The Impact of Autonomous Vehicle Popularization on Safety, Comfort, and Overall Traffic Development

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Abstract:

With the high-speed development of AI, machine learning, visual identification, and varieties of technology, autonomous vehicles are becoming more and more perfect in their design, safety performance, and function, and some autonomous vehicle companies have some chances to test the reliability of their products on roads with vehicle piloted by humans in some countries. The paper aims to understand the impact of autonomous vehicle popularization on safety, comfort, and overall traffic development and the feasibility of solving some existing problems that autonomous vehicles are facing. The paper offers some suggestions for future autonomous vehicle research and accomplishing autonomous vehicle popularization. The paper shows the futural traffic system and people's travel experience.

Keywords: autonomous vehicle, safety, comfort, traffic development, and popularization.

Introduction:

An autonomous vehicle can control and navigate its own movement autonomously without drivers intervening by computer systems, AI, sensors, and other kinds of technology. The concept of autonomous vehicles dates back to Futurama at the World Expo in New York. At that time, General Motors showed its imagination of the Automated Highway System (AHS). Since the 1980s, some universities in the USA, like MIT, Carnegie Mellon University, and Stanford University, began their research on autonomous vehicles and gained some achievements. Among these achievements, the NavLab system from CMU is the most representative. After that, many automobile manufacturers began their layouts in the field of autonomous vehicles. In 2015, Tesla unveiled its semi-autonomous driving system, Autopilot, which is the first commercialized autonomous driving technology.

In 2016, General Motors purchased Cruise Automation, an entrepreneurial firm that produces autonomous driving technology. Nowadays, New technology forces represented by Google have entered the field of autonomous driving. Most of these companies adopt a one-step autonomous technology development route: direct research and development of SAE Level 4+ driverless vehicles. Google Driverless Cars was tested at the end of 2012 and has driven over 480,000 kilometers. These cars were tested on several roads in California by using cameras, radar sensors, and laser rangefinders to see different traffic conditions and using detailed maps to navigate the road ahead. Tesla is taking a different technological route by adopting a purely visual approach compared to Google. Tesla has removed all the ultrasonic radars from its products and uses the Tesla Vision visual processing system based on the Occupancy Network. At the same time, some Chinese electric vehicle manufacturers, such as NIO, ZEEKR, Li Auto, and XPENG, are developing their autonomous driving systems with their original technical routes. They all choose to take the route that includes laser radars and visual cameras. They use this hardware, powerful computing chips, and algorithms to give drivers better driving advice and avoid accidents by intervening in driving. Although autonomous vehicles are becoming perfect and have gained great progress in different conditions, people are still worried that the usage of autonomous vehicles may threaten drivers and pedestrians. Some news articles about accidents caused by autonomous vehicles are destroying people's faith step by step. The study aims to understand the impact of autonomous vehicle popularization on safety, comfort, and overall traffic development and prompt governments, vehicle manufacturers, and the public to speed up the process of misusing manned vehicles and the popularization of autonomous vehicles.

Impact on safety

Safety is one of the most important factors that decide the autonomous vehicle popularization, and it is also what people are worried about the most. Autonomous vehicles perform better than manned vehicles, and autonomous vehicles are becoming perfect. An autonomous vehicle's navigation system and many other safety features are designed to solve almost all problems that may happen in

reality. Autonomous vehicle manufacturers continue to optimize these features and consider all possible scenarios.

Now, driver assistance technologies are widely used and can be seen as intermediate products on the road to autonomous vehicle popularization. " Vehicle safety promises to be one of automation's biggest benefits. Higher levels of automation, called automated driving systems, remove the human driver from the chain of events that can lead to a crash. While these systems are not available to consumers today, the advantages of this developing technology could be far-reaching. What is available to consumers today: active safety systems. These advanced driver assistance systems provide lower levels of automation that can assist a driver by anticipating imminent dangers and working to avoid them. Collectively, these technologies will help protect drivers, passengers, bicyclists, and pedestrians. " (NHTSA, 2023). Autonomous vehicles can avoid many problems and seriously obey the traffic rules, which most drivers cannot do. Autonomous vehicle systems can maintain absolute sanity, which means they will not be influenced by any emotional reason, which causes many accidents worldwide. Human drivers are easily influenced by many things around them and their own emotions. Drivers will feel tired and unable to concentrate after long driving, which means manned vehicles may be out of control, and drivers may not make the right decision in time to avoid the accident. "Through the analysis of the causes of traffic accidents, it is found that vehicle condition, technology, physical and psychological factors are the four major factors that cause car accidents. For drivers who have driven for many years, there is generally no problem regarding technology, and the most important ones are physical and psychological factors. According to statistics, the period from 11 a.m. to 1 p.m. and from 5 p.m. to 9 p.m. is the peak for accidents, accounting for 40% of the total accidents. According to the analysis, people are prone to nerve and visual fatigue during this period, which can easily lead to misjudgment and improper handling. In addition, it is also the peak period for commuting, with many emergencies such as mixed traffic of people and vehicles and pedestrians crossing the road. From midnight to 3 a.m., it is the time when people are prone to feeling sleepy and tired. As few vehicles and pedestrians are on the road at this time, many drivers may relax their vigilance and speed, which may easily lead to cars crashing into trees and buildings on the roadside, thus causing major traffic accidents. According to the introduction of traffic police comrades, beginners and new drivers are the high-risk groups for car accidents. Because these people do not observe the road conditions comprehensively, they often forget to look left and right,

look ahead and behind, and easily get confused and react slowly, which can easily lead to accidents. Not obeying traffic rules and not driving according to regulations are the main reasons for accidents. Drivers should be very careful; otherwise, they will either scratch or bump into something. Unhealthy driving psychology is an important latent cause of accidents. These psychological phenomena mainly include: some drivers drive angrily or aggressively on the road, not allowing other cars to overtake them; some drivers deliberately occupy the overtaking lane for a long time, regardless of the prompts from the cars behind them; some drivers rely on their superb skills and rush through the traffic; some drivers do not turn off their high beams when meeting other cars at night, using strong light to shine on the other party, causing blurred vision; some drivers are dissatisfied with the bad behavior of others and deliberately squeeze and overtake the other party during driving. These bad psychologies can also easily cause car accidents. As we all know, driving after drinking, driving while fatigued, speeding, and violating traffic rules are all very likely to cause traffic accidents. During driving, talking and joking with passengers, making phone calls, playing loud music, etc., can also easily distract drivers and reduce the accuracy of their judgment ". (Department of Information and Publicity, 2019) Autonomous vehicle systems can avoid all the situations above. Besides the intelligent features of autonomous vehicles, autonomous vehicle popularization means all the vehicles on the road can make the best decision and driving strategy, just like the game theory. All the cars can obey the traffic rules seriously, and no one will suddenly cut into the car line or run a red light, protecting both vehicles and pedestrians. Vehicular communication among autonomous vehicles, infrastructure, clouds, and pedestrians can both send and accept information about the traffic the vehicle collects. By sharing information such as location, speed, and direction in real-time, vehicles can predict the behavior of other vehicles, perceive the dynamics of the surrounding environment and other road users in advance, and respond in time to avoid or reduce collisions.

Impact on Comfort

Autonomous vehicles will cause a revolution in the feeling of driving. Drivers may lose their driving responsibility and become passengers if autonomous vehicles realize all the features of drivers and prove to the public that they are ready to replace all the drivers. After that, the drivers will be in the past, and all the people in the car can do whatever they like in the car. Now, thanks to the wide use of driver assistance technologies and fierce competition in the vehicle market, especially in the Chinese vehicle mar-

ket, vehicle manufacturers are constantly improving the comfort of their products and adding some functions that never appeared before. Li Auto, a famous Chinese vehicle manufacturer, brings many features into the design of its products to help bring drivers and passengers close together. Its products even have SPA-level 10-point massage seats and a big screen for the drivers. Driver assistance technologies can now detect hazards and do some driving work in the long-time driving to allow drivers to withdraw from driving and do some recreation. If autonomous vehicle popularization happens in the future, the vehicle will be the same for everyone in it, and everyone can enjoy its recreational facilities. Autonomous vehicle popularization also means that all autonomous vehicles will find the best route to give the passengers the most comfortable ride experience and spend the least time.

Besides, autonomous vehicles can give disabled people and other kinds of people who cannot drive a chance to go out by themselves.

Impact on Overall Traffic Development

Autonomous vehicle popularization means all the vehicle's routes and driving strategies on the road can be predicted by their communication, which can effectively reduce traffic congestion and promote traffic efficiency, especially during rush hour. "Americans spent an estimated 6.9 billion hours in traffic delays in 2014, cutting into time at work or with family, increasing fuel costs and vehicle emissions. Automated driving systems have the potential to improve efficiency and convenience. " (NHTSA, 2023). Autonomous vehicle popularization could force changes in urban planning and redesign of transportation infrastructure. The road now is designed to comfort the manned vehicle's behaviors. After autonomous vehicle popularization, the road may need some special signs and marks to help sensors on autonomous vehicles make more precise decisions and movements. As autonomous vehicle technology continues evolving, urban planning faces unprecedented changes.

Traditional transportation infrastructure design is primarily based on human drivers' needs and behavior patterns, but the introduction of autonomous vehicles will completely change that. As a result, redesigning transportation facilities to accommodate the needs of autonomous vehicles has become an important topic in urban planning. First, the design of traffic signals and signs may need to be updated. Autonomous vehicles rely on high-precision maps and sensors to sense and respond to their surroundings. Hence, traffic signals and signs must be more clearly and consistently set to accurately interpret and respond. Secondly, the design of traffic roads may

also need to be adjusted. Autonomous vehicles are driven more reliant on road markings and lane divisions, so the design of roads needs to be more precise and clearer. In addition, introducing autonomous vehicles may reduce the need for traditional parking facilities, as vehicles can automatically find parking spaces without human driving. Finally, the introduction of autonomous vehicles will also impact other aspects of urban infrastructure, such as public transportation, walking and cycling paths, and more. City planners need to consider these factors to ensure that autonomous vehicles are in harmony with the city's overall transportation system while meeting the needs and expectations of residents. Otherwise, less waste from vehicles means less consumption of resources. For gasoline vehicles, high road efficiency and less time stuck in traffic can reduce fuel consumption and carbon emissions. "The automotive industry is moving toward more automation and electrification, which both promise further safety improvements and better environmental practices. Vehicle automation will potentially change the need for individualized parking spaces and lots, with increased use of automated ride-share and shuttle fleets, which could dramatically transform land use. Also, vehicle electrification opens up possibilities to improve efficiency with less personal driving, further reducing air pollutants from the transport sector." (NHTSA, 2023) For electric cars, high road efficiency and the best route that the design of the autonomous system can help electric cars do more rational distribution of power and drive longer distances, effectively reducing people's anxiety about mileage, especially in winter when the battery cannot store energy well. With the improvement of people's environmental awareness and the strong support of governments for new energy vehicles, autonomous vehicles can have a perfect chance to complete integration with new energy vehicles.

Challenges and Problems

Autonomous vehicles, including radar, lidar, cameras, and more, rely on advanced sensors to perceive their surroundings. However, these sensors have limitations. For example, their performance in adverse weather conditions (e.g., fog, rain, snow) may be affected, resulting in reduced perception. In addition, there may be difficulties in perceiving certain objects (e.g., pedestrians, bicycles, motorcycles, etc.), as these objects may differ from conventional vehicles, and their movement patterns are more complex and unpredictable. Autonomous vehicles need to make fast and accurate decisions in complex traffic environments. However, due to the dynamics and uncertainty of the traffic environment, decision-making and planning algorithms for autonomous vehicles can face challenges. For

example, in traffic jams or complex intersections, autonomous vehicles must consider various factors, such as other vehicles, pedestrians, traffic signals, etc., to make the best driving decisions. This uncertainty in decision-making and planning can increase the risk of traffic accidents. In the event of an accident with a self-driving car, the attribution of liability is a complex legal issue. Traditionally, the driver is responsible for the operation and accidents of the vehicle. However, in the case of autonomous vehicles, liability can involve multiple parties, including the car manufacturer, software vendor, passengers, and more. Therefore, a new legal framework is needed to clarify the attribution of responsibilities to ensure a fair and equitable distribution of responsibilities. Autonomous vehicles may face situations where ethical decisions need to be made. For example, in an emergency, a vehicle may need to avoid harming pedestrians or passengers or sacrifice smaller damage to avoid a larger disaster.

Making these ethical decisions is critical to the widespread adoption of autonomous vehicles. However, how these decisions are made and how to balance the needs of different stakeholders is a controversial issue that requires extensive societal discussion and the development of ethical guidelines. For privacy, autonomous vehicles may illegally collect users' data, which may lead to privacy disclosure. "AI is gradually changing the technological services we use in our everyday lives. Among these is smart transportation, which is called AVs. These new machines are smart and know a lot about their users. They utilize this information to provide new attractive offerings and protect passengers from imminent dangers, among other things. But the problem is that collecting all that data presented new security and privacy attack surfaces that need to be appropriately handled." (Hataba et al., 2022) popularization.

Conclusion

Autonomous vehicle popularization still has a long way to go. An autonomous vehicle system is imperfect and is limited by many reasons. People now cannot fully trust the autonomous vehicle. The infrastructure is inadequate, and governments all over the world do not think it is the right time for autonomous vehicles. However, history tells us that autonomous vehicles need a long road that must be passed. After finishing it, the popularization of autonomous vehicles will come true. In 1885, Karl Benz invented the first motor car. However, the popularization and commercialization were finished in the 1920s. As an important part of the future of mobility, autonomous vehicles significantly positively impact safety, comfort, and overall mobility. By reducing human error, improving road safety, optimizing traffic flow, and reducing energy consumption, autonomous vehicles are expected to bring the public a safer, more efficient, and more convenient travel experience. However, numerous technical, legal, ethical, and social challenges must be overcome to successfully adopt autonomous vehicles. Future research should continue to focus on the innovation of sensor and perception technologies, the optimization of decision-making and planning algorithms, the improvement of laws and regulations, and the construction of ethical frameworks. In the future, autonomous vehicles will be deeply integrated with urban planning, intelligent transportation systems, and other fields to jointly promote the intelligent and sustainable development of transportation systems. With the continuous advancement of technology and the gradual improvement of policies, we believe self-driving cars will bring a better future for human mobility.

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