Development of Autonomous Campus Vehicles

(Technical Topic)

How will society react to losing their autonomy in driving?

(STS Topic)

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On my honor as a 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 1965, the founder of Intel, Gordon Moore, began noticing that every two years, the amount of transistors that can fit onto a silicon chip doubled. At the same time, these more advanced computers were also cheaper. These observations led to the postulation of Moore's Law, which states that technological advancement grows exponentially (Tardi 2020). Society has seen this law in action, considering the fact that 100 years ago there weren't computers, and today one can hold a computer in their hand and talk to someone anywhere in the world. This exponential advancement of computers will continue, and with that, new technologies will emerge. The growing technology to be examined here is that of autonomous vehicles.

My technical project includes the development and hopefully implementation of an autonomous campus vehicle. I am working together with 5 other students, our TA Arthur Pawlica, and Prof. Tomonari Furukawa. Prof. Furukawa has worked on similar projects in the past in conjunction with Club Car and Virginia Tech. When Prof. Furukawa moved from Virginia Tech to UVa, he brought with him the golf carts that have been worked on by past groups. At Virginia Tech, the project goal was to create a leader-follower system so that a golf cart could drive itself, following behind a cart driven by a human. Our project is different, we are taking the golf carts that have been previously worked on and adapting them so that each is autonomous without a leader. The end goal is to create a golf cart that can move up and down Engineer's Way, stop to allow students to hop on, stop when the student wants to get off, and is safe for other students walking around the cart.

Autonomous vehicle technology has the potential to change many different facets of society today. My STS research question centers around society's (particularly American society) reaction to losing their autonomy in driving. This paper will look to gather information

on autonomous vehicles in order to understand the impact they can have on society today. At the same time, I will examine the growing mistrust of science that is on display in the news, on social media, and in advertisements. Then, by balancing the technological and social forces, I will try to lay out a plan for the adoption and implementation of autonomous vehicles onto our roads today.

Despite the fact that this technology could be extremely powerful moving forward, social factors surrounding autonomous vehicles will play an important role in the technology's success or failure. Thus, the STS framework of the Social Construction of Technology (SCOT) will be used to examine the aspects that ultimately determine the technology's outcome. This framework, developed by Wiebe Bjiker and Trevor Pinch, states that human action shapes technology, rather than technology shaping human action. Elements of the sociotechnical that will be explored are interpretive flexibility, relevant social groups, and closure.

Technical Project - Developing an autonomous campus vehicle

From 2015-2019, Professor Tomonari Furukawa was working at Virginia Polytechnic Institute and State University. In 2015, he approached Club Car, the largest golf cart manufacturer in the world, to see if they wanted research to be done on autonomous carts. Club Car agreed to allow him to conduct the research, and has given 4 carts to him over those years. He has used these carts to try to develop leader-follower systems with students at Virginia Tech. When Prof. Furukawa made the switch to the University of Virginia, he brought with him the previously worked on golf carts. It is our job to take these carts, learn what past students have done with them, and then change them to build an autonomous campus vehicle.

It is important to define autonomy to understand the project goal. For a car to be autonomous, it must be able to sense its surroundings and drive with no human input. Currently, automation of cars is separated into 6 levels, aptly named levels 0 through 5 (synopsys.com). A level 0 car has no automation, and the human driver must do everything, whereas a level 5 car performs all driving tasks and requires no human interaction. Vehicles on the road today all have some level of automation, whether that be cruise control or advanced driver-assistance systems. However, no car today has reached level 5. Our goal is to reach level 5 autonomous capabilities with our carts, so students and faculty can easily get around on Grounds.

Autonomous vehicles are systems made up of sensors, actuators, and computers. Although we have not made many decisions about which sensors to use for our cart, the sensor system will most likely be made up of an RGB camera, a lidar sensor, and a radar sensor. Here, we run into our first problem. Often, these sensors are very expensive and sometimes cost more than the golf cart itself, which is impractical for mass development of such carts. Thus, the challenge here is to find accurate sensors that work well but do not break the bank. The next components are the actuators. There must be an actuator for steering, throttle, and braking in order for the cart to run on its own. The current systems deployed by Virginia Tech students include a Nexteer Electric Power Steering system, a DC motor connected to a pulley system for the brakes, and a fly-by-wire system for the throttle (Cox et. al 2019). These systems worked in the past individually, but the students were never able to get the system to work together properly. So, it is up to us whether to use these systems or not, and I think we are leaning towards keeping their systems in place and mostly changing the software. The last part of the system are the computers, or microcontrollers. The carts are currently fitted with four Arduino microcontrollers, each handling its own system (data collection, actuation, and emergency stop).

Although we are planning on taking out and disconnecting these Arduinos, we are most likely going to still use them in the finished product because they are readily available. Discussion of the Arduinos brings up another very important part of the system, software. Complex algorithms and machine learning need to be implemented in order for the cart to understand its surroundings and how to react to them (synopsys.com). While this is a very important part of the project, I will be taking a back seat in order to let the more skilled coders work on this aspect. Our group of six luckily has three people more interested in hardware and three more interested in software development, so the work divide will be even. These are the systems that must come together in order to develop a level 5 autonomous vehicle.

In the end, hopefully, our group will develop 2 golf carts that can drive on their own. The carts will have a designed loop, like a bus route, but the stops can be anywhere along the route. The carts should be able to avoid stationary and dynamic objects, along with recognizing if a student is trying to climb aboard. Lastly, the student will have to tell the cart when to stop in order to get off of it. We would like to have the entire system running by the end of the year, and use the carts as exhibits for the MAE department to show potential new students what we do here.

STS Research question - how will society react to losing their autonomy in driving?

The impact that autonomous vehicles have on society is largely dependent on the social factors surrounding the technology. The goal of this paper is to point out the relevant groups that will interact with autonomous vehicles, understand how they view the technology, and figure out the best way to implement it so that it can have the most impact. The framework that will be used is the Social Construction of Technology, as the social factors are crucial. Despite the fact

that autonomous vehicles could save American lives, plus time and space that could be repurposed for more beneficial use, there is potential for failure if society refuses to give up the wheel. The mistrust of science and technology is displayed across public forums in today's world, and this barrier needs to be broken down in order for autonomous vehicles to succeed.

While driving today is fairly safe, with so many people on the roads, there is bound to be a significant number of human error incidents. For example, drowsy driving is believed to cause 16% of deadly accidents, according to a study run by AAA, and distracted driving caused an estimated 431,000 injuries and 3,179 deaths according to a study by www.distraction.gov (robsonforensic.com 2016). On top of that, according to a study by The Zebra, 20.1% of responders aged 25 to 44 knew someone killed in a drunk driving accident (Covington 2020). Thirdly, Americans sit in more traffic than any other country's citizens. 5 of the top 10 worst traffic cities are in America, which are Los Angeles, New York, San Francisco, Atlanta, and Miami. It is estimated that traffic congestion cost drivers $305 billion in 2017 (mobilitylab.org). Issues like these negatively affect both the society and the car companies that interact with these cars. These statistics could potentially be avoided with the implementation of autonomous vehicles, which would add to the public's view of autonomous cars, helping their success in the end.

A capable autonomous vehicle will never be drowsy, distracted, or drunk. Also, autonomous vehicles could be linked to others so that they know about the environment around them, reducing accidents and traffic jams. It is projected that autonomous cars could reduce traffic deaths by 90% and as few as 5% of cars being autonomous on the road could reduce stop-and-go waves caused by human driving behavior. This has the potential to recover 80 billion hours lost due to driving and congestion, as well as reduce carbon emissions by a possible

40% (Goldin 2018). Lastly, even if there is traffic, the passenger can focus on other, more productive tasks rather than driving. Autonomous vehicles also have the potential to create waves in areas other than driving. For instance, it takes 15% less space to park these cars, as humans do not have to get out after parking. A large portion of land in major metropolitan areas is devoted to parking, and this could free up the land or allow more cars to be parked, which would affect real estate prices. If autonomous vehicles begin to spread, professional drivers will be put out of business. Mechanic shops may start to have to compete with technology-based companies for business on cars, as a lot of the parts will be technologically based. Insurance companies will have to change their car insurance contracts, and urban planning could change, since less congestion means proximity to your place of work will be less important (cbinsights.com 2018). Each of these aspects involve different social groups that will be affected by this technology differently. Professional drivers and mechanics will most likely view the technology negatively, despite its benefits, as it will inhibit the amount of money they can make and change how they live. Real estate brokers may see a potential opportunity, as prices could drop due to repurposing land, or prices could rise in suburban areas since people will be more willing to commute. These few examples exhibit how potentially widespread the effects of autonomous vehicles could be. These effects can be negative for some, but positive for others. Companies need to figure out ways to design and sell their cars so that they are appreciated by the most people and have the most impact.

Battling against these potential benefits is the broader public's mistrust of science and autonomous vehicles. Without society's belief and use, this technology will not be able to flourish the way it could. Many studies have been conducted in order to gauge public feelings on these vehicles. Since the social group being examined here is so large, almost the entirety of the

American population, studies will differ in their results, but many seem to concur. In one study from the Partners of Automated Vehicle Education, 48% of participants said they would never use an autonomous rideshare or taxi, and only 18% of people were excited for autonomous cars to be released (Hawkins 2020). Another study showed that the public is more worried (43%) about these vehicles than enthusiastic about them (39%). Also, it seemed like the participants favored restricting autonomous vehicle policies, including 53% in favor of a person having to be in the driver's seat and 47% in favor of autonomous vehicles-only lanes (Smith and Anderson 2017). On top of this, there is the moral dilemma of the trolley car problem. Should the car save the passenger inside, or save more people that are outside of the car? A recent study showed that 47% of participants believe that more lives should be saved, but 50% of them believe that the passenger's life should be prioritized (pewresearch.org 2019). The social group that is the American public will have many conflicting opinions on this new technology, but it is the car companies' job to design and market the cars in such a way that can break down the obstacles the public's distrust creates.

In my own research, I will be able to create a survey in order to understand potential ways to sway the public opinion to be a positive one. Included in this survey could be potential designs and features and asking if they will change a person's likelihood to use autonomous cars. Additionally, potential policy options could be explored to see what would make people more receptive towards this technology. Although I will not be able to gauge the broader public, surveying people around me has potential to show patterns for the best combination of methods to implement these vehicles so that they have the greatest impact.

Conclusion

Autonomous vehicles have the potential to change many facets of society's lives for the better. Reduced accidents, traffic, and carbon emissions have the potential to help many different social groups and the planet, but the technology also has the potential to negatively impact other groups such as professional drivers. Also, society's distrust of science is battling the potential benefits of the technology. The research here will look to understand people's opinions more and figure out potential ways to change them so that the technology can have the most beneficial impact possible. The goal is to find the best way to construct this technology socially, and make the Earth a better place to live.

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