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Application Strategies of Intelligent Transportation Technology in Traffic Safety Management

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Abstract: At present, transportation construction plays a certain promoting and driving role in the economic and social development of our country. At the same time, because of the accelerated pace of transportation construction, the traffic network structure of each region of China has gradually been optimized and perfected. This not only significantly improves people's quality of life and living conditions, but also provides many conveniences for the transportation of goods. However, in the current process of highway construction and development in China, there is still a certain degree of danger, which will also significantly increase the probability of road safety problems occurring. Therefore, it is necessary to apply intelligent transportation technology to effectively enhance the safety of road use. As a result, this study provides a detailed analysis of the overview of intelligent transportation technology, the advantages of the application of intelligent transportation technology in traffic safety management, as well as an in-depth discussion of the role and application of intelligent transportation technology in traffic safety management.

Keywords: Intelligent transportation technology; Traffic safety management; Information

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1. Introduction

By the end of 2023, the national highway mileage was 5,436,800 kilometers, of which 762,200 kilometers were Class II and above, 183,600 kilometers were expressways, and 122,300 kilometers were national highways. There were 1,079,300 highway bridges and 95,288,200 linear meters, including 10,239 special bridges and 18,730,100 linear meters, and 177,700 bridges and 49,943,700 linear meters. There are 27,297 highway tunnels and 30,231,800 linear meters, of which 2,050 are very long tunnels and 9,240,700 linear meters, and 7,552 are long tunnels and 13,213,800 linear meters [1]. With the significant growth of China's highway mileage, road network traffic is becoming increasingly dense and complex, and people's requirements for traffic safety are soaring. Traditional transportation management methods are increasingly insufficient to meet the growing demands of modern travel, leading to the emergence of intelligent transportation technology. Intelligent transportation

technology refers to the effective integration of advanced technologies, such as information technology, computer science, data communication, sensor systems, electronic control, automatic control theory, operations research, and artificial intelligence, into transportation, service control, and vehicle manufacturing. Its goal is to enhance the connection between vehicles, infrastructure, and users, thereby improving traffic conditions, ensuring safety, and increasing overall efficiency [1–2].

2. Overview of intelligent transportation technology

Driven by the dual forces of information technology advancement and scientific progress, intelligent transportation technology plays a vital role in modern traffic safety management. The current intelligent transportation technology has formed an all-round, three-dimensional, and diversified road safety protection network, which can accurately identify and control the potential risks in transportation, thus significantly reducing the incidence of traffic accidents. The application of intelligent transportation technology is mainly reflected in two key areas, the first of which is the enhancement of intelligence in traffic safety management. It not only provides traffic managers with relatively complete and accurate road traffic information, but also enables them to grasp the real-time dynamics of road conditions, thereby making more scientific management decisions. The second is the application of the technology can also provide convenience for drivers and passengers to travel. For instance, during the journey, it can promptly remind drivers of traffic accidents and speed limit information ahead, etc., to avoid the occurrence of safety accidents as much as possible.

3. The application advantages of intelligent transportation technology in traffic safety management

3.1. Strong universality

Intelligent transportation technology has gradually become an essential tool for supporting traffic management. It has been widely applied across various administrative processes in different regions, significantly enhancing traffic efficiency, increasing freight and passenger flow, and notably improving traffic safety. In 2023, the total commercial freight volume of the highway industry reached 40.337 billion tons, and the freight turnover volume was 7,395 billion ton-kilometers [3]. Compared with the total cargo transportation volume of 33.63 billion tons in the highway industry throughout 2016, it increased by 20% [4]. The total volume of personnel flow on highways throughout the year was 56.556 billion person-times, an increase of 362% compared with 15.63 billion person-times in 2016. In 2023, the number of deaths per 10,000 vehicles in road traffic accidents was 1.38, a decrease of 29.5% compared with 2.1 in 2016 [3, 4].

For example, in urban highway traffic management, the application of intelligent transportation technology allows relevant departments to effectively monitor parking space allocation, road conditions, and vehicle positioning. It also enhances the monitoring and regulation of speeding and traffic violations, thereby improving the overall governance capacity and advancing the development of highway traffic safety[5].

3.2. Higher real-time

In the field of traffic safety management, the advantages of intelligent transportation technology are also reflected in the high timeliness. For example, the event detection capabilities of surveillance cameras can identify traffic accidents, cargo spills, congestion, vehicle fires, and other irregularities. They also enable real-time tracking of hazardous chemical vehicles, oversized cargo transport, and special operation vehicles. For instance, when a road traffic accident occurs, the intelligent transportation system can quickly help relevant departments locate the

accident scene so that rescue operations can be launched immediately. Drivers and passengers can also obtain real-time information through radio, map software, or traffic signs, etc., to make better travel planning. In addition, intelligent transportation technology can also analyze and identify the causes of accidents and the attribution of responsibility, thus greatly improving the accuracy and efficiency of accident handling.

3.3. Wider coverage

At present, intelligent transportation technology is widely used in various fields, especially in the field of traffic safety management, covering almost all application scenarios, from the propaganda of laws and regulations, road safety education, traffic facilities management to traffic safety enforcement. For example, intelligent transportation technology can be used to disseminate safety management information via electronic message boards, address illegal road occupation, unauthorized parking, and support emergency evacuations using drones. In foggy conditions, visibility sensors can automatically activate fog warning systems, while pollutant particle detectors can trigger tunnel ventilation systems as needed. So that the highway traffic management department will be able to quickly take corresponding measures against the illegal vehicles, thus effectively improving the efficiency and quality of road safety management [6].

4. The role of intelligent transportation technology in traffic safety management

4.1. Improve the effectiveness of safety management, prevention, and control

Highway is an important part of the transportation network, which carries people's travel safety and transportation safety. Once an accident occurs in the process of highway transportation, it will cause property loss, and in serious cases, it may also cause casualties. Therefore, after the highway construction is put into use, it is necessary to adopt reliable safety management measures, formulate more perfect safety management and protection standards, and put forward practical strategies to minimize the incidence of road accidents. In addition, the application of intelligent transportation technology in traffic safety management is mainly based on its intelligent and automated features to further integrate and analyze the vehicle information on the road, and according to the actual driving needs to do a good job of intelligent planning, thus promoting the effective realization of intelligent driving, as well as help drivers to identify potential risks in the process of driving in advance and to take targeted preventive measures to minimize the probability of safety accidents [7].

4.2. Improve accident prevention ability

According to the actual needs of road traffic safety management, more advanced intelligent transportation technology can be reasonably applied to carry out more accurate risk assessment on the dynamic information of vehicles on the road and the condition of bridges and tunnels, to effectively predict potential accident risks in advance. In addition, the effective application of intelligent transportation technology can help predict the likelihood of traffic accidents, providing drivers with valuable decision-making support. This enables them to take preventive measures in advance, thereby significantly reducing the risk of accidents. Moreover, intelligent transportation technology can quickly provide regional driving navigation for drivers by virtue of its excellent data integration, collection, and analysis functions on the road. At the same time, drivers can also choose the driving program recommended by the system according to the real-time feedback of the road conditions. In the face of road congestion, the intelligent transportation system can also obtain and communicate congestion information to drivers promptly, to warn drivers to slow down. In addition, under adverse weather conditions, drivers can more accurately determine the road ahead with the help of intelligent transportation technology, which can effectively control the vehicle distance and driving speed [8].

4.3. Accelerate the emergency response speed

Safety accidents are easy to occur in the highway section, and once safety accidents occur, emergency rescue measures must be launched immediately to ensure the safety of personnel to the greatest extent. In addition, to minimize the degree of accident damage in traffic safety management, it is necessary to apply intelligent transportation technology to do a good job of effective monitoring and management. If traffic accidents are detected and reported immediately, the rescue agencies receiving alerts will promptly dispatch personnel to the accident site. At the same time, these agencies can use advanced technology to accurately obtain accident information and conduct analysis and assessment. Moreover, while en route to the scene, they can develop a more comprehensive rescue plan, thus saving valuable time for rescue operations. This approach can enhance rescue efficiency and significantly reduce the negative impact of accidents.

5. The application of intelligent transportation technology in traffic safety management

5.1. Highway traffic safety accident prevention

After the highway is built and put into use, the relevant enterprises and departments must carry out all-round safety monitoring and management, to avoid the occurrence of safety accidents as far as possible. To achieve this purpose, it is necessary to apply intelligent transportation technology, which can provide a strong guarantee for the safety of vehicles. In addition, the application of intelligent transportation technology can also accurately detect the vehicle's driving route and driving trajectory, and through scientific and reasonable planning to achieve the purpose of effective prevention of accidents. Moreover, with the assistance of intelligent transportation technology, a safe and stable traffic environment can be built for the general public, providing a strong guarantee for people's travel safety. At the same time, through the effective use of intelligent transportation technology, drivers can monitor their vehicle's status and plan their travel routes based on relevant information, minimizing the risk of safety issues. In addition, with the ongoing development of road infrastructure in our country, highway construction projects across various regions are progressing systematically. Therefore, the road conditions faced by drivers are becoming increasingly complex during this process. If effective management and planning of driving distance and speed are not implemented when traveling, the probability of accidents will significantly increase. Thus, only by applying intelligent transportation technology to ensure relevant safety precautions can the safety of road use be further enhanced [9].

5.2. Data collection and multi-sensor data fusion

The application of intelligent transportation technology in traffic safety management is mainly based on the concept of safety management and focuses on multiple links such as data collection, analysis, and organization. Among them, in the data collection stage, sensors need to be applied reasonably. Currently, there are various sensors on the market suitable for highway information collection. Staff need to flexibly select more suitable sensors based on the specific conditions of the highway and the information collection requirements. In addition, the main concern in environmental monitoring is the highway temperature, humidity, and the surrounding environmental conditions. At the same time, under relatively adverse weather conditions such as rain, snow and heavy fog, it is necessary to monitor weather conditions that may affect the operation of the road, such as hail, mudslides, rain, snow and strong winds, and effectively collect and transmit the corresponding data by installing corresponding sensors on the road. Furthermore, with the wide application of GPS/5G technology in the automotive industry, the driving status information of automobiles can be collected in real time to determine the driving trajectory of the vehicle, thereby assessing the driving safety of the vehicle and promptly detecting any

abnormal situations that exist, and taking targeted control measures [10].

5.3. Information transmission and processing

The establishment of an information network centered on traffic safety management can ensure the safe and accurate transmission of data collected by various sensors [11]. Moreover, highway management institutions can carry out corresponding tasks through information systems during the processes of data integration, collection, and analysis, thereby obtaining more raw data and information. At the same time, they can also apply data analysis software to deeply explore the value of information. This is a common practice in the information collection stage, which can also ensure the effective transmission of information. In addition, the use of GPS/5G technology in the field of highway traffic monitoring is also a more basic means of monitoring. At present, GPS/5G technology is mainly used for the precise positioning of vehicle positions, and the realization of its functions also relies on the data support of sensors. And through the analysis and sorting of relevant data, the real-time status of highway operation can be presented more clearly, to accurately assess the highway operation [12].

5.4. Reduce the degree of accident injury

Through the application of advanced highway traffic accident prediction methods, the potential traffic accident risks for each section of the road can be analyzed and calculated, with corresponding risk values clearly defined. Drivers can then use this information to make informed decisions and minimize the likelihood of accidents. In addition, drivers can predict possible problems and accidents in advance when monitoring vehicle traveling information, to better protect people's travel safety. Furthermore, when intelligent transportation technology is applied to highway traffic safety, once the risk of a safety accident on the highway is detected, the system will make corresponding preparations in advance and promptly convey the relevant information with the support of intelligent transportation technology to ensure that medical rescue is provided to the injured in the shortest time. This can significantly reduce the number of casualties after an accident, and at the same time, it can also avoid long-term traffic congestion caused by safety accidents [13].

6. Conclusion

Overall, a thorough analysis of the operation status of the highway system in our country at present reveals that there are many potential safety hazards. Therefore, while promoting highway construction, traffic safety management cannot be ignored either. Hence, in the face of a significant increase in the number of highways and the intensification of safety management tasks, relevant departments need to apply intelligent transportation technologies based on advanced information technology. This can promote the gradual development and transformation of safety management work towards informatization and technological advancement. At the same time, through the application of intelligent transportation technology in traffic safety management, real-time monitoring of road conditions can be achieved, ensuring the safety and stability of highway traffic operations. In addition, the application of intelligent transportation technology in traffic safety management not only enhances the security of travel but also contributes to creating a harmonious social environment and provides strong support for sustainable social and economic growth.

Disclosure statement

The authors declare no conflict of interest.

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