Research on Driverless Vehicle Technology based on 5G Communication

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Abstract: Against the backdrop of rapid scientific and technological advancements, the development of information technology is progressing rapidly. The widespread adoption of 5G networks has greatly facilitated people's lives. 5G communication technology not only provides impetus for the further development of technologies like the Internet of Things, but also drives advancements in other areas. Among them, autonomous driving technology in vehicles has attracted increasing attention. The integration of 5G communication technology and autonomous driving technology can further propel the industry's growth and effectively promote the further development of autonomous driving technology. This paper analyzes the application value and key technologies of autonomous driving technology under 5G communication technology, discussing the challenges and solutions in autonomous driving technology.

Keywords: 5G Communication Technology; Autonomous Driving in Vehicles; Automotive Technology

1. Introduction

With the rapid development of the Internet, various advanced technologies have gradually entered households, greatly facilitating people's lives. Technologies such as the Internet of Things and new energy have effectively become part of people's lives, providing various conveniences and significantly improving their quality of life. Cars are essential means of transportation for people's work commutes. While bringing convenience to people, they also pose certain challenges to traffic management. Issues such as road congestion and traffic accidents have always been the focus of attention. The application of autonomous driving technology can effectively address safety issues caused by human factors in traditional transportation methods. Research on autonomous driving technology models should prioritize reliability and safety, while 5G communication technology can better overcome the bottleneck of computing systems, providing a guarantee for the further transformation of the autonomous driving technology field, with profound research value. It can enhance the safety of people's travels, while also being environmentally friendly and energy-efficient, which is of great significance for social development.

5G communication technology, based on 4G networks, represents the fifth generation of mobile communication technology. It significantly boosts data transmission speeds and expands signal coverage, enhancing mobile network performance. With greater network capacity and more stable data transmission processes, 5G technology offers strong bandwidth and communication capabilities, making it applicable in various complex environments. This enables collaboration across industries, driving further advancements in production technology. For instance, utilizing the low latency and remote synchronization features of 5G communication technology allows for ultra-precise remote synchronization over long distances, or conducting large-scale real-time data collection. These advancements serve as a foundation for research in autonomous driving technology based on 5G. The widespread adoption of 5G communication technology presents new development opportunities for the Internet of Things, facilitating comprehensive industry growth by leveraging the advantages of 5G communication technology to deliver more personalized and intelligent services. Currently, 5G communication technology is in its early stages of development, with various industries and countries striving to advance 5G communication technology and related technologies. [1]

The low latency of 5G communication technology, capable of maintaining in milliseconds, and enabling real-time information

transmission at speeds of up to 500km/h, makes it suitable for application in autonomous driving technology. The use of 5G communication technology in autonomous driving ensures driving safety and contributes to alleviating urban traffic congestion. Additionally, the role of artificial intelligence technology in autonomous driving is foreseeable.

1.1 Improve Driving Safety

Studies have shown that drivers typically have a reaction time of about 500ms in emergency situations, assuming they are alert and in a normal state. However, if a driver is fatigued or in an abnormal physical condition, the reaction time will be longer, increasing the likelihood of accidents in emergencies. Moreover, individuals who are intoxicated can utilize autonomous driving technology for transportation. By employing driving simulations to track vehicle movements and ensuring continuous signal coverage during specific applications, the safety of vehicle operation can be guaranteed. This approach can help mitigate traffic safety issues caused by drunk driving and alleviate urban traffic congestion to some extent. [2]

1.2 Solve the Problem of Traffic Congestion

In recent years, China has experienced rapid economic growth, leading to a significant increase in the number of vehicles on the roads. China has become the country with the highest number of vehicles in the world. However, some cities in China currently face issues with their road network systems, resulting in frequent traffic congestion in certain areas. This congestion is particularly common in provincial capitals and major cities, significantly impacting the normal operation of urban transportation systems. The widespread adoption of autonomous driving technology could help regulate car travel, effectively addressing the current traffic congestion issues. By utilizing 5G communication technology, traffic management authorities can input real-time vehicle operation data in bulk, process it centrally through servers, determine the necessary actions for the vehicles, and control them by adjusting steering, braking, and acceleration mechanisms to ensure safe and efficient driving while maintaining a safe distance between vehicles. Additionally, authorities can allocate real-time travel routes to vehicles in different neighborhoods experiencing traffic congestion, implement traffic diversion, and further alleviate traffic pressure.

1.3 Promote the Application of AI Technology to Improve Computing Performance

Currently, AI technology is constrained by the development of intelligent terminals and algorithms, making it challenging to meet the extensive computational demands effectively. The widespread adoption and application of 5G communication technology represent a significant breakthrough for the application of AI technology in autonomous driving. 5G communication technology offers high-speed network transmission, enabling the offloading of computational burdens to high-performance servers through wireless data transmission when extensive calculations are required, thus facilitating rapid results acquisition. This approach not only enhances computational performance but also further meets the computational requirements of AI technology during application. The integration of AI technology and autonomous driving allows for the rapid assimilation of excellent driving habits from skilled drivers, enabling the simulation of these habits. This capability humanizes the driving effects of autonomous vehicles, enhancing their adaptability to unforeseen circumstances and consequently improving the safety of autonomous driving significantly. [3]

2. Key Technologies for Driverless Cars

2.1 Stable Traction Control Technology

Stable traction control technology often requires unmanned vehicles to collect surrounding information, and then utilize the low latency characteristics of 5G communication technology to achieve rapid response, thereby avoiding the occurrence of loss of control during the vehicle's operation. The application of stable traction control technology can efficiently gather various parameter information during the vehicle's operation, analyze the tire conditions, vehicle direction, driving speed, and other information. When the system detects any abnormal operation of the vehicle, it can take control to prevent traffic accidents. Furthermore, with this technology at its core, it can further control the independent operation of tires to improve vehicle operational efficiency and effectively prevent potential traffic accidents.

2.2 Navigation and Positioning Technology

Self-driving cars often have relatively basic positioning systems. Ensuring that the navigation positioning technology functions properly is crucial for the real-time self-assessment of the vehicle's location. Typically, navigation positioning technology achieves navigation effects through autonomous navigation and network navigation technologies, with network navigation utilizing wireless networks to analyze information about upcoming road segments. Ensuring smooth wireless network coverage within the road area is essential for the stable operation of network navigation. Otherwise, it may lead to poor control effects, incomplete information gathering, or even safety issues. With the continuous upgrading of China's network systems and the deepening development of network technology, the application advantages of network navigation technology are becoming increasingly prominent. By applying network navigation technology, self-driving cars can accurately obtain specific information about the surrounding environment, benefiting from rich information resources. Furthermore, they can conduct real-time information retrieval and analysis through the network to assess information accuracy, enabling more scientific and rational decision-making. In addition, the application of automatic navigation technology relies on the premise of utilizing locally stored geographic information resources for positioning assistance, ensuring the basic positioning and navigation functions can still be achieved even under conditions where network application is challenging. However, this technology often relies on computations performed by onboard computers, making it difficult to effectively avoid calculation errors or slow response times. Therefore, it is necessary to further integrate combination positioning technology and absolute positioning technology for comprehensive assessment to minimize errors as much as possible.

2.3 Self-Parking Technology

Many car manufacturers equip vehicles with sensors or onboard computers in the operating system, but this still struggles to effectively address the frequent issues of vehicle damage during parking. The application of automatic parking technology can effectively solve this problem. Automatic parking technology relies on sensors placed around the vehicle to perceive the surrounding environment's status and the car's relative position. Drivers can analyze the specific orientation of the vehicle through a display screen inside the car, quickly assess the surrounding environment, determine the necessary actions, and ultimately park the vehicle in the designated spot. [4]

3. Driverless Technology based on 5G Communication Technology

3.1 Information Perception

The rapid development of 5G communication technology has to some extent promoted the systematic development of autonomous driving technology, laying a solid foundation for the practical application of autonomous driving technology. 5G communication technology can maintain extremely high transmission speeds and large transmission capacities, enabling fast transmission of alarm information, achieving real-time collection and perception of high-speed information, providing accurate and sufficient road operation information to backend systems, thereby ensuring that drivers can anticipate in advance based on road feedback, enabling timely measures to be taken when issues arise.

3.2 Vehicle-Road Coordination

Autonomous driving technology relies heavily on vehicle hardware facilities, requiring precise sensor systems inside the vehicle and close coordination among multiple sensors to ensure the backend system can accurately collect various information and efficiently control vehicle components. Achieving this effect often involves effective interconnection between driving facilities and road facilities, demanding high network transmission speeds, which can be effectively addressed by the widespread application of 5G communication technology. Additionally, the effective application of 5G communication technology in vehicle driving can realize vehicle-road information collaboration, transmitting remote road conditions, signal information, etc., to the driver's end for decision assistance based on cloud computing and big data. Drivers can access remote road information through the system panel, enabling the connection between vehicles and surrounding public facilities, thereby addressing the challenge of autonomous

driving technology in effectively perceiving environmental information within a limited distance.

3.3 Planning Decision

Autonomous driving technology requires high safety standards. To ensure driving safety, low latency communication is essential for autonomous driving to enhance communication efficiency and accuracy. 5G communication technology offers high-frequency information exchange, ensuring efficient and stable information transmission, significantly improving transmission efficiency compared to previous methods, enabling real-time responses. Leveraging 5G communication technology for edge computing allows for more efficient driving strategy responses, enhancing the rapid response capability of autonomous driving technology.

4. Problems and Countermeasures of Unmanned Driving Technology under 5G Communication Technology

Autonomous vehicles are currently gaining momentum in development, but they have also exposed many issues, even leading to traffic accidents. In February 2016, a Google self-driving car incorrectly judged that a bus approaching from behind would slow down and let it pass, failing to take appropriate braking measures when changing lanes, resulting in a collision between the Google self-driving car and the bus. More seriously, in May 2016, a Tesla autopilot accident resulted in casualties. It is evident that as a new product, autonomous driving is still in the development stage and there are many issues that need to be addressed.

4.1 Environmental Perception Lacks Reliability

Under normal circumstances, vehicles controlled by drivers actually have a relatively low probability of safety accidents and possess a certain level of safety. When it comes to the operation of vehicles under autonomous driving technology, it is necessary to consider both liberating the drivers and ensuring safety to prevent a decrease in safety when drivers hand over the driving tasks to technology. Therefore, comprehensive safety measures need to be implemented. Currently, the development of relevant content by autonomous driving technology personnel is not comprehensive enough. For instance, electronic devices are prone to lagging issues during operation and may exhibit slow response or even failure under prolonged operating conditions. These issues in the actual operation of autonomous vehicles may result in delayed reactions and consequently lead to very serious safety concerns. Hence, it is essential to further optimize based on the current software design.

4.2 Map setup Complex Problem

Self-driving cars often have strong sensing capabilities, but in actual operation, they need to combine and process information to plan specific routes on maps, and then operate the vehicles under the guidance of the map. However, with the increasing complexity of urban road traffic construction, many maps have relatively low flexibility and detail. Therefore, directly applying self-driving technology may lead to issues such as discrepancies between planned and actual routes, posing safety hazards to vehicle operation. Taking Google Maps as an example, it collects and optimizes information about the areas where cars have traveled to ensure that vehicles can access the information stored in the Google database during operation. Based on this, it can quickly and flexibly respond to real-time changes in the environment. Currently, the perception capabilities of self-driving cars are still limited compared to ideal conditions, and the accuracy of maps is insufficient to meet the requirements of autonomous driving.

4.3 High cost of Environmental Sensing and Sensor Equipment

In the application of autonomous driving technology, it often requires the integrated use of various types of sensors to accurately identify environmental information, laying the foundation for subsequent comprehensive analysis and decision-making. The accuracy and effectiveness of environmental perception during this process will impact the effectiveness of subsequent vehicle operations. To ensure the effectiveness of vehicle operations, it is necessary not only to determine the presence of road depressions, debris, etc., but also to accurately analyze the types of debris, such as whether it is a nail or a fallen leaf, whether it needs to be avoided or can be directly run over, thus providing a decision-making basis for adopting different operational strategies for the

system. However, the current sensor accuracy used in autonomous vehicles is difficult to effectively meet the operational requirements of these vehicles, and the response speed of the sensors is also insufficient to meet the high-speed operation of autonomous vehicles, which may result in difficulties in timely and effectively responding to emergencies. [5]

Using Google's self-driving car as an example, the cost of the LiDAR sensor in the entire self-driving car accounts for over half of the total cost of Google's self-driving car, making it the most expensive device in Google's self-driving car, with a cost of approximately $70,000. The high cost directly impacts the promotion and popularization of self-driving cars. Additionally, self-driving cars require connectivity, which also means facing certain network security issues, and establishing a reliable firewall will further increase costs.

4.4 Lack of Use Environment and Insufficient Legal Protection

Self-driving cars possess some typical characteristics of artificial intelligence, existing at the intersection of natural and social sciences. This involves contemplating and making judgments on social phenomena, extending beyond mere technological aspects. For instance, when faced with an imminent traffic accident, how should the processor of a self-driving car choose the lesser of two evils to avoid or reduce human casualties? These are ethical dilemmas that self-driving cars must confront.

Currently, China's system for intelligent connected vehicle technology standards is not yet robust, making it challenging to provide corresponding evaluation criteria for intelligent connected vehicles at different development stages. Additionally, identifying the party responsible for accidents is quite difficult because the intelligent systems of self-driving cars are developed collaboratively by vehicle manufacturers, various software providers, and other partners. Furthermore, existing car insurance does not apply to self-driving cars, leaving users concerned about potential issues, which also hinders the application and promotion of self-driving cars.

5. Countermeasures to Promote the Development of Driverless Cars

5.1 Improve Intelligent Decision Making and Environment Awareness Technology

Intelligent decision-making and environmental perception technologies directly determine the reliability and safety of autonomous vehicles. The two traffic accidents involving Google and Tesla self-driving cars reflect the immaturity of these technologies. Autonomous vehicles face complex road conditions such as congested lanes, extreme weather conditions, conflicts with traffic police gestures, and traffic signals. It is essential to accurately reflect the surrounding actual road conditions before making human-like decisions. Therefore, intelligent decision-making and environmental perception technologies, as top priorities, require corresponding policy support for research. Only when these two technologies make breakthroughs simultaneously can autonomous vehicles truly achieve a milestone development.

5.2 Minimize Costs While Ensuring Performance

Autonomous vehicles have unlimited prospects in the future, such as enhancing travel efficiency by sharing transportation resources and reducing accident rates. However, the high cost of equipment such as sensors, cameras, radars, networking systems, high-precision positioning navigation systems, and human-machine interaction systems poses a significant barrier to the widespread adoption of autonomous vehicles. To overcome this obstacle, it is necessary to reduce the equipment costs through technological innovation. Drawing from the successful model of new energy vehicles, establishing demonstration zones and gradually promoting them on a larger scale can help lower costs by increasing usage. Furthermore, providing financial subsidies can encourage manufacturers to reduce production costs once the technology matures, thereby reducing the need for subsidies.

5.3 We will Accelerate the Development of Connected Vehicles and Intelligent Transportation Systems

Accelerating the construction of connected vehicles and intelligent transportation systems is a catalyst for the development of autonomous driving technology. By expediting the construction of connected vehicles and intelligent transportation systems that integrate people, vehicles, and roads, applying internet, communication, and control technologies

comprehensively to the transportation system can not only alleviate urban traffic congestion and enhance traffic safety but also enable autonomous vehicles to anticipate road conditions. Additionally, there is a need to improve the loading speed of the network, expand its coverage, ensure network stability during connections, enhance network security, and reduce the risk of network hackers infiltrating autonomous vehicles.

5.4 Actively Build Relevant Laws and Regulations to Safeguard The System

Drawing on the legislative achievements of developed countries and combining them with the domestic situation, legislation on autonomous vehicles is being enacted, while also standardizing the insurance types and rates for autonomous vehicles. Nowadays, the international competition in autonomous vehicles is becoming increasingly fierce. It is highly likely that autonomous vehicles will enable our country's automotive industry to achieve a breakthrough. Some companies have already developed fully functional autonomous vehicles. If they are not allowed to conduct legal open-road tests, it will hinder the development of autonomous vehicles in our country and lead to lagging behind in foreign development levels. Moreover, it will fail to address the safety risks posed by autonomous vehicles conducting secret road tests.

6. Conclusion

With the widespread adoption of 5G communication technology, the development of autonomous driving technology will further advance. The issues existing in vehicle networking and unmanned driving technology will gradually be resolved with the advancement of technology. Autonomous driving technology based on 5G communication technology features distinct safety and reliability, freeing drivers and effectively ensuring people's travel safety by integrating cloud computing, Internet of Things, and other advanced technologies, thereby addressing urban traffic issues.

Reference

[1] Chen Shanzhi. Debate and Suggestion on Cellular Vehicle Networking (C-V2X) and its Enabling Development of intelligent Connected vehicles [J]. Telecommunication Science, 2022(7): 1-17.

[2] Cui Yingtao, KANG Jianjian. Research on the Problem of Autonomous Vehicle Active Avoidance Control [J]. Automobile and New Power, 2022(2):42-44.

[3] Cui Chen. Research on Vehicle Driverless Technology under 5G Communication Technology [J]. Times Automobile, 2022(3):16-18.

[4] Wang Jimei. Analysis of key technologies of unmanned driving under Patent-based 5G Network Technology [J]. China New Communications, 2021(9):39-40.

[5] Zheng Chunpeng. Design and Implementation of Intelligent Information Interaction System for Remote driving [D]. Zhengzhou: Zhengzhou University, 2021.

