Social Impact of Autonomous Vehicles and their Future

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring 2023

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

Implementation of autonomous design has increased in the past decade, leading to the creation of semi-autonomous vehicles, with the intent of one day having full autonomy. The current technology is imperfect, and raises safety concerns for those who come into contact with it. Prominent semi-autonomous car manufacturers, such as Tesla, Honda, and Waymo, have reported accidents of car crashes when the vehicle was in its self-driving mode. According to the National Highway Traffic Safety Administration, manufacturers of cars with level 2 autonomy reported a total of 367 crashes in a ten month span (NHTSA, n.d.). Level 2 autonomy corresponds to a level of autonomy where the car can control steering and acceleration, however a human still has to pay attention to the vehicle. On the same scale, level 5 autonomy is the highest level, where the car can drive itself fully, requiring no attention from the human inside. Corresponding to the cases of reported level 2 crashes, this means the system relied on a sensor suite and computational power to control the vehicle with little input from the driver. Most recently, another Tesla vehicle crashed into the side of a firetruck while in self-driving mode (News, n.d.). Tesla has also recalled 362,000 vehicles to fix an issue where the cars would "act unsafe around intersections" (News, n.d.).

Autonomous vehicles are supposed to be safer to drive, as they remove human error, however, there is still a long way to go until they can be considered safer than current vehicles and accepted by society. As stated by a AAA survey, 68% of people reported that they were afraid of fully-driving cars this past year (Moye, 2023). While many are scared, there are services that allow people to ride in a driverless car currently, which allows companies the ability to get test data. In January 2023, Waymo achieved the milestone of 1 million miles driven with only a rider in the car and no reported injuries (World, 2023). There were accidents involving the

vehicles, however 55% of the cases were outside drivers hitting the stationary autonomous vehicle.

With these examples, the main focus of the paper is brought to mind: How does the implementation of autonomous vehicles affect society? In other words, what changes can be seen when autonomy is involved in the transportation network. This question can be better researched by breaking it down into separate questions, with one being: how do current safety issues affect society? How this technology can put people in danger is vital to the discussion of autonomous vehicles, and is inevitable with their addition. The other side to that question is then raised: what are impacts of the autonomous vehicle in their ideal world, where there are no safety issues? By asking this question, a comparison can be made between current and future society. Since autonomous cars are meant to end up being safer, and possibly the future of transportation, it is important to consider the change this will bring to society. The last question presented in this paper follows the first: how will these safety issues be resolved? In order to fix the issues brought about by a new technology, there has to be some resolution, which will ultimately end up also affecting people. These questions make up the general cycle of technology: implement and fix, and then reiterating these processes until an acceptable tolerance is reached.

These questions matter because autonomous vehicles are claimed to be the future of transportation. Companies are pushing for personal autonomous vehicles, autonomous trucks, and other systems that don't require human interaction. If implemented, these systems would most likely change how society functions. However, while people may argue that the technology changes society, and that the reverse is not true, the questions presented in this paper can show that society does in fact influence technology. Society creates the need for innovation, such as

companies that have the need to increase their rate of transportation due to pressure from consumers, so they in turn place pressure on new technology to handle the burden of growth. Governments want to make roads safer, and commuters want easier ways to get around, which leads to interest in autonomous design.

In order to understand the complex social interactions better, I will be using actor network theory. In the actor network theory, there are actors, which can be human and nonhuman, and a network, the platform in which they interact. This approach considers nonhuman entities on the same level as humans, and argues that they change each other. Through this framework, the actors and networks are exhaustive, as they include all the elements possible. With this said, it is not possible to discuss all of the intricate connections in this paper, so I have limited my scope to what I believe are the main actors of the story: Autonomous vehicles, the drivers of those vehicles, drivers of other vehicles, pedestrians (anyone not in a car), the government, and the manufacturers of these vehicles. With these actors, and the transportation system as the network that they interact in, I will reorient my frame when discussing each of my questions so that the most relevant actors are present.

In this paper I will discuss the three questions that make up the overall research question. First, I will discuss current safety issues with autonomous vehicles, how they change society, and how society changes them, as well as the impact that an ideal autonomous vehicle will have on society in tandem. Then I will look at how these safety issues can be resolved, and what the effect of those results can have on society. To aid my discussion, I have conducted a literature review. My main search topic focuses on safety concerns with autonomous vehicles, and from this review I have found scholarly articles that discuss specific problems with autonomous

vehicles, as well as surveys on how people perceive the topic. This methodology was chosen because of its capability to incorporate many different studies, data, and opinions. Autonomous vehicles are very complex, so completing experiments myself would yield little valuable data and would be out of the time scope of this paper, so by compiling other reviews into my work, I am able to better answer my research question.

How do current safety issues affect society? What is the impact on society with an ideal vehicle?

Since their implementation, semi-autonomous vehicles have had a visible impact on society through car crashes. As previously stated, the National Highway Traffic Safety Administration reported 367 crashes in a ten-month period. These crashes were listed because they occurred while the vehicle was using some sort of autonomous system at the time. This points to the idea that while semi-autonomous cars have the capability to drive without a human input, they are still experimental, and require a careful eye to ensure they avoid malfunction. With this said, it can be seen that autonomous vehicles affect society directly by contributing to the number of crashes that occur on the road. When they malfunction, they have the ability to take lives. This of course affects society negatively. When they are working correctly, they can save lives by alerting the driver of trouble or by moving around a hazard. In the actor network theory framework, where the autonomous car, driver, and drivers of surrounding cars are all actors, and the transportation system is the network, the impact of this can be seen. Without the autonomous car, the scenario is the same as a normal car crash: a driver is distracted or runs into some hazard that causes them to lose control of the vehicle and crash into other vehicles or go off of the road. In response, drivers of other cars have to make a decision, either by swerving or braking, or some combination of both. This causes a chain reaction through the network, affecting most of or all the cars travelling in the same direction.

When an autonomous vehicle is placed into the scenario, new possibilities are created. Instead of a driver, there would be a passenger with little to no control of the vehicle. If the autonomous vehicle malfunctions, then the passenger inside will be directly affected, and any other cars or pedestrians that are in the path of the vehicle. If instead there is a hazard in the road, the autonomous vehicle can detect it and avoid it. Therefore, while there is a scenario that an autonomous vehicle crashes, there is also the potential for it to save lives. Widening this perspective to the transportation system of a country as a whole, it is possible for these vehicles to prevent crashes on a larger scale. If human error is removed from the system, and autonomous vehicles function properly on the road, society could benefit from fewer deaths. In terms of traffic, at their best, autonomous vehicles could reduce wait times, as they could react to stop light changes at intersections and cars moving in front of them much faster than humans can. They can calculate the quickest route between locations, and it would be possible to implement technology so they can send signals to other cars and coordinate optimal driving scenarios. Since these vehicles currently have safety issues, the negative scenario is more likely at this time.

In order to understand how these vehicles impact society, we can also look at peoples' current perceptions. According to a summary of the Puget Sound Regional Survey which asked about people's concerns towards autonomous vehicles, a majority said that they were concerned about issues with autonomous vehicles in the following topics: equipment and safety, legal liability, system and security, reaction to driving environment, and the cars performance in a poor weather condition (Kim et al., 2022). Because of the safety issues that are current in these vehicles, people are apprehensive towards them. As summarized in the paper, those with a higher income were not as concerned with autonomous vehicles. This ties into a discussion of who the

primary consumers of autonomous vehicles will be. Autonomous vehicles are expensive, and therefore are more likely to be purchased by those in the upper class, and as prices drop, by the middle class. With the ability that autonomous vehicles have to keep people safe due to added sensors and crash detection, their implementation will affect those who can buy them positively, but will not necessarily benefit those without them. This ties into the economic disparity that is in society, where those with money can benefit and achieve healthier, safer lifestyles than those without. As highlighted by the survey, if people with lower incomes are more concerned by autonomous vehicles, they will choose not to buy autonomous vehicles or take autonomous transportation, and the disparity will continue to increase. As autonomous vehicles continue to become more advanced and safer, People with autonomous vehicles will be in a position that allows them to drive more safely, and have less risk placed on them. People who cannot afford an autonomous vehicle, conversely, do not have access to the same level of safety, which places them at a disadvantage.

In the case of a crash of a semi-autonomous car produced by Uber ATG (Advanced Technologies Group), a pedestrian walking their bike across the road was hit by a vehicle driving in autonomous mode, with a person behind the wheel (BBC, 2020). The company was testing the vehicle on the road, and the driver was distracted from watching the road. While this accident could have been prevented if the driver was attentive, the fact that the autonomous car did not detect the pedestrian to begin with is present. This again raises another concern from society: autonomous vehicles cannot yet always detect when people are crossing the street. Because of this, there have been reports of accidents with pedestrians crossing the street, which negatively affects society and can make pedestrians fearful. This is especially true for people who jaywalk.

For autonomous vehicles, it would be easier to recognize a crosswalk because of the large white strips they are normally accompanied with. However, when people jaywalk, which is frequent especially in cities, there is an increased risk that an autonomous vehicle won't be able to predict if or how a person is crossing the street, which leads to the possibility of an accident. These ideas are proposed in a research paper that uses a spatial-temporal graph convolutional network to predict the intention of pedestrians (Zhang et al., 2022). This network maps signals of objects on a space and time scale, and uses convolution, a mathematical operation, to combine these signals, which is then used for future prediction. As stated by the authors, current prediction technology is imperfect, and leads to safety concerns. It is not possible for autonomous vehicles to stop every time there is a small potential of someone crossing the road, so better technology needs to be made. With their approach, a skeleton frame of a person is created, and sixteen frames are made that show the most likely path that the person will take to get across the street. Even in their trials, this technology, while faring better than an older method known as PCPA, still failed in several instances to correctly predict a person's crossing intention.

With all of this said, this again adds to the current risk of pedestrians being hit by drivers while crossing the street. As related to those in a lower income who may not have a vehicle for transportation, their risk of being in an accident is increased. The same is true for children who walk home from school, or people who walk and bike as a daily commute or activity. Especially in busy cities, the risk of a potential crash is increased, and presents an obstacle in the implementation of these vehicles.

Another safety issue with autonomous vehicles relates to the sensors that are used by cars. A suite of different sensors is used in a general autonomous vehicle that includes infrared, ultrasonic, and cameras that use image detection. With these cameras specifically, the image detection may have problems detecting objects in low lighting, or people in dark clothing. This also pertains to people with darker skin, which contends to the idea that there is a bias towards racial groups. Using the Fitzpatrick skin type scale, a study found that images of people in the 4-6 range of the scale (darker skin tones) showed "poorer performance" than those in the 1-3 range (Wilson et al., 2019). While this study states that it would like to experiment more to continue to understand the bias, it raises an interesting point that these systems could contribute to racial inequality. If autonomous vehicles have a harder time identifying a pedestrian because of their skin color, then these groups will be placed at a higher risk of an accident occurring.

The last safety issue that will be discussed is the prioritization of people and vehicles in the event of a crash. Dr. Fleetwood writes about forced-choice algorithms in the American Journal of Public Health, stating that while autonomous vehicles have the ability to prevent crashes, they will inevitably end up in one, and they have to prioritize what to hit and what to avoid (Fleetwood, 2017). This raises the topic of ethics as it pertains to autonomous vehicles. When presented with a choice, these vehicles have to decide what to do without human interaction. In the actor network theory scenario previously mentioned, when an autonomous vehicle needs to avoid a car crash, it can swerve around the car. If there are cars in either lane, however, the question is raised of which car the automated system should choose to hit, and whether it should prioritize the driver, or the outcome that saves the most lives. These ethical dilemmas will directly affect society. The case is raised that in order to make a decision, these

vehicles must have the ability to discern some order of what to hit. This concern is compounded when taking other factors into consideration such as bias in the people who make the algorithms, and also possible legal responsibility of the car manufacturers when the public gets injured by one of these vehicles. Therefore, the priority list created will impact anyone around an autonomous vehicle: drivers of other vehicles, pedestrians, and cyclists. If people are made aware of the priority list, and the mode of transportation that they used is near the top of the list, it may make them scared to drive on the street or walk on the sidewalk.

How will these safety issues be resolved?

Since autonomous vehicles are relatively new, there is uncertainty on how to resolve the issues that have been presented. As previously discussed, there is an ethical dilemma concerning crash prioritization. While there is not a clear resolution, there are certain algorithms that can be used to help reduce the need of the car to run into another vehicle or person. One of these methods, known as Lexicographic Optimization based Model Predictive Controller (LO-MPC), prioritizes obstacles and constraints in a way that allows the vehicle more options to avoid these priority orders (Wang et al., 2020). In the article, they discuss a scenario where there are two cars on the road, one being an autonomous vehicle and the other a regular car, as well as a truck that is switching lanes, but doesn't see the autonomous vehicle. With the traditional decision-making algorithm that they used as a control, the autonomous car prioritizes the truck higher than the other car, and switches lanes to avoid the truck, therefore hitting the second car. In this scenario, there was a shoulder that the car could have chosen to switch into instead, however, as this was not legal, the car did not prioritize this first. With the LO-MPC approach, however, the autonomous vehicle chooses to break the law, and move into the shoulder to avoid the truck, which also prevents a crash from occurring. Newer algorithms like this are strong progress

towards solving this ethical issue. From a societal standpoint, knowing that these priorities are possible would also most likely help ease people's concerns that autonomous vehicles could potentially prioritize them as the first forced-choice in the crash.

In terms of wealth disparity, the creation and iteration of autonomous vehicles will help reduce the price. If they become the norm, then it will be similar to the current car market today. That being said, those in poverty or in the lower class have problems with affording vehicles from the current car market. One way to alleviate some of this concern would be investing in group autonomous transportation, such as buses or ride services that can be used at little or no cost. Looking at sensors and the possibility that they contribute to racial inequality, more testing and research can be done to find new methods that have no bias. There are many different types of sensors that specialize in certain lighting conditions, so working on implementing a wider range of sensors could also help.

One of the best ways to ensure that safety issues are resolved is through careful and thorough testing. In order to ensure that this testing occurs, and that it occurs correctly, regulations can be placed by the government onto these companies. The government, as an actor in the transportation network, has the ability to define a legal autonomous vehicle, and make sure that car manufacturers match these standards. As stated in a synthesis of autonomous vehicle guidelines, "forming a single regulatory board to represent the local authorities would be beneficial and would ultimately ease the AV testing and deployment" (Abu Bakar et al., 2022). In other words, if regulations on how vehicles are tested in different locations are kept consistent, it will be easier compare them overall and create a standard performance level for all of the

vehicles. With this, social concern will continue to be alleviated, and more people would be in less danger during testing of these vehicles.

Conclusion

There are many safety issues with autonomous vehicles currently, and these issues have a negative impact on society. Malfunctions put other drivers, cyclists, and pedestrians in danger in busy cities and on highways. The sensors and algorithms that are used have potential biases and are not able to function properly at all times. Ethical dilemmas are present in the case of a crash, and can lead to consequences that people find unfair. In the view of the future, autonomous vehicles have the potential to impact society positively. More lives could be saved by a reduction in crashes. Cars and transportation systems could function better, leading to faster commutes and the potential for happier lifestyles.

Overall, the field of autonomy is growing, and we are not close to achieving a fully autonomous system. Until this occurs, human error will be prevalent in design, and will lead to safety concerns. In order to minimize this, proper testing and regulations must be enforced. The technology has to be equally accessible by everyone, and must also have no bias, especially in the scenario of a crash. There are new algorithms and technology that can help prevent these issues, however there is still a long way to go until these improvements are fully realized, and society will continue to be impacted as a result. This paper is applicable to people who want to join the field of autonomy, as they should always consider the issues that come with new technology. This paper is not an exhaustive list of issues, and more research can and should be done to continue the efforts of resolving problems with autonomous vehicles. New research questions can also be raised such as what level of responsibility car companies should have when

their vehicles cause a crash, and how we should go about prioritizing objects and hazards in forced-choice events.

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