The Intersection Between Societal and Ethical Laws and the Use of Autonomous Vehicles (AVs)

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ABSTRACT

This report discusses a variety of societal and ethical laws with respect to autonomous vehicles and their gradual deployment across the United States of America. With companies like Tesla deploying weapons that've already being legally faulted with being the cause of tragic road accidents, a deeper analysis of the timeline for deployment is imperative. This report will present the evolution of autonomous vehicles, societal challenges they've faced while operating, ethical challenges faced in developing optimal AV algorithms and software, as well as a synopsis of how U.S. citizens feel about these weapons. The findings of this research may suggest the following: most U.S. citizens feel safer inside of an AV as opposed to outside of one, most U.S. citizens feel that AVs pose great threat to their communities, further deployment of these vehicles will require a revamp of traffic laws and regulation, and manufacturers will not take accountability for faulty vehicles.

Categories and Subject Descriptors

I. Computing Methodologies (CM)
I.2. [**CM**]: Artificial Intelligence
I.4. [**CM**]: Image Processing and Computer Vision
I.5. [**CM**]: Pattern Recognition
I.6. [**CM**]: Simulation and Modelling

General Terms

Autonomy, Vehicle(s)

Keywords

Autonomous Vehicle(s),

1. INTRODUCTION

Throughout history, we've seen vehicles from the first vehicle invented in or around 1886 by Carl Benz, to now modern supercars with self-driving capabilities, manufactured by the hundred thousand by industry leaders such as Tesla, Waymo and Lyft [1]. Throughout the course of this research paper, I will be referring to self-driving vehicles as 'autonomous,' for clarity purposes as the information presented in the online sources, lawsuits and other scholarly articles use this same language.

Let's preface our talk about autonomous vehicles (AV) with some historical facts provided in article, *50+ Car Accident Statistics in the U.S. & Worldwide* by The Wandering RV:

- *On average, there are 6 million car accidents in the U.S. every year; roughly 16,438 per day*
- *Over 37,000 Americans die in automobile crashes per year; roughly 90 per day*
- *Road crashes are the single greatest annual cause of death of healthy U.S. citizens travelling abroad*

While these statistics are not exclusive to autonomous vehicles, they accurately address the issues at hand that the world at large is currently facing. This issue is the rate of human danger as it related to automobiles, whether autonomous or human operated [2].

Since the 1950s, the National Highway Traffic Safety Administration (NHTSA) has worked to establish 'Five Eras of Safety' as well as Six (6) Levels of Automation. These levels of automation range from Level 0 to Level 6–Level 0 being a vehicle that a human driver must operate and Level 6 being a vehicle equipped with an Automated Driving System (ADS) enabling it to operate itself under all circumstances [3].

The first driverless vehicle was actually developed in the 1990s in the Netherlands. The vehicle was called the ParkShuttle, owned by the Rotterdam-The Hague metropolitan area (MRDH) and operated by the Connexxion bus company, designed to fulfil the last mile transport between metro station Kralingse Zoom and businesspark Rivium [4]. The initial idea for this vehicle was to create a vehicle that could use artificial reference points (magnets) embedded into the road to verify a specific position. There were only two successful pilot projects for this vehicle—Schiphol Airport (1997) and business park Rivium (1999). In both, the ParkShuttle carried actual individuals of the general public, billing the vehicle as the first autonomous car known to man. The vehicle did not

feature a steering wheel, pedals, nor a safety driver or steward.

2. METHODOLOGY

The methodology for this study will be a combination of a literature review and a smaller subordinate study via user questionnaire conducted by the author.

2.1 Literature Review

The study will address and discuss the current state of autonomous vehicles, lawsuits filed regarding them, accidents, their positive and negative impact, the underlying algorithms and ultimately how they will change and shape the way we value transportation. These literary sources will only provide a foundation and basis for my hypotheses which will ultimately be proven through the user questionnaire.

2.2 User Questionnaire

A user questionnaire will be leveraged to support claims made in the outsourced scholarly articles, online sources, public lawsuits and headlines regarding autonomous vehicles. This questionnaire features nine (9) questions around the premises of community type, the value of different lives and the individual's views on whether these vehicles seem safe.

The target audience for this questionnaire will be left miraculously generic as the findings should not be subjective to any one group, however, we've come up with the following five audience groups to target which are independent of both race and gender:

Students — Students offer a valuable perspective on technology, whether they're considered old or young. These individuals are typically required to learn ethical behavior using technology and relate it to the world they live in.

Elderly — The stigma on the elderly is that they're not very receptive to change and simply do not understand the next phases of technology; this will either become evident or disproven.

Parents — Parents offer the unique perspective of making decisions by first considering what the outcome may be if their child were the one victimized.

City residents — Currently, only 16 states have enacted deployment of autonomous vehicles – most of which are entities with miles of free, unoccupied land. City residents are subject to faster, more populated environments and may offer a different perspective.

Young adults — Young adults (ages 18 to 44) have the edge for technology and may be more aware of how safe or dangerous these vehicles may be when integrated into everyday environments. These individuals make up some 40% of the entire United States population at large [5].

3. IMPACT

According to article, *Benefits of Autonomous Cars* by Thales, autonomous vehicles are able to change the world of transportation in many significant ways that humans have struggled with as operators of these vehicles. The main seven (7) benefits that were outlined were [6]:

- *90% reduction in traffic deaths*
- *60% drop in harmful emissions*
- *Eliminate stop-and-go waves by 100%*
- *10% improvement in fuel economy*
- *500% increase in lane capacity*
- *40% reduction in travel time*
- *Consumer savings of approximately 6.5B USD*

Since their early deployment, autonomous vehicles have consistently proven to be positively impactful to communities and frequent public transportation users. The thought here is to deploy these types of vehicles onto public roads in order to prevent human error. Statistically, this has been proven to be the case, however not many Americans feel safe with these vehicles being deployed onto their roads, nor would they even opt into using such a service.

4. LAWSUITS

Should competing companies like Waymo and Lyft take into consideration how detrimental an incident can be, they're more likely to release product once it has undergone sufficient testing and supervision by law experts, engineers, physicists and citizens who will ultimately be potentially victimized.

Here we will address some of the lawsuits Tesla has faced and how they've affected the company and world of AV. While Tesla has faced tons of lawsuits from owners filing class-action lawsuits due to "exaggerating capabilities to customers," to specific models of this vehicle being notorious for malfunctions and accidents, there still seems to be a level of trust that Tesla customers have. Not only does a blind trust in the vehicle affect the operators, but it

also affects other individuals whether they're pedestrians, passengers or unfortunately in many cases, mourning family members. In this section I will detail a few of Tesla's most important legal cases that may help provide clarity as to the current state of these vehicles.

Obviously, the intent of an autonomous vehicle is to reduce error and to provide a stable, more trustworthy service than ever before. While this remains the objective, this has not always been the reality, specifically considering some of the lawsuits Tesla has faced, starting in 2016; let's take a look.

4.1 Dean Sheikh et al v. Tesla, Inc.

On April 19, 2017, owners of Tesla vehicles filed a class-action lawsuit against the company. The suit was on the grounds of the company consistently "exaggerating the capabilities of its 'Autopilot 2.0' to customers." It suggests that buyers are perhaps unknowingly becoming test subjects for "half-baked" software, essentially turning buyers into beta testers for the Autopilot feature [7].

The manufacturer allegedly sold the $5,000 feature as an update option for early investors interested in the feature to later get the update over-the-air as a software update once it was finished and tested. Complaints filed against the company once the update had surfaced stated that the features were "completely inoperable" [8]. Tesla didn't put up much of a fight in this legal battle against the class, causing the suit to result in a settlement by the defendant. The settlement included an agreement to pay all class members who purchased the $5,000 feature, a compensation package of between $20 and $280 [8]. This also ultimately resulted in Tesla investing more than $5 million in a new settlement fund, which would be used to cover attorney fees and other pertinent legal costs.

According to AV experts, this case is now closely watched in automotive communities as Tesla continues to spearhead the self-driving movement and remains the industry leader [8].

4.2 Huang v. Tesla, Inc.

On March 23, 2018, a victim of the name of Wei Lun ("Walter") Huang, was killed as a direct result of a car accident in Santa Clara County, California [9]. Huang owned and at the time of the incident, drove a 2017 Tesla Model X. Huang was reportedly travelling on US Highway 101, when his vehicle "smashed into the safety barrier section of a divider," separating carpool lanes from the off-ramp on the driver's left-hand side. In June of 2018, the accident was attributed to a navigation malfunction made by the vehicle's Autopilot feature, discovered by the National Transportation Safety Board (NTSB).

Huang was himself, a software engineer and reportedly, had "doubts" about the performance of the vehicle's capabilities and features. According to the Huang family, Wei's Model X "lacked safety features, such as an automatic emergency braking system." It was also noted by the family that such features come standardly available on much less expensive vehicles, which was leveraged as one of the critical pain points of the family's argument against the manufacturer.

While the *Huang family vs. Tesla Motors (TSLA)* suit accuses Tesla of defective product design, intentional and negligent representation, false advertising, and many other allegations, the state of California was also sued in a separate case. This separate suit was on the grounds of the state's department of transportation (Caltrans) failing to replace a crash attenuator guard which would've absorbed the impact of the collision [10]. B. Mark Fong, a lawyer of the family said to *Bloomberg*, "Huang died because Tesla is beta testing its Autopilot software on live drivers." Though this could seem quite speculative and spiteful, it may hold some truth as Tesla has created a history of incidents with live drivers. Still, to this day, Tesla spokespeople refuse to comment on the suit, instead pointing to the company's public statement which stated that "a damaged safety barrier contributed to the severity of the crash" and that Huang had "about five seconds of unobstructed view," in an attempt to absolve the company of any true responsibility [11].

4.3 Banner v. Tesla, Inc.

On March 1, 2019, there was yet another victim of an autopilot malfunction, this time caused by the Tesla Model 3. 50-year-old Jeremy Beren Banner was reportedly travelling on a Florida highway when he decided to enable the Autopilot feature, reaching a speed of 68 mph. Do note that this [68 mph] was 13 mph above the posted speed limit, which will become an important topic later on. Just within ten seconds of enabling Autopilot, the vehicle managed to collide with a nearby tractor-trailer, tearing the roof off of the car, which traveled another 1,600 feet before completely stopping [12].

The NTSB, in this case, found two interesting things in their investigation of the accident: (1) Banner's hands weren't detected on the wheel for the last eight seconds before impact, and (2) Tesla's instructions tell all drivers to keep their hands on the steering wheel. These findings have made it quite difficult to pin the blame on either the operator or manufacturer. In many arguments made by the media, this incident has parallels with a similar incident in 2016 that also claimed the life of another Tesla driver. Although, this 2016 incident was regarding a different distribution of the Autopilot software, it *did* occur on a Florida

highway, likewise failing to sense a tractor-trailer, causing the victim's Model S to collide with the side of it, killing him. In this case, the victim, Mr. Joshua Brown, was reportedly "watching a movie" just before the crash, not paying attention to the road. This caused Tesla to be absolved from any legal responsibility, thus causing NTSB to not fault Tesla [13].

5. THE ALGORITHM

For the average person hearing the term "self-driving vehicle," it might sound like a bit of a magical black box that does something, with no true explanation of *how*. From the 1990s to now, almost 30 years since the inception of the ParkShuttle which leveraged "low-cost video cameras" and stereoscopic vision algorithms, autonomous vehicles have become much smarter and intelligently crafted.

In most of the accidents already caused by Tesla's Autopilot feature, the vehicle's algorithm and sensors together were unable to detect and anticipate the collision. AV crashes include some relatively easily predicable cases, in which occupants are killed in a collision and or pedestrian(s). In other, more frightening cases, the AV's algorithm is unable to detect a blocked off intersection for pedestrians to cross or similar, putting even more lives at risk. This directly relates to the questionnaire study outlined in the literature review and MIT's research around whose life becomes most important in the time of such an accident.

In this section, I will be outlining four of the most important components of the AV algorithm, which are ultimately responsible for its vision, sensing, detection and decision-making processes.

5.1 Regression

Regression is one of the most common types of algorithms used to predict events that the vehicle is tasked with adjusting to in order to keep both its passengers and other drivers safe. The three main types of regression algorithms seen in AVs and self-driving cars in general are Bayesian regression, neural network regression and decision forest regression [14].

At its core, a regression algorithm is just an algorithm that predicts some output value based on input features from the data that it receives. This is often done by *training* data with some known input and output, much like you'd see in any other type algorithm under the family of Supervised Machine Learning algorithms. What makes regression so useful is the fact that it allows you to test for specific variables within a hypothesis; it shows a clear relationship between one dependent variable and independent variable, which are then compared on different scales.

According to *How Machine Learning Algorithms Made Self Driving Cars Possible,* these algorithms "use repetitive aspects of an environment to form a statistical model" between some base image and relative positions and locations of objects in the image. This type of modelling is essential for image detection and sampling and learning about different objects without really requiring much human intervention or help.

5.2 Pattern Recognition (Classification)

Pattern recognition, often referred to as *classification*, is yet another key concept in how AVs operate. Before data obtained by an advanced driver-assistance system (ADAS) for categorization or classification, information regarding its either usual or unusual pattern must be unpacked and analyzed. This step within the algorithm focuses on filtering and combining line segments between edges identified within the image to constitute something as an object, and perhaps what the vehicle should do now that it has identified the object.

The main way in which the vehicle is even able to collect data about an image and essentially "see" things as a human would, is through some type of sensor such as a Light Detection and Ranging (LiDAR) sensor which uses light in the form of a pulsed laser to measure range to Earth [15].

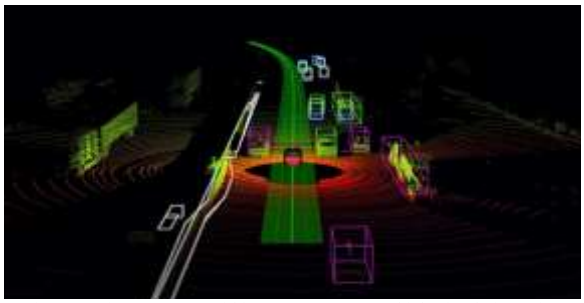


Figure 1. LiDAR sensor within an autonomous vehicle simulation using laser pulse to detect objects.

LiDAR sensors are often referred to as the "eyes" of the AV and can sometimes be spotted atop the vehicle, continuously rotating to detect new objects and analyze new images. This data is used by the AV's internal computer to then make decisions about what to do next, whether classifications were correct based on the trained data, and even whether to signal the driver to do something because there may be a sensor malfunction.

5.3 Cluster

Cluster, though less popularly discussed, is also an important technique for helping the AV to safely operate. These algorithms essentially excel the process of discovering structure within the data points [14].

This becomes essential when perhaps the ADAS cannot properly extract images from the sensors and or identify smaller, more fine objects in a specific frame.

Without cluster, algorithms are not likely to perform above 80%. This is because without cluster, the algorithm may have a difficult time handling low-resolution images with few data points. At a high level, cluster uses centroid-based and hierarchical modelling approaches which are able to essentially classify and categorize data points that share commonalities based on some centroid that connects them.

5.4 Decision Matrix

Decision matrix algorithms are used for decision making of the AV [14]; it's essentially a data-driven solution for decision making for robots, just as the human thought process and analysis is for humans. One of the most difficult challenges to overcome for autonomous vehicles has been the art of real-time decision making, which then addresses the decision matrix. This matrix is practically just a table or list of values in rows and columns that allows an analyst to systematically identify, analyze, and rate the performance of relationships between information.

6. CHALLENGES

Four of the main challenges that autonomous vehicles have faced are (1) adjusting to speed limits, (2) adjusting to weather, (3) implementing an insurance coverage plan amidst an incident, and (4) implementing a plan to handle traffic violations/infractions on the road.

6.1 Speed Limits

Speed limits are –by law– posted on traffic signs on almost each and every street in the United States. Whether the vehicles are taught to adjust to the different legal speed maximums based on prior training or they are live reading the data from the signs that they encounter, there may be ethical concerns here.

Note that reports regarding the tragedy involving Mr. Jeremy Banner back in March of 2019 stated that the vehicle was travelling at least 13 miles per hour over the posted speed limit, while the vehicle had been in Autopilot mode. This should certainly be a concern for both passengers and pedestrians as there was a sense of disregard for the law, for whatever reason, which can be attributed to the loss of Mr. Banner's life. AVs have been marketed on the basis of them making for safer driving and living environments by self-regulating, hence the word 'autonomous,' yet they haven't quite proven to be able to simply adhere to posted traffic signs.

While ideally this does create a safer, less accident-prone environment, it also affects governments as a "proliferation of law-abiding robots" would ultimately reduce or even possibly eliminate speeding and red-light traffic tickets, which local and state governments fiscally rely on each year.

6.2 Weather

Weather is not always very predictable and one thing about precipitation is that it greatly affects traffic, following distance and safe driving speeds for even human-operated vehicles. Should a vehicle be operating in an area with heavy amounts of rain or snow, there would need to be an adjustment in how fast the vehicle should ethically, not legally travel in order to not lose traction and cause an accident.

According to Colin Beresford, writer for Car and Driver, MIT researchers in the Computer Science and Artificial Intelligence Lab (CSAIL) have been developing a localization tool within the AV software that allows the vehicle to scan below ground and detect precipitation, however it is still not "road ready" [16]. This solution essentially serves as a crutch for LiDAR and the other internal cameras and sensors that the vehicles are equipped with but struggle with bad weather.

As this solution is still in a developmental phase, MIT has also indicated that these vehicles find difficulty sometimes identifying lane lines and distant objects, which weakens the algorithm's ability to make an informed decision perhaps as a human would.

6.3 Insurance

If an autonomous vehicle comes into contact with another vehicle (it realizes this by sensor), there needs to be some procedure in place to handle the damage insurance process. In this case, do we expect the manufacturer to be responsible for all accidents caused while the self-driving feature is enabled? How does this work? Amidst an accident, when is the vehicle expected to stop?

Again, note that in the case of Banner v. Tesla, Mr. Banner's vehicle reportedly travelled an entire 1,600 feet after the incident before completely stopping. According to a survey conducted by IEEE, of more than 200 experts working within the field of autonomous vehicles, of the top six potential roadblocks, the top three were legal liability, policymakers and consumer acceptance [17]. This fact itself tells the world that the idea of insurance as we've known it will change drastically. In the future, as autonomous vehicles become the norm, there will still be a need for liability coverage, yet insurance policies will face changes as manufacturers, suppliers and even governments may be called upon to take responsibility for specific accidents, ultimately contingent upon what went wrong [17].

6.4 Traffic Infractions

In this section we'll discuss traffic infractions with the law. Because not *all* vehicles are autonomous right now, there is still a huge need for police patrol on our streets. Due to this, there's still that slight chance that an autonomous vehicle can be caught breaking a traffic law–perhaps the vehicle did not maintain a far enough following distance or did not come to a complete stop due to a malfunction.

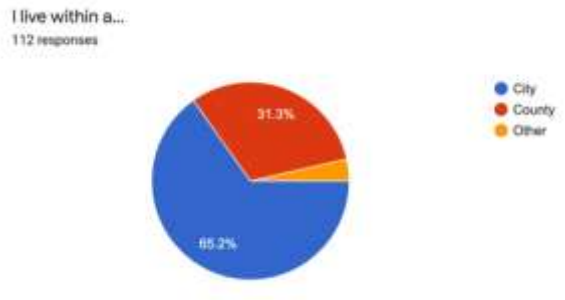
According to *Can a Self-Driving Car Receive a Traffic Ticket*, an article by Barbara A. Bowden, there's still a list of unanswered questions are one of Google's self-driving vehicles was apparently pulled over by an officer for driving too slowly. This raises the general question addressed in the article title, along with the following [18]:

- *Who becomes accountable in this situation?*
- *Is it fair to hold the passenger accountable when (s)he was not technically responsible?*
- *Whose driver's license should be penalized?*
- *Who is responsible for paying the ticket?*
- *How many times can a self-driving car make a mistake before being punished?*

7. RESULTS

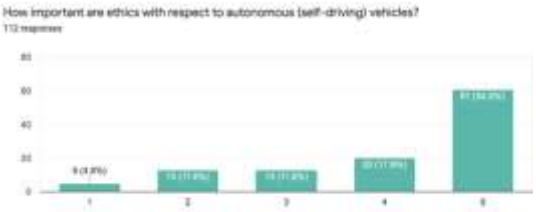
112 responses were collected via the survey outlined in Section 2.2. User Questionnaire. This questionnaire touched the bases of whether or not the majority of participants would agree to ride as a passenger in an autonomous vehicle, how much they valued the ethics of autonomous vehicles and the types of tragic situations to consider before blindly agreeing when asked again would they ride as a passenger at the latter end of the survey.

First, the community type of these participants were asked. Over half of the participants currently live within city-like environments. These are typically fast-paced, high-engaging environments with more traffic and higher population densities. This question itself does not prove anything and has no meaning, but as we take a deeper look into which states have enacted legislation in favor of autonomous vehicles, we find that many of the states have more rural and country-like areas than cities and districts like the District of Columbia and New York City. Because over 65% of the participants are in fact city residents, this guarantees that at least 65% of the data collected is able to represent the opinions and thoughts of these individuals. The data was interpreted both through individual analysis of the submissions and collectively, which is shows in the following chart.



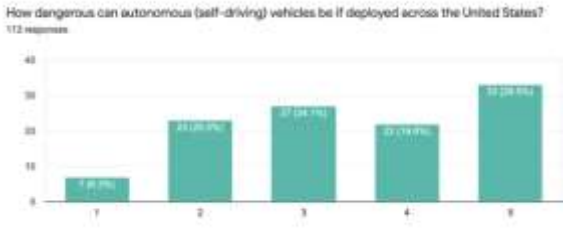
Ethics are essentially what dictate our actions and the lives that we chose to live. It is what we adhere to when we think of "right from wrong" and what is morally acceptable. With respect to AVs, ethics refers to the decisions made by the autonomous vehicle. Ethics also refers to the vehicle's ability to provide a more safe and smooth experience in comparison to current human-operated vehicles. Like with anything else, there's often a fine line between ethics and law. A study performed by researchers at Carnegie Mellon University (CMU) produced some interesting facts about how important ethics were in training an autonomous aerial vehicle to fly and navigate. The researchers *refused* to run a harmless simulation using the vehicles algorithm, and instead allowed the AV to repeatedly crash. The vehicle crashed over a total of 11,500 times [19]. This was an attempt to ultimately teach the AV to survive and learn from its mistakes but can easily be considered an ethical concern, should the same approach be taken for implementing autonomous road vehicles.

Furthermore, according to our study, the vast majority (54.5%) of participants have agreed that ethics are extremely important when we think about AVs.



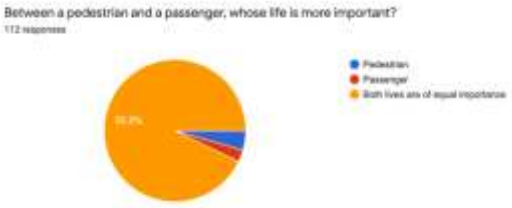
Not only did most participants agree that AV ethics are important, but the majority also sees great danger in the deployment of these machines across the U.S. These facts are not significantly alarming; however, they do yield a need for a deeper understand for why these individuals feel this way and what approach can be taken to recommend a system or experience that the

majority is comfortable with and feel ethically safe using.



73.2% of participants rated autonomous vehicles to be at least a 3 on a scale of 1 to 10, for how dangerous these vehicles could be if deployed across the United States.

In a study conducted by MIT entitled *Driverless cars: Who should die in a crash,* researchers had a hunch about how or even if specific circumstances or characteristics of a situation would determine whether or not one life could become more valuable than another. I used this ideology to prompt the participant to choose whose life means more between a pedestrian and passenger, in which there was almost no disparity; it's as if no one was able to choose, so 92.9% chose the safe answer of "Both lives are of equal importance."



The following two questions were extremely alarming. While being presented with the following diagram depicting the scenario along with an explanation, participants were asked to choose the most reasonable choice of whose life to sacrifice amidst a car crash, should the AV have no choice but to sacrifice the group of pedestrians.

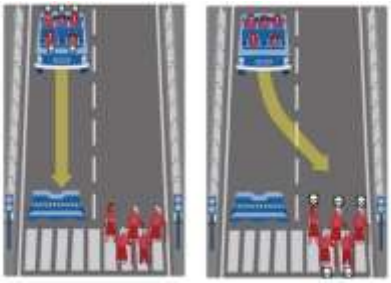
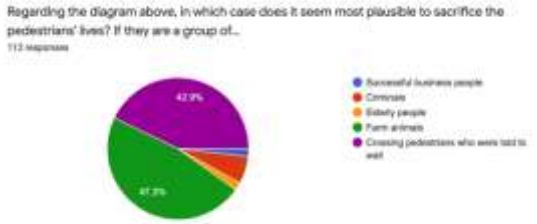


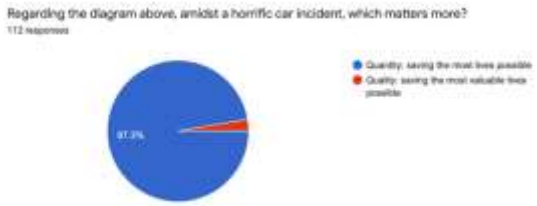
Figure 2. Moral Machine: Should a Self-driving car save passengers or pedestrians? [20]

Participants had the choice between all of the following to sacrifice as their group of pedestrians, should the AV have absolutely no choice if it wants to save all of its passengers:

- *Successful businesspeople*
- *Known criminals*
- *Elderly people*
- *Farm animals*
- *Crossing pedestrians who were told to wait*

The results of this question and the follow up were as follows:

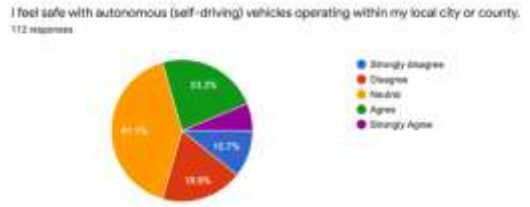




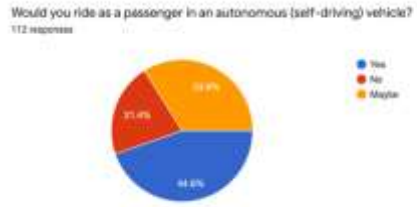
These results were extremely alarming and presented a valid question in this research study: If *quantity* is more important than *quality*, then why do so few participants think it'd be logical to sacrifice the successful businesspeople? There's clearly some allegiance and value for social and economic statuses which essentially protects these individuals. Only 2.7% agreed that quality mattered more, while the other 97.3% answered "Quantity." The finding from MIT's research presented the exact same findings. Having performed the study on some 40 million participants, the results showed that "people preferred to save humans rather than animals, spare as many lives as possible, and tended to save young over elderly people. There were also smaller trends of saving females over males, saving those of higher status over poorer people, and saving pedestrians rather than passengers." [20]. In our study, 47.3% of participants preferred to sacrifice the group if they consisted of farm animals as opposed to any of the groups consisting of actual humans. While this remains a consistent observation throughout the two studies, another alarming takeaway was the fact that crossing pedestrians who were told to wait are almost as likely to be targeted as animals. 42.9% of

participants stated that they believe if these individuals cannot follow the law, they are ultimately at fault and could've prevented the incident.

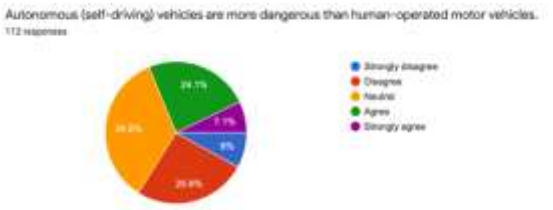
When asked if they'd feel safe with autonomous vehicles operating within their local cities or counties, there was difficulty finding a trend in the responses. The hypothesis here was that after presenting the tragic scenario and making participants aware that pedestrian lives are at just much of a risk as passenger lives, there would be a unanimous decision of "Strongly Disagree," however only about 10% chose this answer. It actually became evident that most participants shifted to what we could consider a grey area, as they became neutral and were unable to say whether they feel safe or unsafe.



Finally, participants are asked about their preferences and feelings regarding perhaps riding as a passenger of an AV and whether or not they think AVs are more dangerous than current human-operated vehicles. The results were as expected. The majority (44.6%) of participants feel save enough with these vehicles to ride in one of these vehicles, however, as seen in the previous section for results, not too many individuals feel that they belong on the road. This observation simply proves that pedestrian lives are more at stake than a passenger's as the data clearly tells us that people feel safer inside the vehicle than on the street walking.



While this isn't particularly wrong, it should be concerning and raise the eyebrows of pedestrians– especially those who may be violating a traffic sign, have criminal history or have no particular social and or economic status as concluded in question five which asks about which pedestrian group's life should be take amidst a car crash in order to save the passengers.



As earlier mentioned, there was a gigantic shift to this grey area. 34.8% of participants agreed that they couldn't necessarily state whether or not autonomous vehicles were more dangerous, perhaps due to insufficient evidence of their capabilities and effects. Also note here that only 15% of total responses belonged to an extreme (Strongly agree or Strongly agree). This continues to tell us that most participants are unable to draw conclusions about their feelings and are not completely convinced of one thing or another.

Conclusively, the results align well with the study performed by MIT and clearly reveal some focal points for the way the algorithms used in AVs must train the behavior of the 'moral machine' if they want to stand a legal chance on the road without being swamped with lawsuits and accusations. This becomes an extremely important issue as some subgroups and demographics are statistically made up of a specific race or gender. For example, African Americans incarcerated in state prisons are at a rate that is 5.1% more than that of the white American. In the following states: Alabama, Delaware, Georgia, Illinois, Louisiana, Maryland, Michigan, Mississippi, New Jersey, North Carolina, South Carolina, and Virginia, the prison population is 72% African American [21]. If the algorithm embedded into an AV is set to default to sacrificing a pedestrian's life if they are a criminal, this issue would then disproportionately affect African Americans, especially in those specific states.

8. ANALYSIS

The results of the substudy were extremely consistent. The nuanced results yielded throughout MIT's study and this substudy revealed a few key things to note: the opinions of U.S. citizens about whether or not they are ready for autonomous vehicles were not concrete or strong, individuals feel safer inside of vehicles as opposed to outside on the street, successful businesspeople and women are highly favored to be saved during an accident, ethics are extremely important to citizens and ethnic groups with higher incarceration rates may be victimized more than others.

Though it isn't apparent yet whether these results can be proven due to an insufficient amount of (1) autonomous vehicles on the road today, and (2) a substantial amount of evidence showing a trend of

these discoveries being validated as a result of accidents caused by AVs, it may serve us better as a people to remain proactive as opposed to reactive. By identifying potential pain points of these vehicles before they've been recalled and proved to target specific individuals for one reason or another, taking the necessary steps to nearly perfect the hardware, software, marketing, legalities and success metrics will prove beneficial.

9. RECOMMENDATIONS

Considering all that we've discussed, there are a few plausible recommendations that can be made to help further a safer self-driving vehicle initiative. These recommendations are as to (1) improve and diversify machine learning algorithms, (2) prioritize simulations and prolong testing, and (3) learn to value feedback.

(1) As discussed, regression algorithms are essentially the basis for identifying situations and predicting events based on some current state of the vehicle. It's been proven that deep learning models are not known for misclassifying images, but completely ignoring objects within images whether as a result of a resolution issue or just the 0.0001% of inaccuracy that you're guaranteed from any algorithm. From a technical perspective, a close analysis of the combination of machine learning techniques used to solve these issues will ultimately be what we as a people rely on for the protection and safety of our lives, so this cannot be a rushed nor fabricated step of the process.

(2) Testing is and always has been, historically, one of those things that is necessary, but everyone wants to sort of bypass to see a product get deployed. While this may not be such a bad idea for something rather harmless such as a website or mobile application, this absolutely cannot apply to an AV. Vehicular accidents total a staggering 6 million per year and could potentially become worse if these machines are not deployed with sufficient testing. Though there has never been a "perfect" robot or anything without defects, even if man made, there's very little room for error when there are lives at stake. My recommendation for this is to continue to use an iterative design process with an emphasis on testing. Many believe that the deployment of these vehicles has been Tesla's first test-run, making live drivers the test dummies and beta testers, which is completely unethical and has resulted in many lost lives.

While the accidents detailed in this paper, for the most part, have involved one individual's life being taken, imagine there could be tens of lives at risk, or even hundreds. There's no limit to how dangerous these machines can be if continually integrated into society without adequate testing and (h)edge case consideration.

(3) Valuing public feedback could be one of the easiest ways to improve upon customer pain points and more importantly, develop a sturdier and more purposeful product. With manufacturers such as Tesla refusing to speak on casualties caused by their product and continuing to push the agenda of making sales, this suggests perhaps sales and revenue are more important than human lives. What may not be considered here is that without humans, there are no sales. What needs to happen here is to make more of a corporate sacrifice to understand the market on a deeper level to provide a service that is not only flashy and innovative but is also safe and has longevity.

Academic institutions often offer groundbreaking research in an everlasting variety of emerging fields, including autonomous vehicles, and often times offer perspectives that gain validity through surveying and other data-driven metrics that would be useful to a corporate entity. Conducting intricate but simplistic surveys and mechanisms to gauge the political and emotional climate of a revolutionary product may seem a bit unnecessary, yet it could yield some pretty interesting results. As a corporation or organization, this type of feedback could definitely be helpful in identifying important clauses for recalling a product or how to improve perhaps in an upcoming software update. There's always this idea of consumers sometimes not knowing what they want until it's presented to them, so asking a bunch of people if they think autonomous vehicles are a good idea might not be that valuable of a question, however there are surveying techniques that can be leveraged to get some useful results and findings.

10. CONCLUSION

There's obviously a promising future for the world of automation and using it to convenience the lives of humans, however, there's still some apparent work to be done. The work done by industry leaders such as Tesla, Lyft and Waymo has definitely proven to be revolutionary and a grand lucrative yet could use an adjustment to the deployment timeline in regard to safety and consumer acceptance.

Hopefully, through this monograph, awareness is brought to both the technical and general societal issues that these vehicles have faced and may continue to face if solutions are not prioritized. Starting with taking moral responsibility, research institutions as well as major corporate entities must be held accountable for the damage that they've done. As a people and consumers, there exists no invention nor piece of technology too powerful to flourish without us. There is value in being the consumer.

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