Self Driving Cars: All You Need to Know

Elizabeth Spoehel
Department of Cyber and Computer Sciences
The Citadel, The Military College of South Carolina
Charleston, SC 29409
Email: espoehel@citadel.edu

Shankar Banik
Department of Cyber and Computer Sciences
The Citadel, The Military College of South Carolina
Charleston, SC 29409
Email: baniks1@citadel.edu

***Abstract*—Self-driving cars are coming closer and closer to being fact not fiction, but are we ready for them? In this research we analyze the current status in place for self-driving cars. We address the gaps that need to be filled, and we identify the questions that need to be answered before having self-driving cars on the road becomes a reality. Towards this, we discuss four issues with self-driving: policies, safety, security, and psychological acceptability of users. Our research will help individuals understand different aspects of self-driving cars and their benefits and challenges. Our paper will educate policymakers on the areas that need to be addressed before we deploy self-driving cars on the roads in a larger scale.**

***Index Terms*—Self-driving Cars, Artificial Intelligence**

1. Introduction

The rise of Artificial Intelligence (AI) has made full automation self-driving cars a reality. In the near future, we will have all the technologies available so that a passenger can hop in a self-driving car. The vehicle will take the passenger from location A to location B, and will move under full automation without the intervention of the passenger. Technology is one piece of the puzzle that we need to address before putting self-driving cars on the road. In this paper, we will analyze current policies (federal and state) for self-driving cars and identify the gaps that need to be addressed by government and law-makers. We will also review the safety features of self-driving cars that are advertised by vendors. We will discuss the security of self-driving cars with respect to cyber-attacks. Furthermore, we will analyze the psychological acceptability of self-driving cars by consumers. This paper highlights the obstacles that are preventing self-driving cars from becoming a reality this decade.

Self-driving cars have been a dream of many. The advent of self-driving cars spells the beginning of ultimate driving safety in some minds, while for others, it means newfound mobility. Consider, for instance, the elderly relative that no one wants behind the wheel; self-driving cars could keep their mobility and autonomy, but not be putting anyone in danger. Or consider someone who never seems to grasp they have had too much to drink, now we could safely see them riding in their car and not worry about their safety or of the others that could be impacted by their impaired judgment. Or consider a handicapped person who is unable to drive today, imagine the possibilities open to them with self-driving cars becoming a reality. There are endless examples of how self-driving cars could help people and why they are needed, at least according to their proponents. To those who are against the idea of a machine having life and death decisions, the closer the automobile industry gets to the self-driving car, the more they worry.

The Trolley Problem has been around for a while; the premise of the problem is should we take an action that will kill one person to save five or should we do nothing and let five people die. This uncertainty is at the root of why people are against self-driving cars in many instances. While driving, there are many unexpected variables involved, and it would be impossible to program a car for all scenarios, but even if we could, what decision would we have it make. For instance, a car is driving down a two-lane road, the car driving in the opposite direction swerves and comes at us with such force the only way to survive would be to swerve into the bike lane, but a child is riding their bike there. What do we do, or more aptly put, what would the code the programmer who designed the car tell us to do? It is a haunting thought, either way, should the programmers prioritize passenger safety or overall safety?

This paper will walk through the current policies on the books, and the lack thereof, the different safety features involved in self-driving cars, the security measures taken by manufacturers, and those recommended, and finally the possible psychological barriers consumers might have in using and buying self-driving cars. In section II, the terms needed to grasp all the topics fully will be introduced. In section III, the different policies will be talked about. In section IV, the overall safety of the vehicles will be discussed. Section V will discuss the security of the vehicles in terms of software and hardware. Section VI will be about the psychological acceptability of self-driving cars and about when they are developed will people feel comfortable using them. Section VII will be the conclusion.

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2. Terminologies

This section will provide the terms necessary to understand the rest of the paper. These definitions are taken directly from the National Highway Traffic Safety Administration's Federal Automated Vehicle Policy [1].

Automation Levels:

Level 0, the human driver does everything;

Level 1, an automated system on the vehicle can sometimes assist the human driver conduct some parts of the driving task;

Level 2, an automated system on the vehicle can actually conduct some parts of the driving task, while the human continues to monitor the driving environment and performs the rest of the driving task;

Level 3, an automated system can both actually conduct some parts of the driving task and monitor the driving environment in some instances, but the human driver must be ready to take back control when the automated system requests;

Level 4, an automated system can conduct the driving task and monitor the driving environment and the human need not take back control, but the automated system can operate only in certain environments and under certain conditions; and

At SAE (Society of Automotive Engineers) Level 5, the automated system can perform all driving tasks, under all conditions that a human driver could perform them.

HAVs (Highly Automated Vehicles): Vehicles that contain systems referred to as Conditional (Level 3), High (Level 4), and Full (Level 5) Automation in SAE J3016. These are systems that rely on the automation system (not on a human) to monitor the driving environment. This will be used interchangeably with self-driving car throughout the paper.

Driver: the human operator of an HAV when it is not operating in a fully automated mode.

Manufacturer: An individual or company that manufactures automated vehicles or equipment for testing and deployment on public roadways. Manufacturers include Original Equipment Manufacturers (OEMs), multiple and final-stage manufacturers, alterers (individuals or companies making changes to a completed vehicle prior to first retail sale or deployment), and modifiers (individuals or companies making changes to existing vehicles after first retail sale or deployment).

Occupant: Anyone seated in or on an automated vehicle.

Operator: An occupant of an automated vehicle who is not responsible for the driving task, but is still responsible for certain aspects of the journey (i.e., inputting a destination for the vehicle).

3. Policy

HAV policy is a convoluted mess due to the different regulations made by neighboring states and the federal government. Further confusing the matter is the fact that no state has any laws on the books or in the works for getting HAVs on the roads for anything besides testing [2]. While states like Arizona, home to testing for Google's HAV company Wamco [3], and California have regulations for testing these vehicles, they do not seem to have prepared detailed laws that are needed to put the self-driving cars on the roads safely. From the research we have seen there is nothing in place to help with the transition from having no HAVs on the road to having more than the occasional test vehicle. While the Federal Government has put out the *Federal Automated Vehicles Policy* that was done back in 2016, and it is, in essence, just a document of recommendations for the states [1].

Proving just how not ready we are, there is no policy in place or in the works determining how liability would be determined in the case of an accident with an HAV. There are many schools of thought in who should and would be liable in the case of an HAV accident. Even if we follow how laws are currently written, it is not clear how things would pan out. The courts could treat an accident with an HAV as a design defect case, and the liability would lie with the manufacture [4]. Zhon [5] argues that there are enough precedents in law for HAVs to be treated as autonomous machines and not vehicles similar to the way elevators and autopilots on boats and planes where the manufacturer is purely liable. Or it could be treated as a typical crash with everyday vehicles where the owner of the vehicle responsible for the crash is liable, or honestly, more aptly put the owner's insurance company.

With liability, the question of ethics is brought into play. If the HAV owner is liable and if their car is in a crash, then it follows that they would be liable in the case of their HAV killing a person. Is it ethical to have them be responsible when they were not in control of the action that brought about death?

4. Safety

Safety is one of the purported reasons to allow HAVs, and no one can deny that research into making HAVs a reality has increased safety. Features like Volvo's IntelliSafe [6] and Subaru's Eyesight [7] have all come from research into making HAVs more than a dream. Tesla boasts "advanced safety features including active lane control, blind-spot monitoring, and automatic emergency braking" [8], all of which are becoming standard in vehicles today. In 2018, the cars with the best safety features consisted of intelligent forward-collision warning, evasion aid, large animal detection, and evasive steering, among others [9]. Vehicles are clearly becoming safer because of technology.

The question becomes safer for whom. Safe for the operator? For the occupants? For the cars around the HAV? For pedestrians? Who is an HAV safer for? The answer that the manufacturers want to be true is, for everyone, but will that indeed be the case?

Why are HAVs considered safer? The answer to that lies in the cause of most accidents, which is human error. By removing human judgment and split-second decision making from the equation, supposedly vehicles will become

safer. The features that would make HAVs safer, or in other words, do a better job than a human, are numerous. The many sensors surrounding an HAV to take in its environment will have greater awareness than a single human driver. The ability to detect changes in the environment more quickly than a human would help keep people safe. Say, for instance, we are driving down the road, hands at ten and two, no music on, phone safely stowed away so as not to distract, no one else in the car and eye peeled for anything. When a child darts out in front of the car, chances are we will be able to stop the car in time as we were paying very close attention, but say that was not the case. Instead, let's assume that while we were driving down the road, there was a screaming child in the backseat, they had just dropped a toy, and we were reaching back to get it, and our phone was ringing. Any number of these distractions could cause us not to see the child dart out in front of the car. This is why a vehicle, an HAV, that could pay even closer attention than the person in the first example is safer.

There is also the flip side, however. What will an HAV do when an accident is inevitable? Who will it prioritize? How will that be determined?

5. Security

Security has become a hot topic in cars. This year both shows NCIS and FBI had episodes involving cars being hacked [10] [11]. Since 2015, multiple researchers have proven that vehicles on the roads today can be hacked [12] [13]. The idea that any car can be hacked is terrifying, let alone a car entirely controlled by a machine. Even the NHTSA has said that "Manufacturers and other entities should follow a robust product development process based on a systems-engineering approach to minimize risks to safety, including those due to cybersecurity threats and vulnerabilities" [1] which just goes to show how serious these vulnerabilities can be. They recommend that manufacturers "incorporate guidance, best practices, and design principles published by NIST, NHTSA, SAE International, the Alliance of Automobile Manufacturers, the Association of Global Automakers, and ISAC" [1].

The vulnerabilities inherent in HAVs come from its many systems. For instance, the HAV will have some kind of sensors to detect obstacles, and if those sensors are corrupted by an outside user to send false data to the central system of the HAV, then it may operate as if there is not an obstacle there and crash into it [14]. There are too many different ways a system could be manipulated to describe here, but suffice to say any electronic system can be manipulated. To mitigate these manipulations serious effort needs to be made to secure the systems. The NHTSA has been encouraging research into anomaly-based intrusion detection systems, cybersecurity of firmware updates, cybersecurity considerations for heavy vehicles, and on reference parser development for V2V communication interfaces [15] to help stop possible cyber-attacks on vehicles.

6. Psychological Acceptability

As talked about in the above section, the idea of a car being taken over while in operation is terrifying. That being said, are we ready for HAVs? Will people buy them if they are available? Will they trust them, be able to give up that kind of control?

As an analogy, self-driving cars are a bit like elevators. Or put more accurately, like what people thought of elevators before Elisha Grave Otis created an emergency braking system for them [5]. To demonstrate they were safe, Otis purposely put himself in a situation where his invention would have to save his life [5]. Until someone demonstrates that kind of faith in an HAV getting into one will be as terrifying as it was to get into an elevator in the 1800s.

The idea that something could go wrong with an HAV is clearly on many minds as more and more futuristic television shows have incorporated that into their stories. Shows, such as Upload, have shown HAVs being hacked and crashed because of different factors [16]. Not only there is a fear of HAVs being hacked, but also there is a concern with the data they collect and what will happen to that data. In the popular show Westworld, everything is longed and connected to a central system that determines every person's path in life. While that maybe an extreme example for HAVs, the idea that our data, our personal information could be used against us is not unrealistic and HAVs will numerous data points that users are not aware of [17]. To use Westworld to demonstrate another reason HAVs may not get off the ground quickly is the cost. It appears in Westworld that most vehicles are rideshares, which would lower prices, but if manufacturers are hoping the average everyday person will purchase their HAV, the inevitable cost seems to be an obstacle. Not only would the cost of the actual vehicle be a burden, but possible costs incurred from a malfunction may make people wary.

However, besides all the reasons for which people may not want HAVs to become a possibility, there are many people who need HAVs to make their lives more meaningful and efficient. HAVs have other positive impact as well. We need to build fewer parking lots as the same HAV can be shared between multiple members in the family. This will lead to less carbon emission. We do not need to have cars sitting around most of the time that could help stop the heat they generate [18]. The ability to get work done while on the go would be a huge advantage for those who work in places that have long commutes.

7. Conclusion

True HAVs (levels 4 and 5) seem like a pipe dream with the way things are progressing. With the lack of relevant policies on the books regarding the operation of HAVs for commercial use, manufacturers do not have a road map for what their vehicles need to do. Given how vulnerable today's vehicles are to hacking introducing more avenues of attack seems foolhardy. People already have a hard time trusting machines to make decisions, and with all the concerns about

where their data would go, the everyday consumer seems unlikely to buy an HAV yet alone afford it. Along those lines, we also have the moral and ethical side of things, do people want to get into a vehicle that would prioritize their safety to the detriment to those around them or vice versa? It seems genuinely impossible for self-driving cars to be on the road anytime soon. If an estimate had to be given as to the timeline, we would say no earlier than 2050 for HAVs to be on the roads for everyday consumers.

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