Autonomous Vehicles Impact on Accessibility to Transportation

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Abstract

Autonomous vehicles are growing in popularity with promises of safe efficient travel. This paper addresses the issues surrounding autonomous vehicles' impact on accessibility to transportation, infrastructure design, and challenges in both cost and time associated with their widespread adoption using Actor-Network Theory and various case studies. The case studies explore the ideas of people's greatest concerns with autonomous vehicles, the most common causes of automobile accidents, and the financial costs associated with public transportation. Safety and trust were found to be the two largest barriers to the widespread adoption of autonomous vehicles, although autonomous vehicles are typically safer than human-driven vehicles. After the widespread adoption of autonomous vehicles, public infrastructure has the potential to require less maintenance and lead to future roads being more minimalistic. Additionally, there can be an increase in accessibility to transportation for people who traditionally could not drive and a reduction in the cost of the public transportation sector.

Autonomous Vehicles Impact on Accessibility to Transportation

Cars needed infrastructure, and people began getting into fatal accidents. In 1925, the annual death rate was 18 per 100 million vehicle miles traveled, and it was not until the 1960s that systematic motor vehicle safety efforts began (Centers for Disease Control and Prevention, 1999). Driving requires the consideration of many factors to ensure a safe trip. As computers became more powerful and widespread, the idea of using a computer to process all the variables associated with driving was born. Autonomous driving systems can provide a higher level of safety for passengers and the surrounding people. Shown in a study done by the National Highway Traffic Safety Administration (NHTSA), 94% of serious crashes are due to human error (National Highway Traffic Safety Administration, n.d.). With this statistic in mind, to increase the rate of adoption of autonomous vehicles many social issues will need to be addressed before this technology can deliver on its promise of increased safety. This paper addresses issues of the impact on accessibility to transportation, infrastructure design, and challenges in both cost and time associated with the widespread adoption of autonomous vehicles.

The scope of this paper is focused on the analysis of how the urban landscape will be altered as a result of autonomous vehicles using Actor-Network-Theory. This will include looking at strategies for redesigning urban areas as well as new requirements for future infrastructure that are based on autonomous driving systems. Finally, high-level challenges such as cost, development, and public trust will be considered using a framework developed in (Cioroaica et al., 2020). Ideas about the ethical challenges and implications of autonomous vehicle systems will not be addressed in this paper.

First, the idea of safety and trust in autonomous vehicle systems will be discussed to help provide more insight into why the adoption of autonomous vehicles is likely. Within the topic of safety and trust, concerns about privacy and security will be addressed. Following this, the way that autonomous vehicles can impact accessibility and alter the urban landscape will be discussed. During this discussion, the costs and requirements of such projects will be considered.

Safety and Trust

For autonomous vehicles to become an acceptable and reliable means of transportation, the people that are expected to use these vehicles must have trust in the systems that they are safe and will work well under the given conditions. If these conditions are not met, the technology cannot provide an alternative accessible means of transportation. Actor-Network Theory is a method to describe the network of relationships among the natural and social worlds. This theory will allow for a thorough analysis of the social and physical impact autonomous vehicles will have on accessibility to transportation, as well as the urban landscape (Crawford, 2020). Actor-Network Theory will be used to analyze the relationship between the companies creating the autonomous vehicle systems, government regulators, drivers with disabilities, drivers without disabilities, urban planners, and public infrastructure. The dynamics of trust and safety are between the companies creating the autonomous vehicle systems, government regulators, and drivers.

Trust in autonomous vehicle systems is currently one of the greatest barriers to the adoption of these systems. Not only does the driver need to trust that the vehicle will not crash while driving to its destination, but the driver may also have concerns about privacy and security. In a study consisting of drivers and non-drivers, the two biggest areas for concern about using

autonomous vehicles were keeping personal data collected by the car hidden, and protection from having the vehicle hacked by an outside entity (Kaur & Rampersad, 2018). This idea of building a system that is secure from outside hackers and preserves the user's personal information creates great additional challenges.

Although building secure systems is particularly relevant in fully autonomous systems, current non-autonomous vehicles are also susceptible to similar types of attacks from outside entities. For example, researchers were able to compromise the onboard computer diagnostic port, a U.S. mandated feature on modern cars. By compromising this feature, the researchers were able to stop the car's engine, lock the doors, and disable the brakes (Wright, 2011). Since securing automotive systems from outside hacking is a common issue throughout the entire automotive industry, it should not significantly hinder the adoption of autonomous vehicles, but people perceive it to be a bigger issue when related to autonomous vehicles. This poses the need for companies to inform drivers of the security of their autonomous vehicles compared to their non-autonomous counterparts if they want to increase the rate of adoption. Government regulators can also play a strong role in shaping the perception of trust drivers have in autonomous vehicle systems. Since the government is generally an elected body, they have an obligation to enact legislation that is both aligned with the views of its constituents and in the constituent's best interest. As the government creates more regulations and benchmark safety standards that must be met, the public trust could be altered for a particular company based on how well they react to the imposed regulations.

One method to attempt to gain public trust in autonomous vehicle systems can be done using the framework described in (Cioroaica et al., 2020). This framework relies on incrementally increasing the functionality of the autonomous vehicle system, while still keeping

the driver well informed as to what decisions are being made and what is being considered. The concept is derived from the neurological feedback loop of human behavior proposed by James Clear. In practice, this would look like slowly adding more features that can do small tasks autonomously to vehicles that are not marketed as autonomous. People will have the option to use the autonomous functionality while remaining fully in control with the standard steering wheel, accelerator, and brake pedals. Compounding many of these small features can smooth the transition to trusting fully autonomous vehicles. Although this framework seems promising, many drivers are enthusiasts and would prefer not to use autonomous features even if they are available because they love driving. Another potential issue with this framework is it assumes that the driver is knowledgeable about how to safely engage and interact with the autonomous system, which may not be true.

A concern drivers often have is if they will arrive safely at their destination. Driving can be a very mentally taxing activity as many variables must be taken into consideration to safely get to a destination. According to the National Safety Council, it is three times more likely that one will be in a car accident if one is fatigued (*Fatigued Driver - National Safety Council*, n.d.). By having computers process the world around us while driving, there can be significantly fewer factors that are overlooked. When analyzing crash casual data from NHTSA, “Thirty-three percent of crashes involved only sensing/perceiving factors” (Mueller et al., 2020). This is a substantial number of accidents that could likely be prevented by utilizing autonomous vehicles to perceive and make choices about their current environment. The feeling of safety is an important factor that auto manufacturers often try to appease. With the potential to save so many lives and significant sums of money by reducing accidents, companies will be incentivized to produce high-quality autonomous vehicles that will likely be widely adopted in the future.

Impact on Accessibility and the Urban Landscape

Once autonomous vehicles begin to expand in their usage, different means of transportation will be altered in the way they are currently used. The different transportation systems such as private vehicles, public busses, and public trains could be automated and provide extended hours of service on demand. As these means of transportation change, the prioritization that travelers place of the various means may lead to a change in the urban landscape.

In the United States, there are currently 25.5 million people who are unable to drive themselves due to a travel-limiting disability (Bureau of Transportation Statistics, 2022). This group of people must rely on others for means of transportation. By having an autonomous vehicle option, this significant number of people would no longer have to depend on others for their transportation needs. Multiple scenarios would permit traditional non-drivers increased accessibility to transportation. The first scenario is the private ownership of autonomous vehicles, which could provide an easy and reliable form of transportation. An alternative is a car-sharing network like Uber in which private autonomous vehicles that are not currently being used by anyone could be summoned and taken to a destination. This idea of creating a car-sharing network can be an incentive to auto manufacturers to build this capability into their vehicles as the owner providing their car to the network could be a way for the owner to generate revenue while the car is traditionally idle. Additionally, by automating public transportation the cost of hiring drivers could be reduced. In the case of Capital Metro, 45% of the agency's operating budget was spent on paying bus drivers (Quarles et al., 2020). With the cost reduction, these funds could be allocated to the running of the transit systems with more expansive hours.

Expanding the service hours that public transportation operates, would increase the accessibility to safe, reliable means of transportation.

Increasing the number of people that utilize ridesharing as their main method of transportation can reduce the total number of vehicles on the road, and thus reduce overall energy usage. Though the ride-sharing application and extensive use in the public transportation system is the most optimistic use case for autonomous vehicles regarding reducing energy consumption while maintaining a safe accessible means of transportation, there will likely be many privately-owned autonomous vehicles. The influx of privately-owned autonomous vehicles will lead to a shift in traffic flow in urban areas. Using the findings from a study done by Levin and Boyles, in the beginning, phases of autonomous vehicle adoption travel times will likely be reduced (Levin & Boyles, 2015). The study uses a generalized cost function of travel time, monetary fees, and fuel to model the cost of a trip. In the early stages of autonomous vehicles, being taken to a destination rather than having the car return to the origin will often result in the lowest overall cost rather than finding paid parking. This relies on standard traffic patterns before the widespread adoption of autonomous systems. As the technology becomes more accessible through price reductions, roads will begin to experience greater forms of congestion as the norm becomes getting dropped off and having the car return to its original location.

As shifts in traffic flow occur during the progression of autonomous vehicle adoption, re-designing the way pedestrians and vehicles interact with the city may make for a more pleasant and accessible experience when traveling. The desire of commuters to redesign transportation routes will put pressure on governments to rethink their zoning laws and design more modern transportation routes. A model to turn low-performance roads into urban spaces better suited for pedestrians is presented in (Consilvio et al., 2019). By converting low-performance roads to

urban spaces, there could be safer bike lanes or pedestrian walking routes while still maintaining the high-performance roads in a traffic network. This separation maintains highly efficient traffic flow, while also making pedestrian routes more accessible to people in wheel-chairs, who oftentimes have trouble navigating narrow sidewalks alongside roadways. Separating pedestrians and vehicles can also reduce accidents involving pedestrians. Many pedestrian crashes occur when the driver does not see the pedestrian before the accident, and at higher vehicle speeds there is a greater likelihood of crashes involving pedestrians (Retting et al., 2003). By separating the places in which pedestrians are walking and vehicles are driving at higher speeds, the number of interactions that could lead to an accident involving pedestrians is greatly reduced.

When thinking about the designing of urban structures going from a driver-centric design to an autonomous vehicle-centric design, there can be many significant differences in the requirements. Humans rely on visual, audio, and tactile cues from their environment to drive. Autonomous vehicles have a variety of sensors that can be utilized to drive. These sensors include LiDAR, radar, cameras, and ultrasonic sensors (Campbell et al., 2018). An issue companies face when choosing which types of sensors to integrate into their autonomous systems is the weight and cost of the sensor. LiDAR is a relatively heavy and expensive sensor, whereas cameras weigh less and are typically cheaper. The cost and weight of the sensors may impact consumers' choice as to which type of autonomous system to go with depending on if they care about having a performance-oriented vehicle or a cheaper effective system. Focusing on the particular case of LiDAR, LiDAR sensors can generate highly accurate 3D models of the surrounding world without the need for ambient lighting. With a highly accurate model, an autonomous vehicle would not need as large of tolerances as humans do when designing roadways. This could result in a smaller area of land needing to be allocated for vehicles to

safely utilize. Similarly, autonomous vehicle systems do not need road signs as they have built-in navigation services that guide them. Additionally, the lack of requirement for ambient lighting for the system to work removes the need for street lights on interstate systems. If a particular system such as LiDAR becomes the predominant choice for auto manufacturers, a shift in requirements from a driver-centric roadway to an autonomous vehicle-centric roadway could result in roads that look very different from the roads we see today, while also potentially reducing infrastructure costs.

Before roadways are designed specifically for autonomous vehicles, there will be a progression in stages where both human drivers and autonomous vehicles will interact. Since the roadways are currently designed for human drivers, this will influence the design approach that companies take when creating their autonomous vehicles. One current design approach is a connected autonomous vehicle system, where the vehicles can communicate with one another to ensure that the actions of one vehicle are not harmful to another. This type of system raises privacy concerns for consumers as each vehicle nearby must know some information about their travel plans. An experiment conducted showed once 10% of cars on the roadway are connected and autonomous, there is approximately a 56% reduction in overall conflicts between vehicles (Virdi et al., 2019). In a scenario where a higher percentage of the vehicles on the road are connected and autonomous, there would be an even more significant increase in the level of safety for everyone on the road.

Financial and Safety Criticisms

One common criticism of the widespread adoption of autonomous vehicle systems is the financial costs associated with making the transition from driver-centric vehicles to fully

autonomous. This is a valid criticism as the upfront cost would be significant, but as previously noted there would be reduced costs for operating public transportation systems, a significant reduction in accidents, and less required maintenance of public infrastructure. The adoption of autonomous vehicles would likely start with private individuals purchasing them as luxury items. Following the luxury market, the adoption of autonomous systems into public transportation could reduce costs by 45% just in driver's wages, this is before accounting for any potential savings from repairing the vehicles from accidents and lawsuits that result from accidents (Quarles et al., 2020). Additionally, as autonomous systems evolve and depending on the particular type of sensors used, the number of resources allocated to creating and maintaining roads could be reduced as the vehicles would not need as much infrastructure to safely operate.

Another common criticism of autonomous vehicles is that these systems are not as safe as a human driver twofold, because humans have more experience driving, and because these autonomous systems are vulnerable to hacking. On the note of the systems not being as safe as human drivers, humans are often the cause of serious accidents. As previously noted, 94% of serious crashes are due to human error (National Highway Traffic Safety Administration, n.d.). Humans get distracted and fatigued while driving, something that would not occur for autonomous systems. In this regard as long as the autonomous system is working properly, it should result in overall safer driving conditions for everyone on the road. Additionally, in many states, the government requires auto manufacturers to meet minimum safety requirements before the systems are allowed to be used on public roadways. Moreover, while the hacking of autonomous vehicle systems is a significant concern, this is not only a concern related to autonomous vehicles but rather all modern vehicles that use digital systems to operate. The perceived notion that it is a bigger deal in autonomous systems likely roots in the idea that there

are no physical inputs for the driver to take back control of the car. Although this is true in some models of autonomous vehicles, the physical inputs in non-autonomous cars can be rendered effectively useless when infected by outside hackers. The driver may feel that they have more power in this situation, but they are in the same situation, either way, therefore in this regard both the autonomous and driver-centric vehicles have the same safety concerns that any modern vehicle would have.

Conclusion

Autonomous vehicles have the potential to greatly alter the urban landscape as well as the way humans interact with various modes of transportation. The major challenges associated with the widespread adoption of this technology are that people must feel safe and trust these systems before relying on them to transport them safely. Companies are at odds with consumers and regulators as they attempt to create safe effective autonomous systems that comply with current legislation. One potential strategy to overcome these challenges is by incrementally adding more small autonomous features to vehicles to build users' comfort levels. While adding these features, users will feel in control and have a better understanding of what the car is doing and why it is choosing to make the choices that it does. After these challenges are overcome, a larger group of people can become transportation independent with the freedom and convenience that autonomous vehicles provide. Once autonomous systems are widely adopted, consumers will likely push their government to shift toward autonomous-centric public infrastructure because of the increases in accessibility and cost reductions associated with this model. However, the path for adoption of autonomous vehicles may vary greatly in societies with differing infrastructure and legal frameworks than the United States.

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