

The Summary of Artificial Intelligence Vehicle Obstacle Avoidance System

Shuo Ma^{1,*}

¹Xi'an Mingde Institute of Technology, Xi'an, 710018, China

*Corresponding author's e-mail: muscle040614@qq.com

Abstract: With the rapid increase in the global number of vehicles, frequent traffic accidents and urban traffic congestion have become urgent social problems that need to be solved. As an innovative solution, autonomous driving technology is gradually demonstrating its potential, and in this cutting-edge field, automatic obstacle avoidance technology is undoubtedly the core. It deeply integrates advanced sensing technology and intelligent control algorithms, aiming to enable vehicles to quickly make safe and accurate evasive actions when encountering potential obstacles. The evolution of automatic obstacle avoidance technology has gone beyond simple functional pursuits and shifted towards deep integration of various cutting-edge technologies to optimize obstacle avoidance efficiency. In summary, the innovation and development of automatic obstacle avoidance technology are leading the technological revolution in the field of autonomous driving, not only profoundly changing the mode of human vehicle interaction, but also having a profound impact on the vision of future smart city transportation systems.

Keywords: History of development; Automatic obstacle avoidance technology; Technology introduction; Hardware and software development.

1. The Development History of Intelligent Vehicles

The earliest autonomous driving experiment can be traced back to 1925, when the world's first self driving car was produced by a wireless control company called the "American Miracle". It could receive wireless signals emitted by rear cars and respond to road conditions, such as acceleration, deceleration, steering, braking, honking, etc. This marked the beginning of research on autonomous driving technology. But at that time, people's ideas were a bit wrong. They wanted to create an "electronic intelligent highway" to match the "smart car" and continuously send signals to the car to keep it running normally. However, the complex technology and huge engineering volume and cost quickly eliminated this technology. After 1946, the concept of smart cars gradually took shape with the development of computer technology and sensor technology, and people's research began to focus on the intelligence of the vehicle itself. In the 1980s, the concept of autonomous driving began to receive more attention and research. For many years, the development of intelligent cars has only been for one goal, which is to enable cars to autonomously complete the entire journey with a set starting and ending point.

In the 21st century, the research and application of intelligent vehicles began to accelerate, and information technology and Internet technology changed rapidly. A 2014 study indicated that high-performance electromechanical information systems have provided possibilities for intelligent vehicles. In the same year, the development of the Internet further provided technical support for the popularization of the Internet of Things in vehicles. In 2015, the research content and key technologies of intelligent vehicles were further explored.

In 2018, the development of intelligent vehicles has shifted from theoretical research to exploration of practical applications. In the same year, autonomous vehicles were considered a product of the efficient integration of automotive

technology and information and communication technology, which effectively improved transportation efficiency and safety. In addition, the technological development trends of intelligent vehicles, including the impact on traffic safety, energy conservation and emission reduction, urban transportation planning, etc., have also been widely discussed.

Until 2020, the technology of intelligent vehicles has involved multiple aspects, mainly including fuzzy logic processing, network intelligent vehicle adaptive calculation, and speech recognition. The application of these technologies has greatly improved the safety performance of vehicles. The series of challenges faced in the development of intelligent vehicles mainly include the level of technological development, industry policy awareness, and the soundness of relevant regulations, which cannot be ignored; Therefore, the development of intelligent vehicles has been improved in terms of supporting policies and regulations for technological innovation industries, as well as the improvement of people's awareness level; To better leverage the role of intelligent vehicles in development; At the same time, it also faces many challenges.

The research results in 2022 once again confirm the pivotal position of intelligent vehicles in the global intelligent technology revolution. Research suggests that smart cars are an important carrier for promoting automotive intelligence and a crucial direction for leading international technological competition and industrial transformation and upgrading. In addition, the development of intelligent vehicles involves many aspects such as vehicle computing, vehicle networking, autonomous driving technology, etc. These fields collectively promote the development and progress of intelligent vehicles. In summary, smart cars are an important component of the intelligent revolution.

2. Key Technologies of Obstacle Avoidance System

At present, there are two mainstream schools of thought.

One is autonomous driving, which mainly relies on cameras to accurately capture the surrounding environment of vehicles. Through image processing and system algorithms, the system can recognize various objects such as road signs, pedestrians, and vehicles. The advantage of this solution is that it can capture external color and motion information, which is more conducive to recognizing visual information such as traffic signs and signal lights. The disadvantage is that it is affected by external light, and its performance will significantly decrease at night and on rainy days. Another approach is based on the laser radar route, using lasers to explore the surrounding environment and generate 3D point cloud images, which can also identify and locate surrounding objects.[1] However, the disadvantage is that the production cost is high, the volume is large, and it is generally inconvenient to place cars in daily life. It can work under any lighting conditions. Compared to cameras, the advantage is to identify and locate surrounding objects. Nowadays, many companies are committed to integrating these two technologies to make smart cars have both advantages. [2]

2.1. Communication Technology

The key to achieving autonomous driving and intelligent transportation systems is the communication technology of intelligent vehicles. These technologies not only support communication between vehicles, but also between vehicles and roadside infrastructure, between vehicles and pedestrians, and between vehicles and everything else. With the development of technology, the communication technology of smart cars has evolved from early infrared, microwave, and millimeter wave based communication to low latency and high reliability communication achieved using 5G technology. The intelligent vehicle communication technology mainly includes the following points:

2.1.1. Internet of Vehicles Technology

Internet of Vehicles technology has become the foundation of the development of intelligent automobiles, which has emerged with the development of intelligent automobiles. Ethernet technology provides a solution for automotive intelligence, as its advantages have been introduced into the field of automotive communication. In addition, the intelligent electronic control system of the car also applies LIN communication technology to support information transmission between electronic devices inside the car. [3]

2.1.2. V2X communication technology

V2X communication technology is an important component of intelligent vehicle communication technology, including communication methods between cars, cars and roadside infrastructure, cars and pedestrians, etc. The application of 5G technology enables V2X communication technology to provide ultra reliable and low latency communication, which is crucial for the implementation of autonomous driving and intelligent transportation systems. [4]

2.1.3. Wireless Communication Technology

Wireless communication technology plays a crucial role in smart cars. WiFi technology is applied in smart car data communication to support the debugging of smart car control systems. In addition, wireless vehicle networking technology has also been widely applied in the development of intelligent transportation application systems and connected vehicle networks.

2.1.4. Sensor Communication Technology

Sensor technology is used in smart cars to collect important

information about the vehicle's operating status, such as air pockets, distance detection, mechanical and electronic components, tire pressure, collision force, and passenger conditions. The transmission of this information is essential to achieve intelligent transportation systems and improve road safety. [5,6]

2.2. Radar system

The purpose of the radar system in intelligent vehicles is to achieve comprehensive perception and autonomy of the vehicle, and it is also one of the key technologies for advanced driving assistance systems. These systems perceive the surrounding environment by emitting electromagnetic waves and receiving reflected signals, thereby helping vehicles identify obstacles, measure distance and speed, and perform path planning. With the development of intelligent vehicle technology, radar systems have made significant progress in both hardware and algorithms. Millimeter wave radar has become the main sensor for long-distance detection in intelligent vehicles due to its long-range, all-weather capability, and low cost. Millimeter wave radar can provide the identification of distance, speed and movement direction of objects in front of the vehicle, which is crucial to the safety and reliability of the auto drive system. In addition, the application of millimeter wave radar is not limited to a single function, but can also be used in conjunction with other sensors such as vision and lidar to further improve system performance. Lidar is another important environmental sensing sensor that emits a laser beam and measures the reflected beam to create a three-dimensional image of the surrounding environment. The application of lidar in intelligent driving includes multiple aspects such as point cloud segmentation, target tracking and recognition, real-time positioning, and map reconstruction. The advantage of LiDAR lies in its high precision and resolution, which enables it to provide detailed environmental information in complex environments.

However, the challenges faced by radar systems are constantly increasing with the development of autonomous driving technology. One of the main issues is interference, especially with the widespread use of radar sensors in automobiles. To address this issue, researchers have proposed the concept of digital orthogonal frequency division multiplexing radar, which is based on cognitive interference avoidance and dynamically adjusts waveforms to adapt to interference, thereby improving the system's anti-interference ability. In addition, research on the Smart in car radar system is also ongoing. For example, the accuracy of radar can be improved by integrating communication and cognitive sparse MIMO radar technology, which is essential for safe driving. At the same time, continuously optimize the integrated design of the radar system, such as the design of highly integrated radar sensors that help reduce costs and improve production efficiency. [7-9]

2.3. Software Technology

2.3.1. Anti lock braking system

Anti lock braking system (ABS) is a technology used to improve the safety and stability of vehicles during emergency braking. ABS controls and adjusts the braking force of the wheels to prevent them from locking up during braking, thereby maximizing the road adhesion coefficient, shortening the braking distance, preventing skidding, and improving directional stability during braking. This system is crucial

for improving the braking performance and safety of automobiles, especially during high-speed driving and emergency braking.

The working principle of ABS is based on precise control of wheel slip ratio. ABS ensures optimal friction between the wheels and the road surface when the wheels are about to lock, and reduces slip by adjusting brake pressure. This control can be achieved through various methods, including PID control, fuzzy logic control, etc. In order to further improve the performance of ABS, researchers have proposed target slip ratio control strategies and variable target slip ratio methods based on Lyapunov theory in recent years to optimize the friction between tires and road surfaces, reduce the yaw moment generated by longitudinal tire road friction.

In addition, besides passenger cars, ABS can also be applied to commercial vehicles. The previous study proposed an ABS control strategy for commercial vehicles to maximize tire road contact friction while minimizing yaw moment. It can be seen that the development and application of ABS technology are gradually extending to a wider range of vehicle types.

Although significant progress has been made, there are still certain challenges and limitations, such as the impact on ABS performance in some harsh road conditions; Therefore, researchers are studying new control strategies and technologies, such as integrated control methods, to maximize road friction and maintain directional stability during emergency braking; This method is based on ABS and combines direct yaw moment control with active front wheel steering through optimization. Therefore, in the field of automotive engineering, these topics are being carried out. [10]

2.3.2. Traction Control System

The Traction Control System (TCS) is an active safety system aimed at improving the acceleration performance, directional stability, and steering control ability of vehicles under various road conditions. It is an extension technology of the Anti lock Braking System. TCS can limit excessive slip of the driving wheels and fully utilize the traction provided by the ground by adjusting the engine output torque and the driving wheel cylinder pressure. The application of TCS is not limited to passenger cars, but also widely used in fields such as off-road vehicles, electric vehicles, and high-speed maglev trains.

The working principle of TCS is based on the corresponding relationship between the wheel slip rate of the driving vehicle and the road adhesion coefficient. Under different road conditions, the optimal slip rate value is obtained by adjusting the driving torque on the driving wheels, thereby obtaining the maximum traction force during vehicle driving. To achieve this goal, the TCS system adopts various control algorithms, including PID control, sliding mode control, optimal control, and adaptive PID control strategy based on genetic algorithm and fuzzy control rules. These control algorithms can effectively suppress excessive slippage of the driving wheels under different road conditions, improving the vehicle's power performance and driving stability. In practical applications, the development of hardware circuit modules and control software, as well as offline simulation analysis and real vehicle road matching testing based on simulation platforms, all involve the design and development of TCS systems. For example, the TCS controller designed and developed based on the MC9S12XS128 microcontroller can effectively control the

slip of driving wheels, improve the acceleration performance of vehicles under complex road conditions, and achieve functions such as signal acquisition and processing, control decision-making, and driving execution mechanisms.

In addition, the research on TCS system also includes the exploration of road surface recognition methods based on wheel acceleration, as well as the consideration of the impact of high-speed maglev train traction control strategies on the suspension system and other road surface recognition technologies. These studies not only improve the performance of TCS systems, but also provide theoretical basis and technical support, enabling TCS technology to be applied in a wider range of fields.

At present, the research on TCS system in China is relatively backward. In foreign countries, comprehensive control of cylinders, clutches, transmissions, and driving wheel brakes has been initially achieved. The main difficulty in China is the inability to effectively avoid external interference, such as electrical signal interference or road emergencies. The key is to make the system more proactive and to determine the coordinated control between local sensors and the overall system in order to ensure the efficient operation of the entire system. [11,12]

2.3.3. Big Data Applications

The development of intelligent transportation systems has shifted from traditional technology driven systems to data-driven intelligent transportation systems, marking a shift from single functionality to multifunctional, multi-source data, and to learning algorithm driven intelligent transportation systems. This transformation enables intelligent transportation systems to optimize their performance more effectively, while becoming safer, more efficient, and profitable. For example, predicting traffic flow through deep learning methods demonstrates the potential application of big data in intelligent transportation systems.

The application of big data analysis technology in intelligent vehicles includes but is not limited to the design of vehicle to roadside communication protocols, smart city traffic management, electric vehicle network analysis, and intelligent management of autonomous vehicles. These applications demonstrate how big data analysis technology can help solve transportation challenges in smart cities, improve traffic efficiency and safety. For example, the ODOT project demonstrated the importance of data cleaning methods in improving data quality by using machine learning techniques to improve travel time prediction. In addition, a distributed big data analysis architecture has been proposed to meet the data acquisition, storage, and analysis requirements in the transportation system, while graph processing technology is used for processing intelligent vehicle network data, demonstrating the potential of big data processing technology in solving dynamic structural challenges.

2.3.4. Path planning technology

Ensuring the safe and efficient operation of autonomous vehicles, intelligent vehicle path planning is one of the key technologies. It can be seen that the research and application of intelligent vehicle path planning cover various methods and technologies, including but not limited to artificial potential field algorithms, hybrid trajectory planning schemes, computer vision based path planning, and methods combining fuzzy decision-making and potential field grids.

The application of artificial potential field algorithm in intelligent vehicle path planning shows that the smooth and

safe path planning and tracking control of intelligent vehicles can be achieved by constructing obstacle point models and constraining steering angles. In addition, hybrid track planning schemes can cope with dynamically changing driving environments and generate responsive tracks through a combination of numerical optimization methods. The advantage of these methods is that they can respond in real-time to changes in the driving environment and improve safety and efficiency in path planning. A path planning system based on computer vision can achieve image processing, monocular vision ranging, and other functions by optimizing ant colony algorithm, thereby improving operation time. This method is particularly suitable for dangerous or unsuitable human activities that can improve the performance of intelligent vehicle path planning. The method of combining fuzzy decision-making with potential grid solves the problem of unreachable and oscillating targets near obstacles, and improves the smoothness of the path by introducing influencing factors and fuzzy decision-making. The effectiveness of this method lies in its ability to comprehensively consider heading angle and potential field value, and select the optimal path in the selection of path points.

The research and application of intelligent vehicle path planning have shown that by combining multiple technologies and methods, the safety, efficiency, and real-time performance of path planning can be effectively improved. Future research may further explore the optimization and combination of these methods to cope with more complex and changing driving environments. [13]

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