioning platooning system to travel from Observatory Mountain Engineering Research Facility (OMERF) to UVA's Engineering Way (E-Way), to implement working sensors, and to apply additional system upgrades, like considering driving behaviors to implement "street stable" conditions using Adaptive Cruise Control and safety message broadcasting.

Reviewing existing team efforts on the ACV over the last four years, they have developed two modified golf carts (leader car and follower) that use a platooning system that copies the lead car's movements. The hardware and software for both carts are identical allowing for interchangeability. However, the current technologies do not successfully complete the accomplished route to E-Way and the lack of sensors is infective with route mapping. Other unresolved issues include a poor platooning system (the current system simply copies the

velocity and acceleration vectors from the lead car so there is no probabilistic algorithm), a lack of compatible graphics cards in the current computers, and a faulty steering bracket in one of the cars.

To improve the ACV, the team will work on reverse engineering the previous vehicles to become familiar with the current systems and to identify any issues for future work. Reverse engineering will be documented by modeling a systems diagram that identifies all electrical and mechanical hardware of the ACV. Also, the team will generate customer needs data, by surveying and interviewing potential user groups, in order to identify quantitative target specifications and identify technical priority and feasibility of these measures.

If successful, we hope to conclude this project with the vehicles successfully traveling the route from OMERF to E-Way. This will allow engineering students, professors, and researchers to travel more efficiently and alleviate challenges in time constraints and the physical ability required to walk between locations. Next, future engineers should consider further improving the platooning system to be more accurate and smoother and adding more vehicles.

The Road to Transport Equity: Automated Driving and the Pursuit of Inclusive Urban Mobility

In the US, how are tech companies, automakers, insurers, advocacies, transit agencies, and policymakers competing to determine the place of AVs, if any, in a more equitable urban mobility future?

As technology companies develop and improve autonomous vehicle technology, social groups compete to determine how these vehicles will fit into mobility systems, and how or if AVs can contribute to a more equitable mobility future. Mobility equity refers to ensuring quality

transportation options for everyone that considers factors like affordability, safety, and accessibility. Many factors contribute to mobility inequality, including, but not limited to, income, gender, age, race, disability, and migrant status (Hidayati, et. al.). If these factors are not adequately considered and planned for, the technology cannot be equitable. Evaluating whether AVs will actually improve mobility issues, as proponents for the technology claim, or if they will further contribute to existing mobility inequality is vital.

Before evaluating any further, it is important to note that current "autonomous vehicles" are more accurately described as "robotic cars". "Autonomous" implies that the vehicle acts fully independently when in reality, these vehicles are programmed and taught by humans. Therefore, despite the habitual usage of "autonomous vehicles" by researchers and participants, these vehicles are only free to do what is intended by the creators of the technology.

Researchers have evaluated robotic cars' capacity to contribute to equitable mobility. For example, Emory, Douma, and Cao (2022) found that policies addressing mobility and economic impacts are the most common, while there is little emphasis on low-income communities, people of color, rural communities, and interpersonal security. They further state that without proper policy interventions, AVs generate equity concerns. Many researchers doubt that current robotic cars can contribute to equity in urban mobility. Wen (2019) contends that AVs should augment existing modes of sustainable transport, such as public transportation, since they are "more acceptable to all the stakeholders and respects the social-purpose considerations such as maintaining service availability." Similarly, Petrovic, Mijailovic, and Pesic (2022) examine how AVs are perceived by persons with physical disabilities and conclude that many people in the community believe the best solution is "introducing AVs in the public transport system following accessibility, reliability, and safety principles". Sparrow and Howard (2020) examined AVs'

economic implications for road transport and their consequences for mobility equity and concluded that introducing robotic cars to the current market will only "reproduce and/or exacerbate existing inequalities." Creger et al. (2019) examine how the "autonomous vehicle revolution could lead us to transportation hell, with a growing mobility divide between haves and have-nots".

Participants have varying opinions regarding robotic cars and the capacity to promote equitable urban mobility. Some participants believe robotic cars will better equitable mobility. The National Association of City Transportation Officials, a professional association, claims to support "an autonomous future that enhances all aspects of cities' transportation systems, from improving safety for all road users, re-balancing the use of the right-of-way, and expanding mobility for all" (NACTO 2020). The National Federation of the Blind, an advocacy, states that it supports "the transformative capabilities fully autonomous vehicles can and will have on the lives of the blind," (Riccobono 2022).

From an industry perspective, technology companies advocate for the benefits of AVs to equitable mobility. Cruise and its parent company, General Motors, develop vehicles capable of automated driving and have a business interest in promoting them. In its public relations, Cruise claims it seeks to "build a better, more accessible product for our riders," (Lee 2023). The Coalition for Safe Autonomous Vehicles and Electrification (SAVE), a professional association, states that "AVs can provide a new, affordable mobility option for those who are unable to drive" and that they "can reduce transportation barriers in underrepresented communities." Likewise, Partners for Automate Vehicle Education (PAVE), another professional association, states "Mobility experts see automated vehicles as an important new opportunity for [those with disabilities, seniors, and those who can't afford a personal vehicle], many of whom could, enjoy

the same freedom and economic opportunity that most of us enjoy." PAVE does not identify any sources for the "mobility experts" however.

Other participants believe that robotic cars will not significantly contribute to equitable mobility. The Urban Institute (2022), a thinktank, endorses AVs as vehicles that "could improve transit access for people with disabilities if regulated appropriately," but "if deployed haphazardly with inadequate oversight and regulation, they could produce even worse inequities than those caused by the current system." Similarly, Advocates for Highways & Auto Safety, a professional association, states that "currently [AVs] are being developed and deployed in a way that is insufficient to protect those in AVs and other road users."

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