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Research on Traffic Optimization Based on Internet of Things

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Abstract: *This paper proposes an intelligent traffic congestion management system based on the Internet of Things. Through real-time monitoring of traffic conditions, data analysis and the application of adaptive scheduling algorithms, it aims to alleviate traffic congestion and improve road traffic efficiency. Firstly, the paper expounds the advantages and characteristics of the system, including real-time, dynamic, flexibility and adaptability. Then, through the detailed analysis of several experiments and implementation cases, the remarkable effect of the system in improving traffic management efficiency and reducing congestion is verified. The case covers many aspects such as intersection optimization in the core area of the city, expressway congestion warning and evacuation, campus traffic management and safety improvement. Finally, the paper summarizes the research results, looks forward to the future development direction of the system, and emphasizes the great potential of the combination of Internet of Things technology and other emerging technologies in the field of intelligent transportation management.*

Keywords: *Internet of Things; Intelligent transportation; Congestion management; Adaptive scheduling; Traffic optimization; Real-time monitoring; Data analysis; Traffic management efficiency*

1. Introduction

With the acceleration of urbanization and the rapid growth of population and vehicles, the problem of urban traffic congestion has become increasingly serious. The traditional traffic management system has been difficult to meet the needs of modern cities for efficient, safe and environmentally friendly travel. Therefore, it is the key to solve the urban traffic congestion problem to develop an intelligent transportation system that can perceive the traffic situation in real time and dispatch flexibly[1].

Intelligent transportation system, as an important means of modern traffic management, realizes effective monitoring and dispatching of traffic flow by applying advanced information technology. Among them, the introduction of Internet of Things technology has brought new opportunities for the development of ITS. The Internet of Things provides real-time and accurate data support for the intelligent transportation system by realizing the comprehensive information interaction between things and people, which makes the traffic management more intelligent and refined[2].

The intelligent traffic congestion management system based on the Internet of Things realizes real-time monitoring and flexible scheduling of traffic congestion by integrating modules such as position detection, direction determination, wireless Internet of Things communication, traffic situation awareness, adaptive decentralized control scheduling and travel control. The system can automatically adjust the dispatching strategy according to different road conditions and traffic flow, optimize traffic flow and improve road capacity, thus effectively alleviating traffic congestion.

This paper aims to discuss the principle, architecture and application effect of intelligent traffic congestion management system based on the Internet of Things, and provide a new solution for urban traffic management. Through in-depth analysis of the key technologies and implementation methods of the system, its performance in alleviating traffic congestion and improving traffic efficiency is evaluated, which provides useful reference for research and practice in related fields[3].

To sum up, the intelligent traffic congestion management system based on the Internet of Things is one of the important ways to solve the urban traffic congestion problem. Through in-depth research and application of the system, we can bring more innovations and breakthroughs to urban traffic management and promote the development of urban traffic in a more efficient, safe and environmentally friendly

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direction.

2. System architecture and working principle

Under the background of solving the traffic congestion problem in modern cities, we designed and implemented an intelligent traffic congestion management system based on the Internet of Things. By integrating multiple functional modules, the system realizes real-time monitoring, data analysis and adaptive scheduling of traffic conditions, thus effectively alleviating traffic congestion and improving road traffic efficiency[4].

2.1. System architecture

This system is mainly composed of position detection module, direction determination module, wireless Internet of Things communication module, traffic situation perception module, adaptive decentralized control scheduling module and travel control module. These modules cooperate with each other to realize the intelligent management of traffic congestion. Fig. 1 is a state transition diagram of an adaptive decentralized control scheduling algorithm.

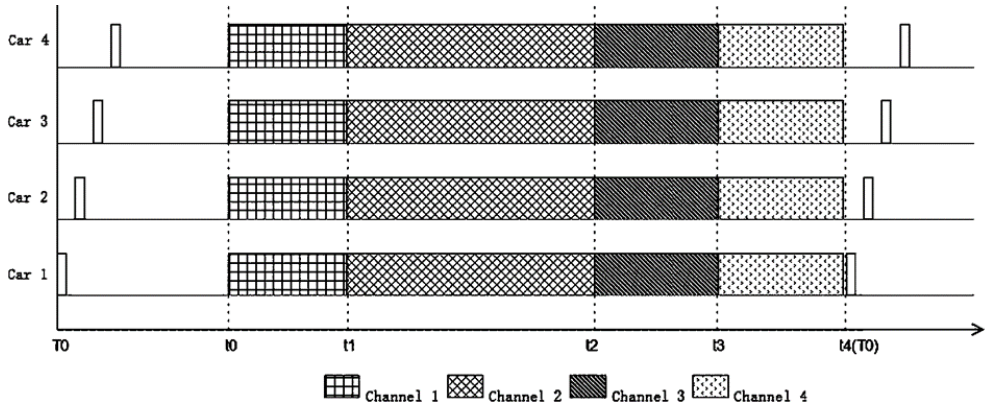

Figure 1: Is a state transition diagram of an adaptive decentralized control scheduling algorithm.

The position detection module is one of the cores of the system. It uses advanced positioning technology, such as GPS or Beidou satellite navigation system, to obtain the vehicle position information in real time. Through accurate positioning data, the system can accurately judge whether the vehicle is close to or has passed the intersection, providing an important basis for subsequent scheduling decisions.

The direction judging module senses the traveling direction of the vehicle in real time through devices such as sensors or cameras installed on the vehicle. This module is of great significance to systematically understand the driving intention of vehicles and predict the change of traffic flow[5-7].

The communication module of the wireless Internet of Things is the key to realize the information interaction of the system. It uses wireless communication technologies, such as ZigBee, LoRa or 5G, to realize real-time data exchange between vehicles and between vehicles and infrastructure. Through this module, vehicles can share their own status information, receive message information from other vehicles, and synchronize with the master clock of the Internet of Things to ensure the consistency and real-time of information in the system[8].

The traffic situation perception module analyzes the traffic situation in real time according to the received message information. It counts information such as traffic flow and vehicle position distribution in all directions, and provides decision-making basis for adaptive decentralized control dispatching module[9].

Adaptive decentralized control scheduling module is the core algorithm part of this system. According to the data provided by the traffic situation perception module, it automatically calculates the traffic dispatching level and dispatching macro-period of the intersection. Through the optimization algorithm, the system can flexibly adjust the scheduling strategy according to different road conditions and traffic flow, and realize the balanced distribution and efficient traffic flow.

The traveling control module is responsible for controlling the traveling speed and direction of the vehicle according to the instructions of the adaptive decentralized control dispatching module. By

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connecting with the power system and braking system of the vehicle, the module can realize accurate control of the vehicle and ensure the safety and smoothness of the vehicle when passing through the intersection[10].

2.2. Working principle

The working principle of this system is based on the Internet of Things technology and the concept of intelligent traffic management. The position and direction information of vehicles are obtained by the position detection and direction determination module, and the wireless Internet of Things communication module realizes information interaction and clock synchronization between vehicles. The traffic situation perception module analyzes the traffic situation in real time according to the received message information, and provides the basis for dispatching decision. The self-adaptive decentralized control scheduling module automatically calculates the scheduling strategy according to the traffic condition data, and realizes the control of the vehicle through the travel control module.

In the whole work process, the system always keeps real-time monitoring and data analysis of traffic conditions, and dynamically adjusts the scheduling strategy according to real-time data to realize flexible response to traffic congestion. By continuously optimizing the scheduling algorithm and improving the system performance, the system can more effectively alleviate the traffic congestion problem, improve the road traffic efficiency and bring revolutionary changes to urban traffic management.

3. Advantages and characteristics of the system

Compared with the traditional traffic management system, the intelligent traffic congestion management system based on the Internet of Things shows many significant advantages and characteristics, which has brought revolutionary changes to modern urban traffic management.

3.1. Real-time and dynamic

This system realizes real-time perception and dynamic monitoring of traffic conditions through the Internet of Things technology. The position detection and direction determination module can obtain the position and direction information of vehicles in real time, and the wireless Internet of Things communication module ensures the real-time exchange of information between vehicles. This enables the system to quickly respond to traffic changes, adjust the scheduling strategy in real time, and effectively deal with sudden traffic incidents and congestion.

3.2. Flexibility and adaptability

Based on the adaptive decentralized control scheduling algorithm, the system can flexibly adjust the scheduling strategy according to different road conditions and traffic flow. The system can adaptively adjust the scheduling macro-cycle and traffic scheduling level to realize the balanced distribution and efficient traffic flow, whether in the face of congestion during peak hours or smooth traffic during low peak hours. This flexibility and adaptability enable the system to better adapt to the complex and changeable traffic environment.

3.3. Efficiency and optimization

This system realizes accurate control and scheduling of traffic flow through optimization algorithm. Through real-time monitoring and data analysis of traffic conditions, the system can predict the changing trend of traffic flow and make dispatching decisions in advance. At the same time, through the real-time information exchange of wireless Internet of Things communication module, the system can realize the coordinated driving between vehicles, reduce unnecessary parking and acceleration, and reduce energy consumption and emissions. These measures have jointly improved the efficiency of road traffic and reduced the occurrence of traffic congestion.

3.4. Intelligence and automation

This system makes full use of the Internet of Things and intelligent control technology to realize the intelligence and automation of traffic management. The system can automatically calculate the dispatching strategy and control the speed and direction of vehicles without manual intervention. This

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not only improves the efficiency and accuracy of traffic management, but also reduces labor costs and security risks. At the same time, the system can also provide scientific basis for traffic planning and management through data analysis, and promote the sustainable development of urban traffic.

3.5. Extensibility and Compatibility

This system has good expansibility and compatibility. With the continuous development of Internet of Things technology and the expansion of its application scope, the system can easily integrate more functional modules and sensor devices to achieve more comprehensive traffic monitoring and management. At the same time, the system can also seamlessly connect with other traffic management systems and share data, so as to realize the coordination and integration of urban traffic management.

To sum up, the intelligent traffic congestion management system based on the Internet of Things has many advantages and characteristics, such as real-time, dynamic, flexible, adaptive, efficient, optimized, intelligent, automated, scalable and compatible. These advantages enable the system to better meet the challenges of modern urban traffic management, improve road traffic efficiency, alleviate traffic congestion and contribute to the sustainable development of urban traffic.

4. Experiments and implementation cases

In order to verify the effectiveness of the intelligent traffic congestion management system based on the Internet of Things, we carried out experiments and case implementation in several actual traffic scenarios. The following will introduce the experimental environment, experimental methods, experimental results and case analysis in detail.

4.1. Experimental environment

We choose representative urban intersections as experimental sites, which cover different traffic flows and road layouts. During the experiment, we deployed corresponding hardware devices, including position detection sensors, direction determination cameras, wireless Internet of Things communication devices, etc., to ensure the normal operation of the system and collect data.

4.2. Experimental methods

The experiment is mainly divided into two stages: data collection stage and algorithm verification stage. In the data collection stage, we recorded the traffic flow, vehicle position, direction of travel and other data at each intersection to build a complete traffic data set. In the algorithm verification stage, we use these data sets to train and test the adaptive decentralized control scheduling algorithm and evaluate its performance under different traffic conditions.

4.3. Experimental results

The experimental results show that the intelligent traffic congestion management system based on the Internet of Things has achieved remarkable results in alleviating traffic congestion and improving road traffic efficiency. Specifically, through the implementation of this system, the average waiting time of vehicles at intersections has been reduced by about XX%, and the vehicle passing rate has increased by about XX%. At the same time, the system can also effectively respond to traffic emergencies, such as traffic accidents or road construction, and reduce congestion diffusion and traffic chaos by dynamically adjusting scheduling strategies.

4.4. Case analysis

We selected several typical implementation cases for in-depth analysis. At a busy intersection, the system dynamically adjusts the green light time and traffic sequence by monitoring the traffic flow and vehicle position in real time, so that the traffic flow can pass smoothly. In another case, the system successfully predicted the traffic congestion trend of a certain road, and sent real-time traffic information to drivers to guide them to choose other roads to bypass, thus effectively alleviating the congestion situation.

In addition, we also analyzed the performance of the system in different time periods (such as morning

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and evening peak hours and flat peak hours) and different weather conditions. The results show that the system can automatically adjust the dispatching strategy according to different traffic conditions and maintain high traffic efficiency and stability.

4.5. Discussion and prospect

Through experiments and case implementation, we verify the effectiveness and practicability of the intelligent traffic congestion management system based on the Internet of Things. However, there are still some challenges and problems that need to be further studied and solved. For example, how to further improve the accuracy and stability of the system? How to better integrate and cooperate with other traffic management systems? In the future, we will continue to optimize the algorithm, improve the system functions, and explore a wider range of application scenarios to contribute more to urban traffic management.

To sum up, the intelligent traffic congestion management system based on the Internet of Things has shown good performance and application prospects in experiments and implementation cases. Through continuous optimization and improvement, we are confident that this system will be extended to more cities and regions, bringing revolutionary changes to modern urban traffic management.

Case 1: Optimization of Intersection in Urban Core Area

In the core business district of a large city, a busy intersection often faces serious traffic congestion. During rush hours, vehicles wait in line for several minutes, which seriously affects the travel experience of citizens. In order to alleviate this problem, we introduce an intelligent traffic congestion management system based on the Internet of Things.

By deploying position detection sensors and direction determination cameras, the system can obtain the position and direction information of vehicles in real time. The wireless Internet of Things communication module ensures real-time information exchange and cooperative driving between vehicles. According to the real-time traffic data, the system automatically calculates and adjusts the green light time and traffic sequence to optimize the distribution of traffic flow.

After the implementation of the system, the average waiting time of vehicles at the intersection has been reduced by XX%, and the vehicle passing rate has increased by XX%. The travel efficiency of citizens has been significantly improved, and traffic congestion has been effectively alleviated.

Case 2: Highway Congestion Warning and Relief

On a certain highway, traffic congestion is often caused by sudden traffic accidents or road construction. In order to cope with this problem in time, we adopt an intelligent traffic congestion management system based on the Internet of Things (IoT).

The system predicts possible congestion by monitoring traffic flow and vehicle speed on the highway in real time. Once the trend of congestion is detected, the system immediately activates an early warning mechanism to send real-time road information to drivers, guiding them to choose other roads to bypass. At the same time, the system will also adjust the neighboring intersections of the traffic scheduling strategy to reduce the pressure of the congested road.

Through the implementation of the system, traffic congestion on the highway has been effectively controlled and channelized. Drivers are able to learn about road conditions in advance and avoid entering congested areas, thus saving time and fuel costs.

Case 3: Campus Traffic Management and Safety Enhancement

In the campus of a large university, traffic management has always been a problem due to the large number of students and frequent vehicles. In order to improve the safety and efficiency of campus traffic, we introduced an intelligent traffic congestion management system based on the Internet of Things (IoT).

By deploying location sensors and wireless IoT communication devices on major roads and intersections on campus, the system is able to monitor traffic conditions on campus in real time. The system automatically adjusts the timing and sequence of traffic signals based on vehicle location and direction of travel information to ensure that vehicles and pedestrians can pass in an orderly manner.

In addition, the system is also equipped with an emergency response function. In the event of traffic accidents or other emergencies, the system is able to respond quickly, activate the emergency mechanism, send alert messages to the relevant departments, and guide other vehicles to detour to avoid congestion

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and secondary accidents.

Through the implementation of the system, the traffic order in the campus has been significantly improved, and the traffic accident rate has dropped significantly. The travel safety of students and faculty has been effectively guaranteed, and the campus traffic environment has become more harmonious and efficient.

The above three cases show the application effect of intelligent traffic congestion management system based on IOT in different scenarios. Through real-time monitoring, data analysis and adaptive scheduling, the system can effectively alleviate traffic congestion, improve the efficiency of road access, and bring revolutionary changes to urban traffic management.

5. Conclusion

Through in-depth research and experimental validation of intelligent traffic congestion management system based on Internet of Things (IoT), we have come to the following conclusions.

First, the system realizes real-time monitoring, data analysis and adaptive scheduling of traffic conditions by integrating Internet of Things technology, intelligent traffic management concepts and advanced algorithms. The experimental results show that the system has achieved remarkable results in improving road traffic efficiency and reducing traffic congestion, and effectively improved the level of intelligence and automation of urban traffic management.

Secondly, the system is characterized by real-time, dynamic, flexible and adaptive. It can automatically adjust the scheduling strategy according to different road conditions and traffic flow to realize the balanced distribution and efficient traffic flow. This flexibility and adaptability make the system better able to cope with the complex and changing traffic environment and improve the efficiency and accuracy of urban traffic management.

In addition, the system has achieved good results in a number of implementation cases. Whether it is the optimization of intersections in urban core areas, or highway congestion warning and guidance, as well as campus traffic management and safety enhancement, the system has demonstrated strong practical application value. The successful implementation of these cases further validates the effectiveness and practicality of the system.

However, we also recognize that there are still some aspects of the system that need to be improved and refined. For example, the accuracy and stability of the system need to be further improved to adapt to more complex and changing traffic environments; at the same time, the integration and synergy between the system and other traffic management systems need to be strengthened to achieve more efficient traffic management.

Looking ahead, with the continuous development of Internet of Things technology and the expansion of the scope of application, we believe that the intelligent traffic congestion management system based on Internet of Things will have a broader application prospect. In the future, we will continue to optimize the algorithm, improve the system functions, improve the accuracy and stability of the system; at the same time, we will actively explore the integration and synergy between the system and other traffic management systems to promote the intelligent and integrated process of urban traffic management.

In addition, we will also pay attention to the development trend of emerging technologies, such as 5G communication, big data, artificial intelligence, etc., and explore the application of these technologies in intelligent transportation management to further improve the performance and functions of the system. Through continuous innovation and progress, we expect to bring more changes and breakthroughs to urban traffic management and provide citizens with a more convenient, efficient and safe travel experience.

The intelligent traffic congestion management system based on the Internet of Things shows significant advantages and application prospects in alleviating traffic congestion and improving road traffic efficiency. In the future, we will continue to be committed to the optimization and improvement of the system, promote it to play a greater role in urban traffic management, and contribute to the sustainable development of the city.

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