THE IMPACT OF AUTONOMOUS TECHNOLOGY ON SAFETY PROTOCOLS

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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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PREVENTION OF AUTONOMOUS VEHICLES

Even before the creation of cars, the concept of a self driving vehicle had already existed. In fact, “the first self-driving vehicles were ships” which were invented centuries before cars and used the forces of nature to move (Townsend, 2020, para. 1). Once cars had been developed, humans and engineers hoped to apply this same idea to the vehicles. The luxury to reap all the benefits of the car without actually having to put in the effort and mental concentration to learn and operate it was a dream for many. However, the technology when cars were first introduced was not even close to being capable of such tasks. This led to autonomous vehicles being an abandoned idea for decades as society and companies were more “invested in electric” cars along with improving other novelties, leading to self driving software to be put on the backburner (Heller, 2019, p. 25). However, with the rise of computers and the digital age, the technology and software have advanced to a point where developing such a vehicle is extremely probable and some prototypes even have “million[s of] miles of fully-automated driving on public roads” along with traditional cars (Adams, 2018, para. 1). While society may not have noticed it, “advanced driver-assistance systems” have been slowly advancing each year to “help drivers park, stay in their lane or avoid objects” and companies are trying to improve and combine these systems to a point of fully driving the car itself (Nicola, 2021, para. 1). With advancements in our vehicle’s designs, assistance systems, and software, this dream of a fully hands free self driving has become closer to a reality with each passing day.

While the rise of autonomous vehicles seems like a widely beneficial advancement for society, the main concern from consumers is the safety of the passengers and civilians. The technical project of developing an autonomous driving simulator under the guidance of Tomonari Furukawa and Yuxiang Guan along with group members Anne Forrest, Johnny Grant,

Chet Kleppin, Mosed Saroor, and Casey Welch, helps promote a solution to directly combat this issue as the relationship is tightly coupled. Society's safety and other concerns will be investigated *via* the social construction of technology (SCOT) framework pioneered by Trevor Pinch and Wiebe Bijker (Bijker, Hughes, & Pinch, 1987; Bijker & Pinch, 1984; Kline & Pinch, 1999). “Given the vast amount of car accidents that are due to human error”, the self-driving car removes this aspect and theoretically should be safer on the roads (Müller et. al, 2020, p. 1550). However, because self-driving cars are still not widely adopted, it is hard for consumers to justify purchasing such a vehicle and putting their lives at risk without fully understanding the technology.

This is where the driving simulator comes into play, as it allows for consumers to try the product and test it within a real world scenario without being put in danger. The simulator also has an alternative purpose of teaching the current software in self-driving vehicles by being able to run through real scenarios thousands of times at once in order to track rates of failure and other causes that may affect the real life vehicle. Autonomous driving simulators fulfill these two purposes, ensuring that when the eventual rollout of self-driving cars comes around, consumers will not be afraid for their safety. Looking deeper into the question of safety concerns for these vehicles also leads to questions about media portrayal and human psychology as a whole. While on the surface, society seemingly refuses the adoption of autonomous vehicle technology because of the dangers it possesses. When looking deeper into the root of the issue, is it actually a culmination of issues including human nature’s inability to adapt, slow regulation, difficult communication between groups, and media manipulation which leads to society unwilling to try this technology? Media portrayals of these cars are also either seemingly too good to be true or portray them as dangerous machines. While these misleading statistics go both ways and cater

towards both those for and against the autonomous car movement, being misled causes more "troubling arguments against self-driving cars" leading to more pushback from those previously supporting the technology (Zipper, 2022, para. 22). There are many reasons for the lack of adoption of autonomous vehicles from the inherent risk to simple human behavior and in order for these cars to develop onto public roads, manufacturers and companies will need to find a way to bypass the culmination of all these potential problems.

HOW AUTONOMOUS DRIVING AFFECTS THE SAFETY OF OUR SOCIETY

The problem of autonomous driving is not necessarily the actual vehicles and the software they use. It is the lack of trust that the public has for this technology because of their novelty and the inherent risk that comes along with new products. While many are excited about the positive outcomes that the media portrays these vehicles bringing such as reduced accidents and traffic congestion, and environmental benefits, they also bring upon new risks related to safety, security, liability, and regulation (Anderson et al., 2016). If this concern continues without engineers showcasing the safety capabilities of the technology and persuading the public, it is a possibility that these self-driving vehicles will not be able to be commonplace among the roads anytime soon. The software's sophistication also depends on the amount of other autonomous vehicles on the roads, meaning the less autonomous vehicles there are, the less communication there is between the software leading to higher potential for danger. In a more extreme case, if not enough people will have the faith to become early adopters, this decades-long project will never reach takeoff as depicted in Figure 1 on page 4, resulting in the loss of millions of dollars and thousands of hours in research.

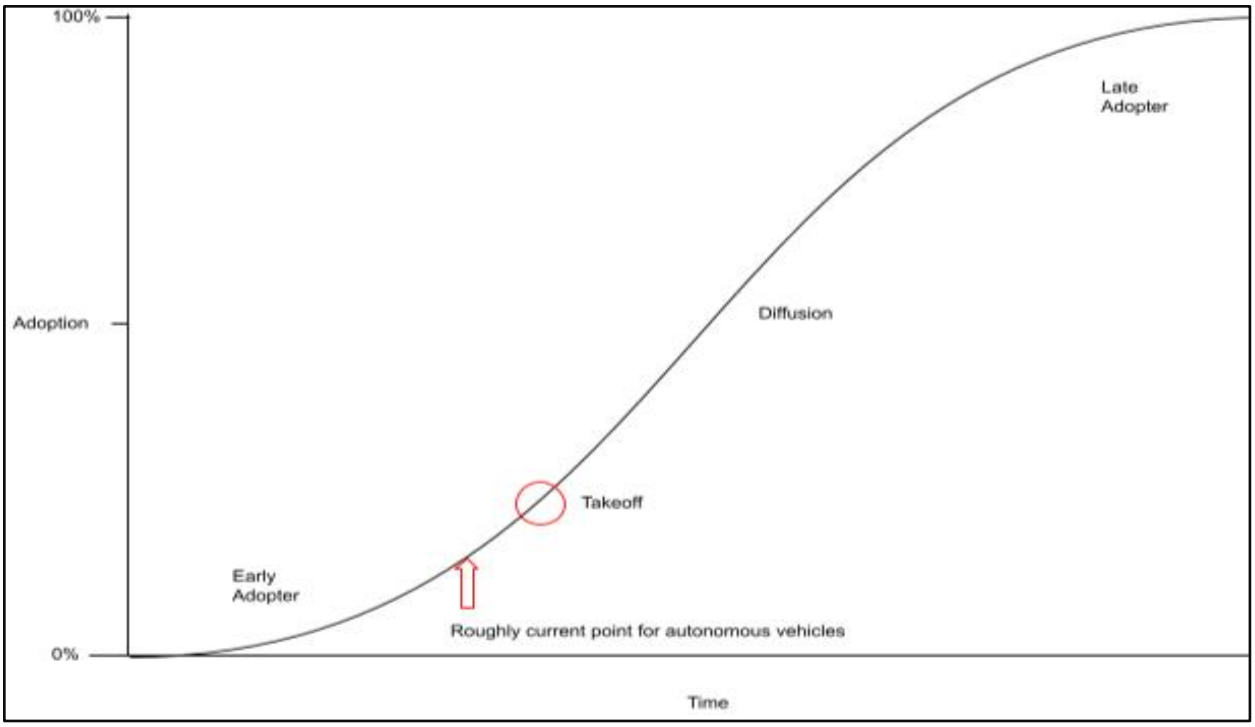

Figure 1: Diffusion curve. Depiction of diffusion curve and the current location of autonomous vehicles in the S-curve. (Adapted by Lin (2021) from Rogers et. al, 1996).

Because the main concern is the lack of trust in the systems, simulators have been created in order to represent a real life scenario within a safe environment. Simulators also allow for companies to take data points on just how safe a user's driving truly is. It can then be compared to actual self-driving vehicles data which helps determine the safer form of traveling. Simulators provide quantitative data and evidence in order to prove the effectiveness of self-driving software which in turn helps ease the general public's distrust of the reliability of these vehicles. Allowing for the simulator to take in data from humans that represent good driving habits also help the AI learn what choices to make in unpredictable scenarios. Teaching the software is essential as human drivers are "inefficient, dangerous", and unpredictable, having roads mixed with both manual and autonomous vehicles may confuse the computer leading to safety implications (Both, 2020, p. 103). It is also essential for companies to use this data and technology to further their own software as quickly as possible because the competition to build

self-driving cars has spread world-wide (Townsend, 2020). Many well known companies have started to take part in this race such as Uber, Google, Tesla, and those are just the largest in the United States (Metz, 2017, para. 2). This increase in competition has resulted in many large companies improving their software at an astounding rate and without these simulators, a company may lose traction to others.

While the obvious concern of safety is the physical danger these vehicles pose, digital safety is just as important as much of the information of driving is going to be held within the software. Hackers having access to "vehicle records… [along with] personal information" leaks information that may not be consensual (Collingwood, 2017, p. 35). This potential attack on the digital safety that the users have has to be addressed by the software teams of these automotive companies. While simulators are not able to represent our digital safety being secure, users will have to trust in the software's security to keep their information safe or companies will need an alternative method to show that their software is unbreachable.

LEGAL ISSUE AND MANUFACTURING DECISIONS WITH AUTONOMOUS DRIVING

Questions arise for lawmakers when it comes to driverless ethics and regulations. This is because the line for responsibility becomes more blurred when failure in the software occurs. Advanced driver-assistance systems (ADAS) are already known for being a hot topic in relation to the law as one of the main pitfalls for failure is that there is no clear cut person to place the blame upon. In regards to driverless ethics, Nicola (2021) explains:

> Fatal crashes involving ADAS garner a lot of attention [and] driverless ethics are a tricky parasubject, given that robot cars would have to make life-or-death decisions in some scenarios -- like choosing which person to crash into if a collision can't be avoided. (para. 5)

The dilemma that "while self-driving cars could potentially reduce the number of accidents, not all [fatal] accidents can be avoided" does not only affect lawmakers, but every party involved (JafariNaimi, 2017, p. 304). While future laws and regulations may see a passenger in an autonomous vehicle accident as innocent, personal values and morals may be compromised with guilt weighing on the victim, even though they were not in control of the situation.

In order to help prevent this issue, experimental ethics come into play by helping engineers determine the ideal decision the software should make in an ethical dilemma scenario of saving the passenger or saving the majority. Bonnefon et al. describes experimental ethics as a mode of ethical inquiry that seeks out common principles based on how people respond to ethical cases. Because these autonomous vehicles will inevitably be placed into the classic trolley problem when the software has to make a choice of who to save, engineers will have to decide beforehand what the vehicle should do (JafariNaimi, 2017). However, JafariNaimi explains that there will never be a consensus on whether the algorithm will always prioritize the majority of lives at stake or if the system will always prioritize the safety of the passengers. The reasoning behind it is that people will tend to choose whichever option benefits them the most. This leads to "systemic biases and power structures" as those that are affected the most "have the least power in deciding its makeup" as car manufacturers and sellers can give the consumer/driver the option of choosing the algorithm that either protects them or the majority of people (JafariNaimi, 2017, p. 314). Lawmakers have to form new restrictions and exceptions for these vehicles and have to implement rules for companies to prevent discrimination. Having to work through all these issues leads to delays which prevent the autonomous software from being put onto the market. Communication between engineers and lawmakers will take time for explanations to fully be passed through in order to make informed regulations.

Looking into the future, will society still have this same argument over whether autonomous vehicles are safe enough for the roads, or will we expect to see the opposite question on whether traditional driving should still be allowed for the same reasons of safety concerns? Autonomous cars at the moment are already advanced enough to be able to drive on their own within street legal roads but it is the laws and restrictions against fully driverless cars that are preventing the software from being shipped out. Müller (2020) questions if manually driven cars should eventually be outlaws as in the future, "autonomous cars are likely to be much safer than manually driven cars" (p. 1552).

IS THE PROBLEM THE CAR'S SAFETY, OR IS IT HUMAN BEHAVIOR?

Naturally, human nature is not fond of change for a multitude of reasons. The loss of control and excess uncertainty are two main contributors to this effect and is why humans avoid drastic change in their lifestyle (Kanter, 2012, para. 2). These self-driving cars cause both of these issues in the human psyche which is why there is immense pushback from certain actors in society against the use of autonomous vehicles as our daily drivers. There is also a "lower trust in" autonomous vehicles, and drivers want them "to be 4-5 times as safe" as their vehicles currently (Liu et. al, 2020, p. 700). This is because of the previous statement as drivers are losing their control over the vehicle so that they want the safety to be compensated drastically. Simulators help ease the other issue that society has against these vehicles as they help represent the expectations that users may have when riding in an autonomous vehicle. The immersed experience should be able to help them understand the safety precautions that these cars have and will help convince them to switch over.

MISLEADING MEDIA

From marketing misinformation about "percent[ages] of crashes [that] are caused by human error" to the environmental benefits, automakers have leveraged this information in order to hype up and push forward a potentially dangerous product (Zipper, 2022, para. 9). While it is true that humans make many errors on the road, most are simply a result of external factors such as poor road designs, environmental conditions, and blind spots. These cars will be able to fix human impediments such as drowsiness behind the wheel, but until the system is perfected by experience on the road, it will "inevitably lead to mistakes that human drivers wouldn't make" such as struggling to identity the color yellow in signs and pedestrians (Zipper, 2022, para. 11). Companies also make the software out to be exceptionally sophisticated, but there is still a struggle to have the software machine learn all aspects when driving such as differentiating animals, signs, people, and the roads which tend to be conveniently left out of demonstrations for the media (Siddiqui, 2019). Removing human error from the equation does not perfect the driving experience as relying on a system that is 99 percent accurate will still return errors from time to time.

The benefits in safety and the environment are the two main selling points for autonomous vehicles. Zipper argues against both these points that they are not as appealing as they appear to be. These cars rely on machine learning which "struggles with things it hasn't seen before", so until the technology has experienced the area, placing these cars within populated areas endangers all parties involved (Zipper, 2022, para. 12). Automakers are also rushing to develop these cars and begin profits, but Zipper questions why not focus on other driving assistance systems like automatic emergency braking which have already proven to increase safety but have yet to be standardized in all production vehicles.

For the environmental benefits, it is no question that electric autonomous vehicles are much more efficient for the atmosphere. The problem is that when the chore that is driving is removed, people tend to use their cars more often. An experiment was conducted where individuals were given a chauffeur to replicate the experience of an autonomous vehicle which resulted in the individuals traveling 83 percent more miles than when driving themselves. Charging these vehicles and manufacturing them expands the "vehicles' total carbon footprint" which in turn still hurts the environment (Zipper, 2022, para. 20). Because the media will not give out unbiased statistical information as it would hurt profits, it leads to potential customers refusing to risk their safety which in turn deters people from autonomous vehicles.

SOCIAL CONSTRUCTION OF TECHNOLOGY

The SCOT framework pioneered by Trevor Pinch and Wiebe Bijker, represented by Figure 2, brings about various groups that affect the development of autonomous vehicles because of their own values and expectations (Bijker, Hughes, & Pinch, 1987; Bijker & Pinch, 1984; Kline & Pinch, 1999).

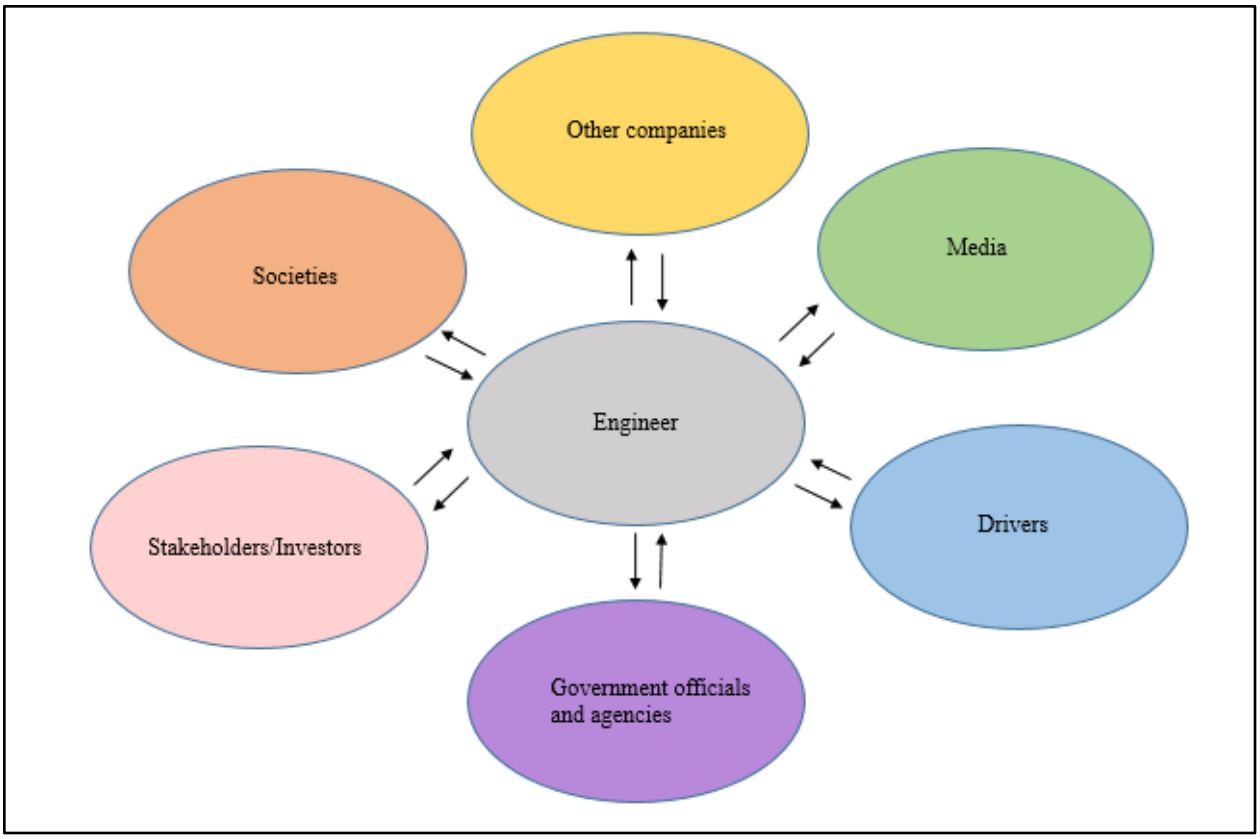

Figure 2: Autonomous driving SCOT model. The engineer negotiates between each social group to enable the incorporation of each group's values and goals. (Adapted by Lin (2021) from Bijker & Pinch, 1984)

Each group communicates their wishes for this technology to automotive companies' engineers which help them grasp an idea of what a final product should entail. This helps create an idea and allows the engineers to be able to work towards and create a resulting product that will take into consideration aspects of all group's concerns. Some groups may believe in safety above all else, while others prefer a balance of functionality and safety in order to maximize sales and "shareholder return" (Zipper, 2022, para. 26).

While it may appear at first glance that the reason for the lack of advancement on these systems is purely a safety concern, it also has many issues pertaining to the law, human behavior, and media manipulation that delays these car's production. All in all, these cars have the potential to provide an immense amount of productivity and convenience to each group within

the SCOT model, but “ripple effects” of the media, “more work” for the government, along with “excess uncertainty” by the users leads to blockage of production for the engineers (Kanter, 2012, para. 3-9).

IMPLICATION OF SAFETY IN AUTONOMOUS DRIVING

Safety is one of the most important, if not the most important aspect when developing technology. It is the duty of engineers to prioritize the safety of the users of the product in development above all else. However, at what point does over cautiousness hinder development of products that have the potential to drastically change and improve the quality of life for millions of people? Engineers should be providing a safe and reliable product but when human nature resists change too much and expectations become too high, products will be dropped even when they are satisfactory enough to be rolled out.

While the media should be biased in giving opinions to warn society about possible pitfalls that a new technology may have, misleading statistics ruin the possibility of allowing the audience to create an informed opinion for themselves. Although their goal is to spread their own values to others and to profitize off of eye-catching stories and statistics, it is detrimental in the long run for development of large scale projects. It may not be seen as significant, but delaying development can lead to investors pulling out and groups unaffiliated themselves with the product in turn possibly ruining a project.

Finally, the bridge of communication between each group within SCOT in Figure 2, and the engineer needs to be seamless. Media cannot be warping the values of the engineers and automaker companies but also cannot make society seem as if they are too resistant to autonomous vehicles as it breaks a line of communication and clarity between groups. Communication between engineers and lawmakers also needs clarity as each group has jargon

pertaining to their field. A bridge needs to be created in order to facilitate faster communication in order to expedite processes.

For future work, further research can be done on these four topics of safety, laws and regulations, misleading media, and human behavior. However, there are many nuances in the morals that each group from SCOT has with autonomous vehicles so research into more explanations on what is either driving a group or preventing a group to either support or defend autonomous vehicles will be an interesting study. Autonomous vehicles have been regarded as the next technological change that will drastically change human lifestyle, but these potential blockers could prevent this revolutionary technology from being adopted by the masses.

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