

Autonomous Driving



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1 Introduction

This paper focuses on the inherent risks, liability, and compares positive and negative aspects of autonomous driving and how it will affect society as a developing technology.

1.1 Research Purpose

Autonomous driving is the idea of automating the act of driving vehicles. The purpose of this paper is to analyze the risks and benefits in this development of technology. The first section focuses on the history of the study and how it works. This document also analyzes the ethical implications associated with the technology. Legal jurisdiction and liability will also be discussed for the topic. Because this is an increasingly developing field, there is a heavy outlook on what the future will hold for the expansion of this technology and how it will affect people's safety, the economy, and the laws associated with autonomous driving.

2 Information on Autonomous Driving

Fully Autonomous driving is the idea that a vehicle can maneuver completely free of human intervention. Though fully autonomous cars are not yet on the market, there have been several autonomous inventions for vehicles that are incorporated in all new cars. There are however many current projects exploring the possibilities of making the common car fully autonomous. These topics will be discussed in this section, as well as important safety information pertaining to the system and development of the autonomous car.

2.1 Existing Autonomous Functions

There are many common applications in vehicles that exhibit autonomous properties including anti-lock brakes (ABS) and cruise control. The graph in [Appendix B](#)¹ shows a diagram of the current progression of autonomous driving, as well as an outlook to what the future may hold. As shown on the left portion of the graph, there are currently three categories of automated systems on vehicles that exist today, warning and information, assisted driving, and automated driving.¹ Fully autonomous driving is not something that will happen all at once, but instead will be a continuing process of improving technology and creating new abilities.

2.2 Fully Automated Vehicles

Several major projects exist for the creation of autonomous vehicles, most of which are conducted by members of several universities. The project that will be analyzed in this paper is that of Carnegie Mellon University, which they named “Boss”. Boss was the winner of the 2003 DARPA grand challenge, a contest for the best technology in autonomous cars.⁴ The car functions by itself by using sensors, GPS mapping, and other techniques to keep track of what is around it and where the road is at

all times. [Appendix A](#)¹ gives an extremely simplified version of what the outline for an autonomous vehicle might look like. The motion sensors give the car the ability to tell what is around the car. Equally important is the GPS system, which tells where the car is on the road. All readings from the sensors, GPS, and other devices are input into a central processor which causes the car to perform the appropriate actions judging by the surroundings and location.⁴ There are many other problems to consider as well, such as construction zones or waiting for a parking spot in a full lot. The computer then calculates the predicted action, judging by where the car is going and the following actions that must occur. The system must also have the ability to detect errors in the calculation methods, such as obstacles in the road or yielding for traffic, and quickly recover from them.⁴

2.3 Safety Measures

There is no system in the world that can fully simulate, or perform remotely close to the capabilities of the human brain. In accordance, humans themselves do not possess the ability to use the brain to its fullest potential. For drivers, this includes distractions, reaction time, and impulse-driven responses to surroundings. Most humans do not have the ability to analyze a situation and determine the best result consistently in a matter of seconds, or in some driving circumstances an instant. The question is, can we develop a computer system that can judge what the best action will be to produce a positive outcome more quickly and accurately than a human?

Systems in autonomous cars are built to do just this. In order to prevent accidents, the system analyzes the set of all possible behaviors from a given situation. This is done by computing an algorithmic verification technique.⁵ This algorithm uses a model checking system to produce the action whose outcome is the least likely to cause collision.⁵ The difference is that a computer will not get distracted. It takes in all aspects of the problem into account and produces mathematically the best outcome.

3 Effect on Society

In 2008, there were 10.2 million reported accidents that occurred on the road in the US.⁷ Around 20% of people injured in accidents were in those involving some sort of distraction.⁷ There is something to say for the inability of humans to focus on what is in front of them, even when it is something that is a common cause of fatality, such as driving. The overall goal of autonomous driving is to reduce these rates and improve the safety of transportation. But what other aspects of society will be affected by the development of cars that drive themselves’?

There are several positive aspects of fully autonomous driving that will have major affects on society. Deciding whether the technology is fully beneficial to society is an argument of constant debate. While there are those that argue saying there will be less accidents and more efficient traffic flow, many are concerned about potential job-loss and allowing technology to take over control. This section will take into account some of the major issues concerning the impacts that this technology will have.

3.1 Economical Affects

With all of the accidents that occur yearly comes a high price tag. In 2008, AAA estimated the cost of traffic crashes in the US to be \$166.7 billion including medical, emergency services, police services, property damage, lost productivity, and quality of life.⁸ The difference between this cost and other consumer expenditures is that it includes cost to the government for civic services and support. Money spent in car accidents is not money being used to boost the nation’s economy. With the introduction of autonomous vehicles would come a great reduction in the amount people are spending on accidents, leaving them to spend their money on other things.

Another major change would come in the shipping industry. This would increase the speed and efficiency of all ground shipping, while lowering the cost. What this would mean to consumers is cheaper products and less cost. Without the need to pay drivers that require the basic needs to eat,

sleep, and stop to relieve their bowels, shipping companies, as well as postal services, would save hundreds of millions of dollars per year.⁶

3.2 Societal Affects

Along with the significantly large price tags on accidents, there is an upside. With all of the accidents and injuries, there is a need for a larger available medical staff, a higher number of active police, more insurance agents, and a large demographic for specialty companies such as towing or roadside assistance. If there are fewer accidents, there is a lower need for these people that work occupations in this group. Some argue that if we allow technology to do everything for us, there will be no more jobs in the future. However, when it comes to preventing injuries and fatalities, it is not necessarily ethical to argue against progression to benefit those whose jobs are to serve, protect, and provide for those in an emergency. Other working groups that would be faced with unemployment due to autonomous vehicles would be those in the shipping industry, postal service, taxi service, and public transportation services.

3.3 Traffic and Road Affects

Heavy traffic is somewhat of an inner-city pastime. If someone has to get across town in a big city like New York or Seattle, they need to make sure to leave an appropriate 45 minutes to get there on time. Traveling five miles in 45 minutes seems like a major waste of time, money and resources. In a future with autonomous cars, traffic would be split evenly across different routes and heavy traffic would be eliminated. Not only does this positively affect people's schedules, but it would also lower the emissions from cars, making for cleaner air.

Roads themselves would also be affected. If everyone was using a system that drove for them, roads would not need to be as wide. They would also have a consistent wear however and need to be repaired more often. Also, included with reducing the number of accidents is a reduction in property

damage, such as crushed guard rails and upended street signs. All of the cost to the government of repairing these roads would be greatly reduced.

4 Legal Issues

Much of the legal matters concerning fully autonomous cars has not yet been decided and is a topic of much debate. Many questions come up, such as who is held liable, how of the control of the car should be given to the computer, and for what forms of transportation should autonomous driving be allowed. This section looks at current accident jurisdiction, cases where automatic driving was involved, and what we might expect in terms of legal jurisdiction for fully autonomous vehicles.

4.1 Jurisdiction for Normal Wrecks

Traffic litigation today assumes that the cause of a wreck is either due to human or technical failure, environmental conditions, or a combination of the two.¹ Currently, the driver is held completely responsible for the control of the vehicle.¹⁰ There are four basic levels of fault; negligence, recklessness or wanton conduct, intentional misconduct, and strict liability.⁹ Examples of negligence would be failing to yield or running a red light.⁹ Reckless conduct would be considered doing something with disregard to the safety of others, such as texting or eating while driving. Judge Learned Hand came up with a mathematical formula stating that “If a measure to prevent the harm cost more than the cost of the harm multiplied by the probability of the harm, it would not have been efficient for the defendant to have taken and the defendant should not be considered negligent.”¹⁰

There are several different laws concerning the liability for drivers involved in an accident. On such law states that a party is held liable for harms caused by unreasonably failing to prevent the risk.¹⁰ An example of a scenario where this law would come into effect would be somebody not repairing their broken headlights, but driving at night and hitting somebody they could not see. Strict liability is reserved for malfunctions in car systems (i.e. braking system fails).⁹ With strict liability, manufacturers insure users against all harms that come from their product, regardless of fault.

If manufacturers are not careful, they can end up consuming much of the liability for accidents. It is said that the seller of a product is held liable for any accident caused by products that are sold in a “defective condition unreasonably dangerous to the user.”¹⁰ Products can also be considered defective in there is insufficient warnings to inherent dangers. Along with this, a manufacturer can be held liable for giving the consumer the belief that the technology does something out of the scope of the intended use of the system. However, Section 2 of legislation states that a seller is not liable for failing to warn of known risks and risk-avoidance measures that should be obvious.¹⁰ Suppliers and manufacturers are responsible for being certain that their product is safe for appropriate use before selling it to the consumer. Expenditures on products that do not hold up to their warrantee can be redeemed by the buyer.

4.2 Jurisdiction for Current Autonomous Technology

Autonomous technology has already started to change some of the legal scenarios for automotive accidents. One such case was that of the Google car that drove 140,000 miles before it got in its first accident, which was simply being rear-ended at a red light.¹² Newer law states that “Actors involved in highly unusual activities are more knowledgeable about the risks that such activity entails and should consequently bear the associated costs regardless of whether that are legally at fault for the crash.”¹⁰ By this jurisdiction, the driver of an autonomous car will be held fully responsible for any accidents that happen while the car is in control. Though this law includes cars that are fully autonomous, what about automatic vehicle functions such as warning systems or guided assistance? Simple warning systems are not likely to divert the responsibility from the driver of the vehicle, as they still have control.¹⁰

4.3 Future Jurisdiction of Autonomous Vehicles

For accidents involving autonomous cars, it is difficult to place blame on humans for the actions that a machine has taken. There might not always be a person for a victim of a car crash to sue. It is always possible to sue the manufacturer, but that is time-consuming and extremely costly. So where then does the liability get pushed to? There will more than likely be a shift in the way accidents will be judged.

There are several approaches that jurisdiction may take concerning the future of fully autonomous vehicles. These options lie in the balance of liability and defect. First, we will look at the different forms of liability. Manufacturers have been reluctant in introducing this new technology because of the increase in liability they will face. However, this group is somewhat protected by the law of negligence. If they can save thousands of lives and millions of dollars by implementing this technology, they are technically legally obligated to do so. By using cost-benefit analysis techniques, manufacturers can claim that the overall benefits outweigh the risks associated with the technology.¹⁰ However, before proper jurisdiction can be written, the definitions for the cost-benefit must be created.

Defects in an autonomous vehicle can include the structure and parts themselves or, more likely, a fault in the system that controls the car. A vehicle can be seen as defective solely by the cost-benefit analysis for a particular situation and the maker will not always be protected.¹⁰ Manufacturers must also consider the fact that this is extremely complex technology with many integral parts. If something in the system were to go wrong, such as a sensor picking up false readings, they could be held liable for a manufacturing or system defect.

One last major obstacle standing in the way of current jurisdiction is the inherent expectations of the consumer. As stated previously, humans are prone to distractions and have a hard time focusing, especially when they are not directly engaged. So when a manufacturer tells the consumer that the can

be on the freeway without holding the steering wheel and the car will stay in the lane and keep a safe distance from other cars, what is stopping the driver from considering freeway time nap time?

Manufacturers must be extremely careful in how they convey the capabilities of the technology to the user. If they provide an unrealistic conjecture concerning the capabilities of the new system, they can be held directly responsible for causing the accident.¹⁰

With the fault of accidents pushed away from the drivers of autonomous vehicles, manufacturers may decide not to adopt the technology for autonomous driving because of the predicted cost of the liability. For this reason, it would be best to implement the cost-benefit analysis approach to jurisdiction, as it would leave the liability away from the manufacturer and help to progress technology, improving the safety and efficiency of travel in vehicles.¹⁰ Incorporating this with a no-fault policy would be the most reasonable answer. As part of the no-fault policy for autonomous crashes, insurance companies, or even the government, could cover the loss to the victim. Though it seems like this would be an extra expenditure of money by the insurance company or government, it would ultimately increase the progression of the technology. By encouraging autonomous cars, they would lower the number of injuries for crashes and reduce the millions of dollars spent on accidents every year, which in turn only saves them money.

5 Ethical Issues

While there are many positive aspects of developing the fully autonomous car, what ethical challenges will it propose and how must we address them? We have covered how autonomous vehicles work, some of the key societal affects that making them a mainstream product will hold, and what laws will have to change and be formed to accommodate them? This section covers the view of autonomous cars from an ethical standpoint.

5.1 Concern for Human Safety

For consumers, the largest ethical issue for the introduction of autonomous vehicles is putting their life into the hands of a computer. Though statistics show that a large majority of automobile accidents are the fault of human error, many people are not ready to surrender the control of the vehicle to a machine. In reality, however, the technology would greatly improve fuel efficiency and the safety of driving.¹³ The preservation of human life can be found in any code of ethics, so it would be common ethical sense to employ any measure to invest in the safety of humans. There are numerous other benefits to a future with fully autonomous vehicles as well. For example, it could provide the ability for someone who lives far away from a dispatch for an ambulance to get to a hospital quickly by telling the car to take them there.¹³

Along with the numerous positive aspects to this technology, it is important to analyze possible negative outcomes of introducing fully autonomous cars. As with any other form of technology, it will be misused. In fact, there have been several incidents in Europe where the driver of a car that offers a lane correction system allowed themselves to fall asleep at the wheel, resulting in the wreckage of the car.⁶ Inappropriate use is not limited to just the people in the car though. Pedestrians could also learn to take advantage of the system. For example, we are all taught to look left and right before crossing the street. However, if autonomous cars become mainstream, that natural action might be lost because the car always seems to stop. Well this in turn could cause more pedestrian incidents with cars that are not fully

controlled. To provide another example of mistreatment of the technology, picture approaching a group of children playing street hockey as an autonomous driver. Of course, the car stops as there are people in the road, but knowing that the car will not move as long as they are there, the kids continue to play. As a driver there would be nothing you could do to avoid a confrontation. There are many other possible reactions and misconduct that must be analyzed before the technology can be implemented.

Another concern with this new technology is how it will react in different situations. Driving is not something that can be predicted with 100% accuracy. Factors such as hazardous conditions or road construction can cause major issues. If it is ten degrees Fahrenheit and the roads are covered in a sheet of ice, is the car going to know that it shouldn't be driving? If the car were to stop due to hazardous conditions, the driver cannot be expected to sit in the cold car and weather out the storm, as that could take hours or even days. Another main issue is mixing cars on the road that are fully autonomous with those that aren't. Today, drivers are somewhat predictable, but that may not be the case with autonomous cars. If these new vehicles are going to stop suddenly for obstacles or take an awkward angle at a turn, other drivers on the road might be put at risk. These issues and many more must be properly analyzed before fully autonomous vehicles can be integrated into everyday traffic flow.

5.2 Concern for Personal Property and Authority

It is guaranteed that the cost of these autonomous vehicles is going to be higher than that of regular cars because of the heavy amount of high-tech equipment and manufacturers compensating for liability. With the high cost, consumers must be assured that they are fully protected against an incident caused by the car or the market for the technology will be small. It is predicted that when these cars get released, insurance agencies will offer lower rates as incentive to buy the cars with this technology.¹⁰ The government may also decide to offer special trade-in compensation, just like they did to reduce the amount of cars on the road with poor emission levels. This is not only because the cars are proven to be

more safe, but also because of all the benefits that the technology will bring to society. Also, if the no-fault policy is instantiated, it is faster and cheaper for insurance companies to compensate victims.¹⁰

Traffic flow and legislation would not be the only areas affected by the introduction of the autonomous vehicle. There would have to be a major change in the procedures and policies of law enforcement as well.¹³ Though the technology will greatly reduce the occurrence of traffic violations, if a car is pulled over there is no driver, say for example a tail light is out, the officer must still handle the situation in some way. Another example would be if an autonomous vehicle is used to rob a jewelry store and the thief puts the loot in the car and uses a different one to get away.¹³ There would be no hard evidence that he is the one that took the jewels, as they are not technically in his possession. Along with authorities, the government would also have to assume much more of the control of the roadways than they currently do.¹¹

5.3 Concern for Human Rights

As the government takes more control of the roadways, that means less privacy for the driver. While the car operates, it uses GPS and records literally everything about the surroundings and actions of the car. It is important to define how much information available to others is too much and when it becomes a violation of privacy.¹¹ Another ethical concern is the equal treatment of those that possess cars with the technology and those that don't.¹¹ One could argue that prices of insurance should not be lower only for those who can afford autonomous cars. This discrimination might also be seen in the jurisdiction concerning accidents between the two. The last major problem the technology would bring is the loss of jobs, as mentioned in section 2. Drivers in shipping and postal fields will more than likely suffer drastic layoffs, along with law enforcement since the cars will not be speeding. Though it may seem unethical to force these people to surrender their jobs to this technology, the potential benefits outweigh the negative ethical impact.

On the positive end, there are many opportunities that would be granted to people that weren't previously available. Having cars that drive themselves would reconnect the elderly and disabled to society. Imagine technology that gives blind people the ability to drive themselves for errands or to visit relatives. The improvement on the quality of life is immeasurable. But the line is not drawn at the disabled. Everyone would benefit from more efficient and faster traffic flow, leaving people with more time to spend with their families or leisure.¹³

6 Conclusion

While fully autonomous driving is the technology of the future, it is important to analyze the implications of the technology today. We have talked about the positive and negative effects that this technology will have on society, what legal issues and complications must be considered, and the ethical issues surrounding autonomous vehicles. As we have seen over the last decade or so, the integration of such a heavy change in a daily routine function has been gradual.¹⁰ It is important to keep introducing each concept one at a time so that people can get comfortable with the way the technology works and so that, as a society, we can solve problems such as legislature of liability and properly analyze the risks and benefits.

Currently, autonomous functions in cars exist primarily to assist the driver in routine functions. Though there are inherent risks in the development and introduction of this technology, the forecasted benefits heavily outweigh them. As the technology becomes more and more readily available, it is humanity's ethical duty to progress this concept, especially when it can increase the level of safety offered to society.

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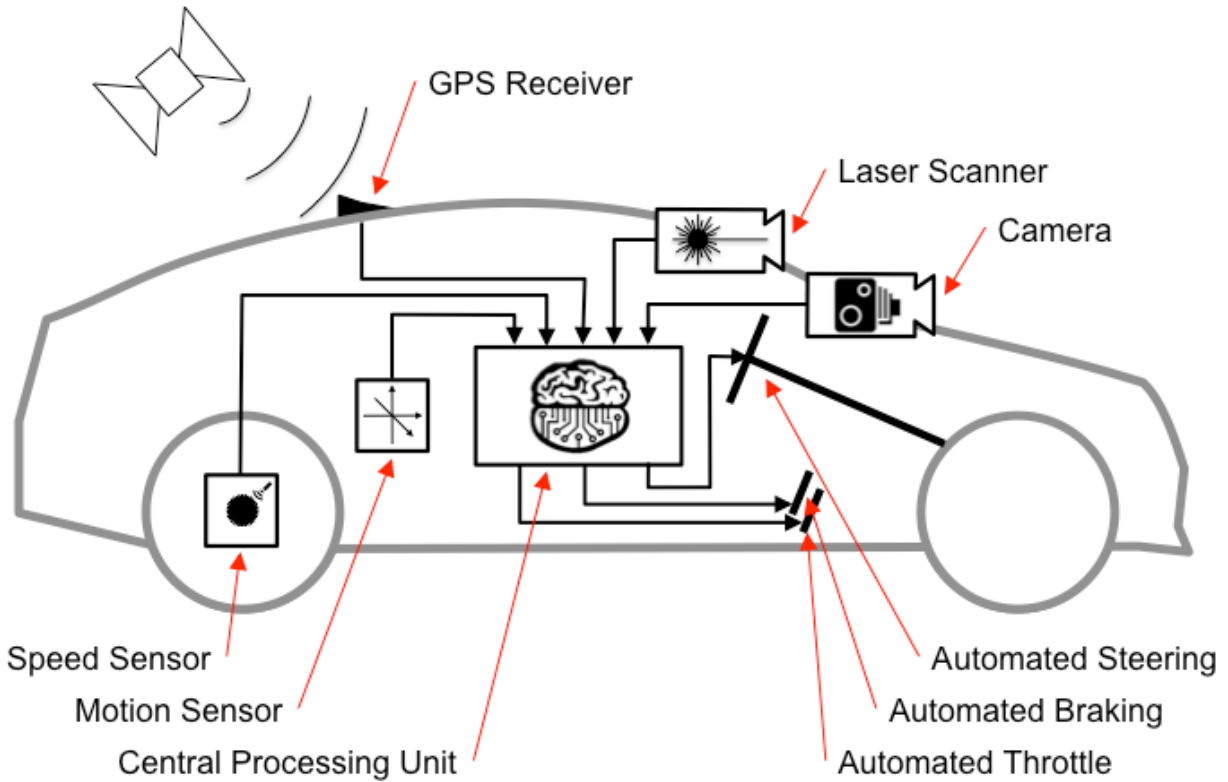
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8 Appendices

8.1 Appendix A – Example of Autonomous Vehicle



8.2 Appendix B – Development Chart

