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Autonomous Vehicles: An Ethical Theory to Guide Their Future

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The technology leading to fully autonomous vehicles is increasing exponentially with each passing year. It is both exciting to be living in such an inventive time but also worrying. Current driving practice is relatively dangerous due to the faults of humans. Humans sometimes operate vehicles without being entirely aware of their surroundings. Fully-autonomous cars would theoretically eliminate the error introduced by human capabilities. The main problem that arises in this is the lack of ethics in a computer program. It is difficult to ascertain how a car should behave in the inevitable event of an accident. The scope of this paper is to develop a dominant governing ethical theory to determine how cars will be programmed, how blame will be administered in the event of accidents, and what laws and regulations should be implemented in the future.

1.1 DEFINITION OF AUTONOMOUS VEHICLES

Before going forward, it is important to outline terminology being used in this paper. The broad term “autonomous” can encompass varying amounts of automated control. For this reason, the levels were defined by The National Highway Traffic Safety Administration seen in Figure 1.1

Most cars made today fall into Level 2 self-driving, including features such as cruise control and auto-parking. The analysis performed in this paper will focus primarily on Levels 3 and 4 of automation. Autonomous vehicles will be considered vehicles in which the driver is not required to monitor the road conditions; cars will react with no human interaction required. This paper will refer to these levels throughout.

1.2 HISTORY

The first mention of driverless cars dates back as early as the 1920s and 30s. As reported by The Free Lance Star, a car nicknamed the “Phantom Auto” was developed to be controlled by radio signals being sent from a trailing car. This was the first attempt at driving a car indirectly. Large advancements were made at Carnegie Mellon University...
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1.2 History

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1 INTRODUCTION

The idea of autonomous vehicles, better known as “self-driving cars,” are becoming increasingly popular in the modern world. Each year, cars are able to do more by themselves. In theory, fully self-driving cars would be purely beneficial to society. In current transportation practices, drivers are at the mercy of their own abilities, as well as those of others on the road. Drunk driving, lack of driver awareness, and slow reaction times contribute to many accidents and fatalities. If cars drove themselves, it would eliminate the human aspect that is prone to error. The problem with self-driving cars is just that; however, they would eliminate the human aspect. The human driver is also ingrained with how to act in an ethical dilemma. A human brain can understand the complexities associated with morality. This is something artificial intelligence has not been able to fully conquer yet. Herein lies the problem with self-driving vehicles. Prior to widespread release and acceptance into everyday life, the integration of autonomous cars must be analyzed from an ethical perspective. The scope of this paper is to develop a dominant governing ethical theory to determine how cars will be programmed, how blame will be administered in the event of accidents, and what laws and regulations should be implemented in the future.

<table>
<thead>
<tr>
<th>NHTSA Automation Level</th>
<th>Description</th>
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<tbody>
<tr>
<td>0. No automation</td>
<td>Driver is in complete control of steering, braking, and throttle, although vehicle may provide warnings.</td>
</tr>
<tr>
<td>1. Function-specific automation</td>
<td>Vehicle may independently automate one or more control functions.</td>
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<tr>
<td>2. Combined-function automation</td>
<td>At least two control functions are automated and operated in conjunction (e.g., adaptive cruise control and lane centering). Driver may have to take control with no notice.</td>
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<tr>
<td>3. Limited self-driving automation</td>
<td>Driver can cede full control to the vehicle in some situations, and driver has a reasonable amount of transition time before he or she must take control.</td>
</tr>
<tr>
<td>4. Full self-driving automation</td>
<td>Vehicle can safely pilot the vehicle for an entire trip, with no expectation for the driver to take control. Such a vehicle does not yet exist.</td>
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functions together. All construction work and other obstacles will be continuously streamed into the cars so the entire road is to have an entire communication system between Level 3 autonomous vehicles by 2017. Their main goal is one of the final steps towards full autonomy. These vehicles, other people in nearby cars, and pedestrians. The common scenarios presented with regards to self-driving cars are shown in Figure 4.

Figure 4a shows a situation where the car only has two options: hit the crowd of people in the road, or swerve and kill only one person. Figure 4b poses the dilemma of a presumed one-to-one tradeoff. In this case, the driver either swerves into a wall to save the pedestrian while killing the driver, or continues on the path killing the pedestrian but sparing the driver. In the last scenario, Figure 4c, the driver faces the same decision as Figure 4b, but there is a full crowd of people. If a vehicle were to be Level 4, and fully autonomous, it would need to be programmed to be able to make these decisions. This is one of the final steps towards full autonomy. These situations will be looked at from different ethical theories in an effort to develop one specific to this topic.

2.1 UTILITARIAN PERSPECTIVE

Analyzing the scenarios in Figure 4 from a utilitarian point of view, all situations should be handled in the manner that minimizes loss of life. This would mean putting the good of society over the safety of the car’s passenger. This is an inverse tactic to traditional car design, which prioritizes the safety of riders in the vehicle over all else.

A survey conducted by Bonnefon, Shariff, and Rahwan showed that 76% of those asked would prefer cars to behave in a utilitarian manner given the scenario of Figure 4a. This would sacrifice the driver for the good of those in the road. In the case of Figure 4b, people were less likely to agree to kill the driver, with only 23% of participants agreeing to save one life. The number of people on the road was continuously increased in the survey until it reached a situation similar to Figure 4c, with the approval of driver sacrifice growing until it reached rates consistent with Figure 4a.

The same people were asked how likely they were from 0-100 (0 being not likely at all, 100 being definitely) to buy a self-driving car that valued protecting passengers over everything else. The results yielded a median of 50. This is relatively low to begin with, but the ethical dilemma is evident when the participants were questioned on the same scale how likely they were to buy a self-driving car programmed with a utilitarian mentality, giving only a median of nineteen. Even though three-quarters of people agree utilitarian perspectives should govern, only a small percentage of them would buy one for themselves.

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The following excerpt from the study summarizes the issue facing autonomous vehicles (AVs):

“Although people tend to agree that everyone would be better off if AVs were utilitarian (in the sense of minimizing the number of casualties on the road), these same people have a personal incentive to ride in AVs that will protect them at all costs. Accordingly, if both self-protective and utilitarian AVs were allowed on the market, few people would be willing to ride in utilitarian AVs, even though they would prefer others to do so.”

The main problem, illustrated by the lack of willingness of people to buy these cars, is the fact that few people are willing to put their life in the figurative hands of a computer. The utilitarian strategy is not a poor place to start when it comes to deciding on how to program autonomous vehicles. It takes into account saving as many lives as possible, which is a foundation for most ethical concepts. The main problem, illustrated by the lack of willingness of people to buy these cars, is the fact that few people are willing to put their life in the figurative hands of a computer. Assumptions that the majority of people make decisions ethically, meaning they abide by their own personal code of ethics, there must be something that minimizes loss of life. This would mean putting the good of society over the safety of the car’s passenger. This is an inverse tactic to traditional car design, which prioritizes the safety of riders in the vehicle over all else. The results yielded a median of 50. This is relatively low to begin with, but the ethical dilemma is evident when the participants were questioned on the same scale how likely they were to buy a self-driving car programmed with a utilitarian mentality, giving only a median of nineteen. Even though three-quarters of people agree utilitarian perspectives should govern, only a small percentage of them would buy one for themselves.

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driven hundreds of thousands of miles on roads, implying functions together. All construction work and other obstacles will be cars, so that if a car is broken down somewhere, it will is to have an entire communication system between Level 3 autonomous vehicles by 2017. Their main goal another car company, Volvo, plans to lease one hundred including General Motors, Ford, Tesla, and Google. Today, autonomous cars are being developed by most (CMU) in the 1980s through the Autonomous Land processing. The work conducted in the ALV Project laid foundation for many of the autonomous systems (CMU) in the 1980s through the Autonomous Land

2. ETHICAL DECISION MAKING STRATEGIES FOR AUTONOMOUS VEHICLES

In order for self-driving cars to be placed on the road for widespread use, they need to be trusted in making unique decisions due to unforeseen circumstances. The car needs to be able to react in an ethical fashion; protecting the passengers, other people in nearby cars, and pedestrians. The common scenarios presented with regards to self-driving cars are shown in Figure 4.

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2.2 INDIVIDUAL’S RIGHTS PERSPECTIVE

Although people tend to agree that everyone would be better off if AVs were utilitarian (in the sense of minimizing the number of casualties on the road), these same people have a personal incentive to ride in AVs that will protect them at all costs. Accordingly, if both self-protective and utilitarian AVs were allowed on the market, few people would be willing to ride in utilitarian AVs, even though they would prefer others to do so.

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The main problem, illustrated by the lack of willingness of people to buy these cars, is the fact that few people are willing to put their life in the figurative hands of a computer. Assuming the majority of people make decisions ethically, meaning they abide by their own personal code of ethics, there must be somethingworth with a strictly utilitarian performance. This is explored further in the next section.
the choice to direct the car, not the car in Level 2 or 3 autonomous driving. As indicated in the previously mentioned study, many people would be in control of their own life, rather than leaving it to a computer. This is something that needs to be taken into account when programming a car. The best outcome may be remaining at Levels 2 and 3 rather than progressing to the fully autonomous Level 4. This would allow for some leeway where a car would make a decision, unless a human overrides it. Another perspective would be limiting the choice to buying a Level 4 self-driving car. When designing as the decision, the individual already exercised their freedom of choice: the choice of buying the car. Another way of analyzing from a rights perspective is by protecting the car owner’s right to live. The main goal of today’s driven cars is to keep passengers safe. In this way, cars could be programmed to avoid injuring the driver, at all costs. This would highlight the rights held to one human will become injured or dead. Programming abilities have not yet come to the point where technology can have a fully ethical conscience, but by programming autonomous vehicles using the most utilitarian path, humans are instilling a bit of a conscience into the vehicle. With this situation though, we assume that Level 4 autonomy is taking place. This means that the car is completely independent of the people inside it and that passengers essentially have no way to input their own decisions.

In this case, situations that minimize fatalities would mean that there is maximum benefit. When it comes to how utilitarianism plays into autonomous vehicles, one would assume that many car manufacturers would program the vehicles to always choose the route that minimizes fatalities, both physically and figuratively, that would lead to the least people dying, assuming that either way at least one human will become injured or dead. Programming abilities have not yet come to the point where technology can have a fully ethical conscience, but by programming autonomous vehicles using the most utilitarian path, humans are instilling a bit of a conscience into the vehicle. With this situation though, we assume that Level 4 autonomy is taking place. This means that the car is completely independent of the people inside it and that passengers essentially have no way to input their own decisions.

Because the humans involved have no input and are completely at the mercy of the programmed system within the autonomous vehicle, there are two parties who can potentially be at fault in any given situation: the manufacturer of the autonomous vehicle, or the person who has chosen to purchase and utilize the autonomous vehicle. Because the case involves more than one human, it is important to analyze the responsibility that each individual should take.

3 LIABILITY
In creating a system of autonomous vehicles, one must assume that accidents are going to happen, people will be injured or killed, and therefore, the blame will have to fall onto a party. In the situation of autonomous vehicles, there are two parties who can potentially be at fault: the car manufacturer, or the person who has chosen to purchase and utilize the autonomous vehicle. In order to fully analyze the myriad of situations that can lead to liability issues in autonomous driving, this section will discuss from an ethical perspective who would be at fault from both a utilitarian and individual rights view.

3.1 UTILITARIANISM
As previously discussed, the utilitarian perspective favors situations where overall benefit to the majority is acquired. In this situation, situations that minimize fatalities would mean that there is maximum benefit. When it comes to how utilitarianism plays into autonomous vehicles, one would assume that many car manufacturers would program the vehicles to always choose the route that minimizes fatalities, both physically and figuratively, that would lead to the least people dying, assuming that either way at least one human will become injured or dead. Programming abilities have not yet come to the point where technology can have a fully ethical conscience, but by programming autonomous vehicles using the most utilitarian path, humans are instilling a bit of a conscience into the vehicle. With this situation though, we assume that Level 4 autonomy is taking place. This means that the car is completely independent of the people inside it and that passengers essentially have no way to input their own decisions.

So, under this mindset, the car manufacturer would be at fault and would be liable if any situation were to take place where more people died than could have, given other possible scenarios. Something that is a bit more obvious, but still worth mentioning in order to relate back to utilitarianism, is a situation wherein the car manufacturer did not choose the most utilitarian path, humans are instilling a bit of a conscience into the vehicle. With this situation though, we assume that Level 4 autonomy is taking place. This means that the car is completely independent of the people inside it and that passengers essentially have no way to input their own decisions.

A recent problem occurred with a popular car manufacturer, Tesla, which has always been on the forefront of the concept of autonomous vehicles. A driver was driving in autopilot on a highway when a tractor-trailer drove across the highway in a perpendicular fashion. At this time, the sun glare was so bad that the human driver could not see to intervene. In addition to that, the car was not programmed to properly assess the situation at hand. Tesla automated their vehicles to ignore high-hanging signs because if they didn’t, vehicles would stop every time they passed under any sort of overhang. Unfortunately, because the tractor-trailer was very tall and because it ran perpendicular to the car and driver, the vehicle took it as an overhanging sign and did not stop. Even though this is not necessarily the case, if we were to assume for a second that the autonomous vehicle was under Level 4 automation and the driver had no way of interfering with the situation, the liability would obviously fall onto the car manufacturer because the vehicle simply could not minimize the loss of lives. Although this would require incredible programming technology, the vehicle failed to assess the situation and produce a situation in which lives weren’t lost. So, ethically, this would fall completely into the lap of the car manufacturer. This situation does still need to be assessed under the perspective of individual rights though, which will be discussed in the following section.

Recently, Germany’s Federal Office for Motor Vehicles became a bit concerned, claiming that they would refuse to approve a feature on German roads if it was referred to as “Beta.” What Elon Musk, CEO of Tesla, was trying to say though, was that these autonomous vehicles are obviously still in a testing phase, and by using the word “Beta” to describe them, Tesla was trying to say that they understand that the models aren’t perfected and that they are also expecting the people who are driving these cars are acknowledging that they are still in the testing phase. This phase is said to stop when one billion miles of data have been collected, and although Tesla was at 780 million at the end of July, Musk states that it’s not too late yet. In terms of this “Beta-phase” situation, Tesla is almost trying to share liability with the drivers of autonomous vehicles because basing this decision on what people are doing to acknowledge that the models aren’t perfected yet, safety is not completely guaranteed, and that each person driving must assume the situation with their own discretion. This is highlighted in an article written by Fred Lambert in Electrek, which is a website dedicated to the latest highlights in the transition from fossil fuels to electric power. They say Musk “emphasized again that the use of the word beta is to highlight that the system is not perfect and that Tesla drivers do not have to use it.” He is leaving the decision up to the drivers so that their fate lies in their own hands in this still-developing stage for Tesla. In the end though, Musk and Tesla as a whole are trying to make autonomous driving something to be trusted, as Musk is quoted saying that Tesla will work until “it is statistically true that there is a substantial improvement in safety if a vehicle is autonomous versus non-autonomous.” Until that point of view can be achieved, one billion mile mark, though, the liability in situations where drivers are injured or die might have to fall partially on the affected person, too, rather than just on Tesla.

3.2 INDIVIDUAL RIGHTS
The idea of individual rights is an interesting one in the topic of autonomous vehicles because one has to consider whether there actually is even a presence of individual rights in this situation. Going back to the definitions of the classifications of autonomy, Level 4 did not necessarily need to be assessed under the perspective of individual rights though, which will be discussed in the following section.

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Another way of analyzing from a rights perspective is by protecting the car owner’s right to live. The main goal of today’s driven cars is to keep passengers safe. In this case, cars could be programmed to avoid injuring the driver, at all costs. This would highlight the rights held to protect the car owner’s right to live. The main goal of autonomous vehicles, there are two parties who can potentially be at fault in any given situation: the manufacturer of the autonomous vehicle, or the person who has chosen to purchase and utilize the autonomous vehicle.

Because the humans involved have no input and are completely at the mercy of the programmed system within the autonomous vehicle, situations in which the liability must fall onto the car manufacturer if something were to go wrong. In situations like this, it is assumed that with any decisions, whether it be made by the autonomous vehicle or the driver, someone will die or at least become injured. According to the utilitarian perspective, situations in which the liability does not fall onto the autonomous vehicle manufacturer because the user did not minimize the loss of lives. Although this would require increasing the technology, the vehicle failed to assess the situation and produce a situation in which lives weren’t lost. So, ethically, this would fall completely into the lap of the autonomous vehicle manufacturer.

Because of these reasons, Level 4 autonomy, situations in which the vehicle were to choose a path that kills any passengers as opposed to killing no passengers, would be at fault. Even though this is not necessarily the case, if we were to assume for a second that the autonomous vehicle was under Level 4 autonomy and the driver had no way of intervening within the situation, the liability would obviously fall onto the car manufacturer because the vehicle simply did not minimize the loss of lives. Although this would require increasing the technology, the vehicle failed to assess the situation and produce a situation in which lives weren’t lost. So, ethically, this would fall completely into the lap of the autonomous vehicle manufacturer.

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The whole situation becomes difficult because it all comes down to how intricately and how advanced the programming is in the vehicle. If the programming is advanced enough to make decisions like that, and the driver doesn't have to intervene, then it could fall on the manufacturer specifically and the programmer. The programmer is not designed to make those types of decisions and the person willingly purchasing the vehicle knowing that piece of information, most of the issues that arise will fall on the driver.

One cannot simply just view something from one perspective though because there are so many nuances and aspects that don't fit perfectly into one or the other. For example, the perspective that the human is back in play, the liability of certain unfortunate situations.

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In determining who is liable, one must also determine which ethical perspective they are going to view the entire situation from. Will the ethical cases be evaluated under a utilitarian perspective; under which automated vehicles might one day be created to act? Or will we have to view the given situations from an individual rights perspective, considering there is no Level 4 autonomy in our world yet and therefore each vehicle today and in the near future will probably be used in other normal situations. In addition, an insurance company must only worry about faulty. A government must impose regulations that will probably run at least somewhat through the driver. And therefore each vehicle today and in the near future will probably be used in other normal situations. In addition, an insurance company must only worry about faulty. A government must impose regulations that will probably run at least somewhat through the driver.

The ethical perspective of individual rights connects back to the value that we have in our own lives and how our decision making process is a personal result of that. Level 4 autonomy takes that away and is therefore left up to the car manufacturer to then program how the vehicle will make decisions.

In determining who is liable, one must also determine which ethical perspective they are going to view the entire situation from.

Viewing the situation with Tesla from a perspective that includes individual rights brings in many other questions to the dilemma at hand. Because this was a situation in which the human population would actually want a machine to make the ethical decisions that would have normally been assigned to a human that has the moral capacity to make those decisions themselves.

In the end, liability is a tough situation because in determining who is liable, one must also determine which ethical perspective they are going to view the entire situation from. Will the ethical cases be evaluated under a utilitarian perspective; under which automated vehicles might one day be created to act? Or will we have to view the given situations from an individual rights perspective, considering there is no Level 4 automation in our world yet and therefore each vehicle today and in the near future will probably be used in other normal situations. In addition, an insurance company must only worry about faulty. A government must impose regulations that will probably run at least somewhat through the driver. And therefore each vehicle today and in the near future will probably be used in other normal situations. In addition, an insurance company must only worry about faulty.

4 THE DIRECTION OF AUTONOMOUS VEHICLE ADOPTION

Today driverless cars with Category 3 or greater automation are still in the testing stage. The vast majority of cars are limited to cruise control and parking assistance. The governing and insuring of these features are simple. However, not making all the decisions, so when there's an accident either the driver made a mistake, or the system was faulty. A government must impose regulations that will make decisions so when there's an accident either the driver made a mistake, or the system was faulty. A government must impose regulations that will make decisions so when there's an accident. And therefore the car manufacturer will be reviewing the situation because it should be determined whether the programming, and therefore Tesla, was at fault, or if the driver could have done more prevent the situation from happening. In general, though, there will also be a bit of question in most of these situations until the technology has been perfected enough until Level 4 automation. And that also brings up another point as to whether Level 4 automation is even feasible, or if the human population would actually want a machine to make the ethical decisions that would have normally been assigned to a human that has the moral capacity to make those decisions themselves.

In determining who is liable, one must also determine which ethical perspective they are going to view the entire situation from. Will the ethical cases be evaluated under a utilitarian perspective; under which automated vehicles might one day be created to act? Or will we have to view the given situations from an individual rights perspective, considering there is no Level 4 automation in our world yet and therefore each vehicle today and in the near future will probably be used in other normal situations. In addition, an insurance company must only worry about faulty. A government must impose regulations that will probably run at least somewhat through the driver. And therefore each vehicle today and in the near future will probably be used in other normal situations. In addition, an insurance company must only worry about faulty. A government must impose regulations that will probably run at least somewhat through the driver. And therefore each vehicle today and in the near future will probably be used in other normal situations. In addition, an insurance company must only worry about faulty.
be making all the decisions. The ethical perspective of individual rights connects back to the value that we have in our own lives and how our decision making process is a personal result of that. Level 4 autonomy takes away the driver’s control over the vehicle and its decision making. This entire situation becomes difficult because it all comes down to how intricately and how advanced the programming is in the vehicle. If the programming is advanced enough to make decisions like that, and the driver doesn’t have to intervene, then it could fall on the manufacturer’s shoulders. It is not designed to make those types of decisions and the person willingly purchases the vehicle knowing that piece of information, most of the issues that arise will fall on the driver.

The ethical perspective of individual rights connects back to the value that we have in our own lives and how our decision making process is a personal result of that. Level 4 autonomy takes away the driver’s control over the vehicle and its decision making.

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4 The Direction of Autonomous Vehicle Adoption

Today driverless cars with Category 3 or greater autonomy are still under development. The vast majority of cars are limited to cruise control and parking assistance. The governing and insuring of these features are simple. Cars are limited to cruise control and parking assistance. The currently available data shows that self-driving cars do not make decisions on their own. They rely on data from sensors and algorithms. The ethical decision-making process of these cars is not fully autonomous. The driver still has control over the vehicle and can intervene if necessary.

Viewing the situation with Tesla from a perspective that includes individual rights brings in many other questions to the dilemma at hand. Because of this situation in which the car actually fell under Level 3 autonomy, should the blame fall on the owner? The problem is that Tesla, and many other car manufacturers sell these vehicles knowing that clear that the vehicles will for the most part keep you safe but there are situations where the driver will need to intervene because today’s technology cannot yet cover all bases. Tesla at the time could not program the vehicle with advanced enough thoughts to be able to distinguish between a tractor trailer and an overhanging sign, but to the driver’s knowledge, in most other normal situations, the vehicle would have been able to act in a manner that would have saved the driver’s life. But since there was room for the driver to act, does it fall on the driver to blame or does it fall on Tesla? This entire situation becomes difficult because it all comes down to how intricately and how advanced the programming is in the vehicle. If the programming is advanced enough to make decisions like that, and the driver doesn’t have to intervene, then it could fall on the manufacturer’s shoulders. It is not designed to make those types of decisions and the person willingly purchases the vehicle knowing that piece of information, most of the issues that arise will fall on the driver.

In determining who is liable, one must also determine which ethical perspective they are going to view the entire situation from.

at it from an individual rights perspective because you have to consider the individual’s right to the power and the ability to stop the disaster from taking place, but the question comes when you ask: should they have had to make that decision? This is why that specific office will be reviewing the situation because it should be determined whether the programming, and therefore Tesla, was at fault, or if the driver could have done more to prevent the situation from happening. In general though, there will also be a bit of question in most of these situations until the technology is perfected. That is where we are until Level 4 automation.

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THE LEHIGH REVIEW

4.1 INFLUENTIAL STATISTICS

The difficulty in governing autonomous vehicles comes when cars begin making the decisions. A government cannot impose punishments on a vehicle that was in an accident. Cars cannot pay tickets. So what happens when a Level 4 autonomous vehicle speeds or runs a red light? Whose fault is it? Who pays the ticket? These questions, along with those scenarios presented in the previous sections, lead to a much more difficult regulatory issue. The complicated nature of autonomous vehicle legislation is the reason that only twelve states have passed any laws on the topic. These laws are all over the map in terms of scope, and only aim to set a foundation for future regulation on these types of vehicles.

Many people ask the question why should we bother creating or even allowing the use of autonomous vehicles. Evidence provided in section 2 suggest that people aren’t eager to put their lives in the hands of computers. They would rather control their own vehicles. So why don’t we just outlaw this technology and make it easy?

The answer is that the traditional human driven car is not very safe. Whether people would rather drive their own vehicle or not, it can’t be argued that humans are perfect. According to the Association for Safe International Road Travel, almost 1.3 million people die in road crashes every year. That doesn’t include the twenty to fifty million people who are injured in accidents. These accidents are expensive too. They cost the United States, for example, 230 billion dollars every year. This is $820 per capita. It’s clear there is room for improvement, and automated vehicles could be the answer. To ignore the potential safety improvements of autonomous vehicles would be to ignore the value of the lives they could save.

The safety of autonomous vehicles cannot be precisely evaluated as a Level 4 system does not yet exist. However, considering a world where a computer sending and receiving impulses at the speed of light and is quicker reacting than the human brain is not difficult. As previously discussed, utilitarianism finds it essential to maximize benefit to a society rather than to an individual. Even without forcing cars to be programmed in a utilitarian manner, this ethical theory would side in a utilitarian manner, this ethical theory would side with not allowing humans to drive on the road. Although each individual driverless car may not make a utilitarian decision when it comes to the crossroads presented in risk when self-driving cars are available? On the other hand, should people be forced to be at the mercy of an autonomous vehicle if they would rather be in control of themselves?

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The current statistics on the safety of driving are troubling. However, the potential savings from the prevention of accidents caused by basic human error are reassuring for the future of autonomous vehicles; these driverless cars could be the solution. It is clear that the easiest solution would be not to deal with the issue and prevent driverless cars from hitting the road to avoid dealing with the difficult situations that arise. However, not saving lives that could be saved in order to prevent conflict is unethical. When technology becomes better at controlling a vehicle than humans are, it will be necessary that we encourage the development and adoption of the technology.

4.2 DRIVING RESTRICTIONS

The previous section established the idea that autonomous vehicles could be the answer to the dangerous state of the roads in the world today. In order to save the most amount of lives, we must adopt the safest practical method of transportation. If the autonomous vehicles does indeed surpass the safety of traditionally driven cars, what will be the fate of traditional vehicles? Today traditionally driven vehicles are the only choice for people needing to travel by car. If technology continues to progress, one day that will not be the case. At that point, either driverless cars and human-driven cars will have to share the road with each other, or human drivers will be no more. This reality results in a few ethical dilemmas; Is it right to allow people to drive cars themselves and put others lives at risk when self-driving cars are available? On the other hand, should people be forced to be at the mercy of an autonomous vehicle if they would rather be in control of themselves?

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Figure 5: Estimates of Annual Economic Benefits from Autonomous Vehicles in the United States

<table>
<thead>
<tr>
<th>ASSUMED ADOPTION RATE</th>
<th>10%</th>
<th>50%</th>
<th>90%</th>
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<tbody>
<tr>
<td><strong>CRASH COST SAVINGS FROM AVs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lives saved (per year)</td>
<td>1,100</td>
<td>9,600</td>
<td>21,700</td>
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<tr>
<td>Fewer crashes</td>
<td>211,000</td>
<td>1,880,000</td>
<td>4,220,000</td>
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<tr>
<td>Economic cost savings</td>
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<td>$48.8 B</td>
<td>$109.7 B</td>
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<tr>
<td>Comprehensive cost savings</td>
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<td>$158.1 B</td>
<td>$355.4 B</td>
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<tr>
<td>Economic cost savings per AV</td>
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<td>$960</td>
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<tr>
<td>Comprehensive cost savings per AV</td>
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<td>$3,100</td>
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<td><strong>CONGESTION BENEFITS</strong></td>
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<tr>
<td>Travel time savings (millions of hours)</td>
<td>756</td>
<td>1680</td>
<td>2772</td>
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<tr>
<td>Fuel savings (millions of gallons)</td>
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<td>$244</td>
<td>$550</td>
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<tr>
<td>Savings per AV</td>
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<td>$63.0 B</td>
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<tr>
<td>Savings per AV</td>
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<td>$590</td>
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<tr>
<td><strong>OTHER AV IMPACTS</strong></td>
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<td>Parking spaces</td>
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<td>$15.90</td>
<td>$28.70</td>
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<tr>
<td>Savings per AV</td>
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<td>$250</td>
<td>$250</td>
</tr>
<tr>
<td>Vehicle miles traveled increase</td>
<td>2.0%</td>
<td>7.5%</td>
<td>9.0%</td>
</tr>
<tr>
<td>Change in total # of vehicles</td>
<td>-4.7%</td>
<td>-23.7%</td>
<td>-42.6%</td>
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<tr>
<td>Annual savings: economic costs only</td>
<td>$25.5 B</td>
<td>$102.2 B</td>
<td>$201.4 B</td>
</tr>
<tr>
<td>Annual savings: comprehensive costs</td>
<td>$37.7 B</td>
<td>$211.5 B</td>
<td>$447.1 B</td>
</tr>
</tbody>
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The complicated nature of autonomous vehicle legislation is the reason that only twelve states have passed any laws on the topic.11 These laws are all over the map in terms of scope, and only aim to set a foundation for future regulation on these types of vehicles.

Many people ask the question why should we bother creating or even allowing the use of autonomous vehicles. Evidence provided in section 2 suggest that people aren’t ready to give up control of their own vehicle. Why don’t we just outlaw this technology and make it easy?

The answer is that the traditional human driven car is not very safe. Whether people would rather drive their own vehicle or not, it can’t be argued that humans are perfect. According to the Association for Safe International Road Travel, almost 1.3 million people die in road crashes every year. That doesn’t include the twenty to fifty million people who are injured in accidents. These accidents are expensive too. They cost the United States, for example, 230 billion dollars every year. This is $820 per capita.23

It’s clear there is room for improvement, and automated vehicles could be the answer. To ignore the potential safety improvements of autonomous vehicles would be to ignore the value of the lives they could save.

The safety of autonomous vehicles cannot be precisely evaluated as a Level 4 system does not yet exist. However, the potential savings from the prevention of accidents caused by basic human error are reassuring for the future of autonomous vehicles; these driverless cars could be the solution. It is clear that the easiest solution would be not to deal with the issue and prevent driverless cars from hitting the road to avoid dealing with the difficult situations that arise. However, not saving lives that could be saved in order to prevent conflict is unethical. When technology becomes better at controlling a vehicle than humans are, it will be necessary that we encourage the development and adoption of the technology.

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Figure 4, a community of safe autonomous vehicles would be as safe as a whole in a mixture of autonomous and non-autonomous cars. This would suggest that it is best to disallow the use of human driven cars once automated vehicle technology is widely available and affordable.

However, the human rights perspective of ethics would suggest that forcing everyone to use driverless cars is unethical. According to this theory, people’s individual rights are of the utmost importance. The most applicable right in this situation is one’s right to a freedom of choice. Applying this right to the question of allowing human-driven cars on the road with autonomous cars would lead one to conclude that each person should have the right to decide what type of vehicle they are most comfortable with. They should be able to decide whose hands they put their own lives into. It is for this reason, that disallowing human-driven vehicles may prove to be controversial; it may be unethical to deny people the freedom of choice.

The solution is much more clear, however, after realizing that the individual rights theory of ethics breaks down in this situation. Although it is important that people have the right to decide for themselves what type of car they get into, it is also important that others have the right to keep themselves out of harm’s way. The individual also has the right not to put themselves on the road with human drivers who are more dangerous than automated vehicles. It could be said that these people still have the choice not to get on the road at all. However, that would be putting the rights of someone wishing to drive themselves over the rights of someone wishing to be safe. Therefore, the ethical theory of individual rights as applied here contradicts itself. The rights of one cannot be put above the rights of another to keep themselves out of harm’s way.

5 CONCLUSION
Vehicles are becoming ever more independent from the input of human beings. The creation of autonomous vehicles that are capable of operating without any input from human beings is ethical. According to this theory, people’s individual rights are of the utmost importance. The most applicable right in this situation is one’s right to a freedom of choice. Applying this right to the question of allowing human-driven cars on the road with autonomous cars would lead one to conclude that each person should have the right to decide what type of vehicle they are most comfortable with. They should be able to decide whose hands they put their own lives into. It is for this reason, that disallowing human-driven vehicles may prove to be controversial; it may be unethical to deny people the freedom of choice.

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5.1 DERIVE AN ETHICAL THEORY TO APPLY
In the United States, individual rights are often seen as the only important rules guiding ethical dilemmas. However, sometimes individual’s rights conflict with each other. At this point it becomes difficult to discern the right decision from the others. It is for this reason, that individual rights cannot be the solution to all of the issues regarding autonomous vehicles. Utilitarianism is also not without its faults. What is best for society is often times not what is best for the individual. This means that an individual may not make decisions that are compatible with utilitarianism. At this point, utilitarianism also breaks down.

The first issue discussed in this analysis of automated vehicle ethical dilemmas was a situation in which a car must choose between harming its passengers or pedestrians. Automated vehicles must be programmed to handle this situation before they are able to operate on public roads. The theory of utilitarianism would suggest that the person in the car is not worth more just because they are the owner of the vehicle. Therefore, balancing harm to multiple people in a crosswalk rather than the individual in the car would likely be unethical behavior for a car. However, utilitarianism conflicts with each other as well. It is illegal to override one’s programmed thinking. Therefore, that vehicle must be programmed this way. If cars are programmed not to make their passengers’ lives the most important thing, fewer people may be willing to purchase them. In addition, in order for these vehicles to be created, car manufacturers are going to be seen as less of the blame placed on them as possible in the event of an accident. A car that is programmed to not give the driver choice in the matter and act in a utilitarian manner will likely result in more blame being placed on a manufacturer. This is because the only choice that was

made was by the manufacturer itself, rather than the car owner. Therefore the car owner could not easily be found to be at fault.

If automated vehicles became safer than non-automated vehicles, then the utilitarian goal would be to encourage as many people as possible to purchase this type of vehicle. This is contradictory in that utilitarian vehicles would be less popular, and therefore society would be worse off, contradicting the utilitarian goal.

5.2 ETHICAL DILEMMA
The solution is much more clear, however, after realizing that disallowing human-driven vehicles may prove to be controversial; it may be unethical to deny people the freedom of choice.

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Although it is important that people have the right to decide for themselves what type of car they get into, it is also important that others have the right to keep themselves out of harm’s way.

The right of the individual to control the movement of the vehicle they are within should never be overridden. It must be possible, but not necessarily legal, that an autonomous vehicle be overridden by a passenger at any time. A lack of legality may be maintained in order to assure the maximum safety of society. However, the maintenance of human control allows one to step beyond the law and exercise their individual rights in the event of an emergency. In other words, human control of autonomous vehicles must be possible, but not necessarily without consequence.

Finally, as autonomous vehicles become increasingly safe in comparison to their non-autonomous counterparts, the right of an individual to drive shall not overrule the right of another to safe travel. Therefore, in order to ensure the maximum safety and benefit to society, self-driving vehicles, at a time where they are comparable in price and availability to non-autonomous vehicles, should be the only vehicles permitted on public roadways.

These guidelines will ensure the maximum benefit to society while maintaining as much of an individual right as possible.

The ethical dilemma that is the autonomous vehicle is a complex issue to resolve with a simple code of ethics. It needs to be sure to encourage the adoption of the technology that will benefit society. It also has to be compatible with the rights and the desires of the individual, or they will make the decision not to adopt the technology. In order to ensure the most positive outcome of the advancement of automated vehicle technology for society and the individual, the following guidelines should be applied:

I. Automated vehicles must value the wellbeing of all individuals within and outside of the vehicle equally in order to ensure a minimization of net damage to society in the event of an accident. In other words, they must be utilitarian while operating on their own.

II. The right of the individual to control the movement of the vehicle they are within should never be overridden. It must be possible, but not necessarily legal, that an autonomous vehicle be overridden by a passenger at any time. A lack of legality may be maintained in order to assure the maximum safety of society. However, the maintenance of human control allows one to step beyond the law and exercise their individual rights in the event of an emergency. In other words, human control of autonomous vehicles must be possible, but not necessarily without consequence.

III. Finally, as autonomous vehicles become increasingly safe in comparison to their non-autonomous counterparts, the right of an individual to drive shall not overrule the right of another to safe travel. Therefore, in order to ensure the maximum safety and benefit to society, self-driving vehicles, at a time where they are comparable in price and availability to non-autonomous vehicles, should be the only vehicles permitted on public roadways.

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However, the human rights perspective of ethics would suggest that forcing everyone to use driverless cars is unethical. According to this theory, people's individual rights are of the utmost importance. The most applicable right in this situation is one's right to freedom of choice. Applying this right to the question of allowing human-driven cars on the road with self-driven cars would lead one to conclude that each person should have the right to decide what type of vehicle they are most comfortable with. This would be able to decide whose hands they put their lives into. It is for this reason, that disabling human-driven vehicles may prove to be controversial; it may be unethical to deny people the freedom of choice.

The solution is much more clear, however, after realizing that the individual rights theory of ethics breaks down in this situation. Although it is important that people have the right to decide for themselves what type of car they get into, it is also important that others have the right to keep themselves out of harm's way. The individual also has the right not to put themselves on the road with human drivers who are more dangerous than automated vehicles. It could be said that these people still have the choice not to get on the road at all. However, that would be putting the rights of someone wishing to drive themselves over someone wishing to be safe. Therefore, the ethical theory of individual rights as applied here contradicts itself. The rights of one cannot be put above the rights of another, and therefore the ethical theory applied to the situation. For this reason, a decision on public roads. The theory of utilitarianism would suggest that the person in the car is not worth more just because they own the car in question. Therefore, harming multiple people in a crosswalk rather than the individual in the car would likely be unethical behavior for a car. However, utilitarianism conflict with each other. At this point it becomes difficult to discern the right decision from the others. It is for this reason, that individual rights cannot be the solution to all of the issues regarding automated vehicles. Utilitarianism is also without its faults. What is best for society is often times not what is best for the individual. This means that an individual may not make decisions that are compatible with utilitarianism. At this point, utilitarianism also breaks down.

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