IoT in Urban Traffic Prediction Development Case Studies and Future Trends

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Abstract: The problem of urban traffic has become quite serious in recent years. This problem seriously affects the daily travel of urban residents and urban safety and brings great challenges to the sustainable development of the transportation system. This paper first briefly summarizes the development process of using the Internet of Things (IoT) to calculate future road traffic. As early as 1999, Kevin Ashton proposed to apply the Internet of Things to traffic, but the application in the traffic field is not mature, such as the early ETC (electronic road pricing system). With the rise of wireless communication technology, vehicle GPS navigation systems began to appear, which can provide real-time traffic information and route planning. Nowadays, various sensors, radio frequency identification devices (RFID), cameras, and other devices are widely used, making real-time data collection and analysis possible. Then it analyzes the current actual successful cases of using the IOT to calculate future road traffic, discusses in detail the promotion of traffic and the advantages of using the Internet of Things compared with the previous traffic, and gives the corresponding data. Finally, the future research direction and development trends are put forward. First, edge computing is introduced into the IOT, and edge computing is mixed with cloud computing to obtain a prediction system with better performance and lower robustness. The second is to optimize the existing network transport layer protocol. Finally, this paper makes a summary.

1 Introduction

China's urbanization process is accelerating, and road traffic is becoming more and more developed. The number of vehicles in the country has also increased year by year, which has brought more and more serious road congestion problems. Road traffic congestion has brought great hidden dangers to people's travel and has also become a factor restricting the development of cities. In 2021, China's road traffic accidents caused a total of 616,703 deaths, 250.723 injuries, and direct economic losses of up to 1,29072 million yuan [1].

Traditional traffic control systems already can not adapt to modern urban traffic management requirements in terms of traffic management, there is an urgent need for a new system to control the increasingly complex traffic system. In recent years, smart city

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transportation has risen the traffic control system using the mixed deep learning of the Internet of Things (IoT) has aroused wide discussion in society. Due to its superior resource management and information collection capabilities, in recent years, more and more applications in all walks of life, such as information management, warehousing logistics, and so on. Deep learning technology has also achieved rich results in natural language processing [2].

Internationally, some countries have carried out related research and achieved a series of results. For example, Jakarta is the capital of Indonesia. To improve traffic efficiency, the Bus Rapid Transit (BRT) system of Jakarta combines IOT technology, so that the real-time location of buses can be tracked. At the same time, a supporting traffic Application is developed to enable passengers to obtain the arrival time of vehicles in real-time through mobile phones [3].

This paper presents the current research status of related work, using IOT to infer future road traffic conditions. This paper discusses the specific use of IOT technology in inferring future road traffic conditions through case analysis and summarizes the advantages and limitations of existing methods, such as the combination of neural network algorithms and IOT. This paper aims to provide improvement suggestions for How to use IOT computing to predict future road traffic flow

2 Analysis of research status

2.1 Road traffic prediction method using Internet of things technology

To supervise the urban traffic flow conveniently and accurately, IOT technology is introduced into the application of intelligent transportation and the construction of smart cities. Traffic data can be quickly collected using IOT technology. As the main source of data in the IOT, Sensor technology can increase the speed between data collection and data transmission and enable initial information screening. Provide real-time, accurate, and stable data sources for deep learning technology. Use deep learning technology to achieve more accurate Probability prediction of road traffic conditions.

2.2 How to use the IOT technology for probability prediction of road traffic

by K Ashton [4]. Researchers have found that the traffic data has both temporal and spatial characteristics Probability prediction of road traffic conditions. In particular, the time characteristics have certain periodicity, ranging from daily, weekly, each different season, To the time in the morning when people are rushing to get to work and the time in the evening when people are rushing to get home from work. Compared to other times, the roads during these two hours are congested and accidents are more frequent. Similarly, if it analyzes the periodicity of road traffic congestion throughout the year, it can see that the periodicity of road traffic congestion conditions varies greatly from season to season. Therefore, due to the influence of external factors, the flow will show a roughly cyclical change. This is precisely because people's behavior has a certain law on the impact of traffic, so it is possible to infer the road traffic situation. Bing Liu integrates IOT technology into road traffic situation prediction, which can make traffic roads more intelligent and urban development more harmonious. The key technologies are shown in Fig. 1 [5].

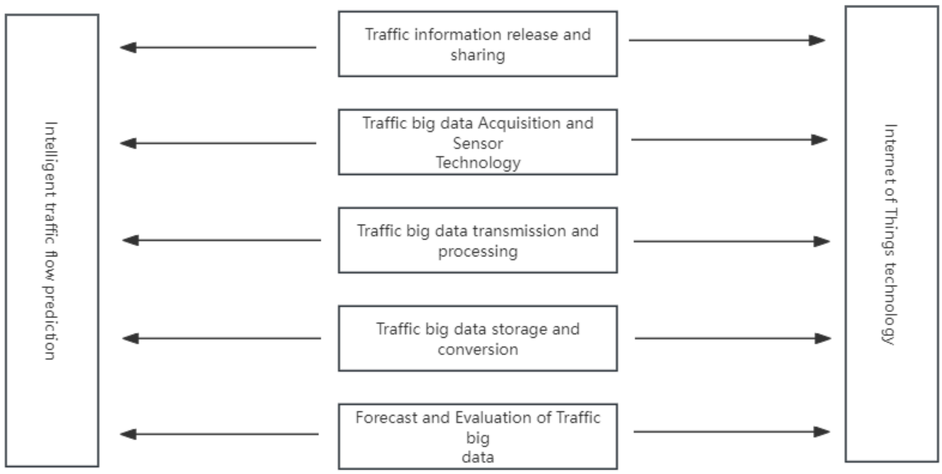

Fig. 1. Smart road with IOT mixed big data technology [5].

Meanwhile, Bing Liu et al. use the Back-Propagation (BP) neural network model, which passes through a multi-layer Feed-forward neural network. BP networks have multiple layers of hidden units. Most neural networks use variations of BP networks. The BP network differs from the perceptron in its structure, with its core characteristic being the unidirectional propagation of signals. By analyzing the topology structure of the three-layer BP neural network, it can gain an understanding of its implementation process. This process begins with the initialization phase of the network, during which training data needs to be prepared. The data then moves from the input layer, passes through any possible hidden layers in turn, and finally arrives at a result in the output layer, completing the entire forward propagation process. Subsequently, based on the output results, adjustments are made to the network's weights to assess whether the prediction error meets predetermined accuracy requirements. The specific process is shown in Fig. 2.

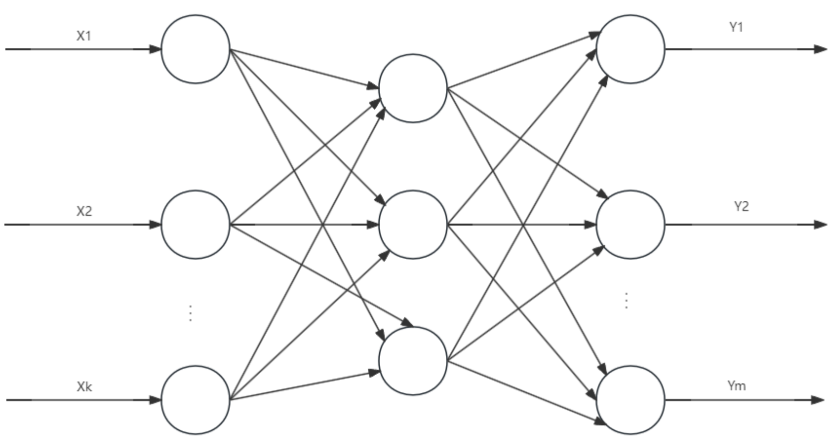

Fig. 2. BP network [5].

On this basis, Bing Liu and his team proposed the hybrid use of Kalman filter (KF) and BP neural network, using KF's state estimation ability and BP neural network's learning and adaptation ability to solve complex system and control problems Fig.3.

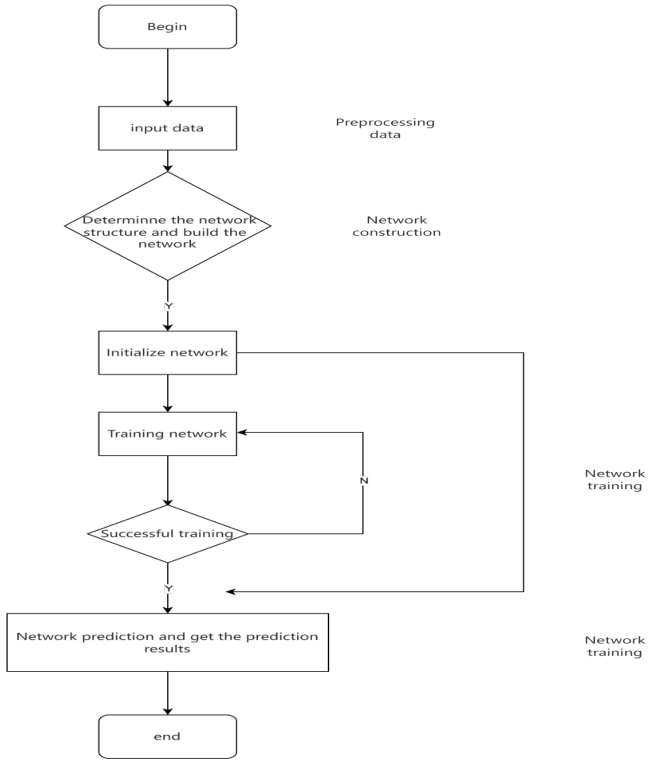

Fig. 3. Network prediction process [5].

3 Case analysis

In terms of intelligent management, the construction of smart cities benefits from the rise of the Internet of Things. The interconnection of everything makes system management more convenient and fast. At the same time, the cooperation between multiple equipment systems can be more intuitive and effective, and the effect of each device is maximized.

For example, Surtrac, an information control optimization system that is now in use, was developed by a team at Carnegie Mellon University. The technology aims to increase the efficiency of urban roads by using artificial intelligence and deep learning to predict the traffic conditions of roads within a certain period, thereby optimizing traffic signal control. Surtrac provides real-time signal control at multiple intersections, reducing waiting time and improving traffic flow. Preliminary trials in Pittsburgh's East Liberty neighborhood have shown remarkable results: a 25 percent reduction in the time it takes vehicles to reach their destination and a 34 percent increase in the speed of road vehicles. At the same time, the time spent stopping vehicles due to various traffic signals decreased by more than 31 percent, and the waiting time for vehicles at traffic lights also decreased by more than 40 percent. In terms of environmental protection, the road environment has been improved by increasing the speed of the vehicle and reducing the waiting time, and vehicle fuel emissions have been reduced by 21%. Compared to traditional traffic control methods, SURTRAC's road signal control system increases road traffic capacity by approximately 25 to 40 percent and reduces emissions by at least 20 percent [6].

With the continuous development of artificial intelligence technology, the combination of deep learning technology in Internet of Things applications will improve the application performance of the Internet of Things. However, in the traditional traffic flow forecast, the nonlinear fitting model of a single road is usually adopted. In the absence of accurate road data, this method often leads to severe overfitting. The emerging deep learning methods, especially RNN-based Long Short-Term Memory (LSTM), can effectively extract effective information from time series. At the same time, combined with a stacked Autoencoder (SAE), SAE technology automatically learns from raw data to provide more accurate characterization. The LSTM-SAE algorithm proposed by Chen et al. can achieve a data compression rate of 20% when processing high and large-scale traffic data in urban road networks through the method of ensemble learning. In addition, the hybrid model of LSTM-SAEs performs better in fitting actual traffic flow and demonstrates higher predictive accuracy than other algorithms such as GRU, DBN, and ARIMA. When the data compression loss rate is 20%, the prediction accuracy of the hybrid model can reach 97%.

At the same time, not only developed countries are using Internet of Things computing in transportation, but also some developing countries. For example, in Qingdao, China, the PTS-Qingdao parallel traffic system was built in 2013-2014 to improve the local traffic environment [7, 8]. The Qingdao municipal government spent about three months evaluating the effects of the PTS system after it was completed. The results of the assessment show that the traffic situation has improved significantly. Six months after the implementation of the PTS system, the driving time of vehicles on major roads in Qingdao has decreased by 20%, while the number of temporary vehicles stops on the road has decreased by 45%. Not only that, the length of the road marked red on the main traffic sections that often have various types of congestion has been reduced by 30%, the time for vehicles to start and reach their destination has been shortened by 25%, and the efficiency of vehicle operation on the road has been improved by 43.39%. In addition, the timeliness of real-time information provided on the corresponding map app has also been improved. At present, the accuracy rate of publishing real-time road traffic information has exceeded 90%

4 Problems and challenges

The security risks of traditional Internet of Things systems are still huge. Because of the connected device and the protocol to transmit data and the inefficient encryption method, it is easy to become the target of attackers, and it is necessary to strengthen security measures to prevent data leakage and malicious intrusion. When it comes to privacy issues, the collection and analysis of large amounts of data may touch on users' privacy rights, interoperability, and standardization Interoperability issues between different vendors and devices may lead to integration difficulties and inefficiencies. The design, deployment, and maintenance of an Internet of Things system can be very complex and may require significant investment and technical support because of the daily input and management of large amounts of data on servers. Otherwise, it may cause information overload to damage the system hardware.

5 Future research directions

At present, the IOT in traffic flow prediction is closely related to the performance development of the IOT itself. If the IOT wishes to play a more significant role in future road traffic trends and smart cities, that must address its performance bottlenecks. Due to the short research time of the Internet of Things as an emerging research direction, there are still many issues worthy of in-depth discussion. The following points may become the focus of future research:

(1) The Internet of Things (IIOT) plays an important role in the field of intelligent manufacturing and industrial automation. With IOT systems, various networked devices and intelligent machines can exchange information over the Internet, a process that is often automated. This automation reduces the reliance on human intervention. In the field of automation, the technology used for the Internet of Things is often referred to as the Industrial Internet of Things (IIOT), and it faces several challenges, including the management of applications and IIOT devices. In addition, heterogeneous networks and a large number of devices in an industrial IOT environment require different configurations to cope with different work tasks. Software Defined Networking (SDN) technology is one of the potential solutions to solve these problems. (2) In addition, because most of the network layer transmission of the Internet of Things is based on the TCP protocol, resulting in the transmission rate can not be effectively improved. The QUIC protocol proposed by Google has both the security of TCP and the rate of UDP

(3) Secondly, Within the domain of the Internet of Things and traffic flow forecasting, although the use of cloud computing can assist computing power to a certain extent, due to the characteristics of cloud computing, there will be excessive power consumption and insufficient bandwidth in the face of a large number of devices access, with the current level of cloud computing, it is difficult to ensure its speed and stability in the face of a large number of calculations. At present, some studies combine Edge Computing (EC) and Cloud Computing (CC) [9, 10] to reduce the robustness of the system in the face of a large number of device data influx. In this way, the computing mode can be distributed, and the initiative of the supervisor at each level can be exerted, and a large amount of data can be filtered step by step at the bottom, and finally summarized. This computing model not only reduces the robustness, but also improves the speed and security, so that it is no longer completely dependent on the network but can still operate to a certain extent when the network receives fluctuations. If this computing model can be realized, then this combination of cloud computing and edge computing will make the transportation rate and stability of the Internet of things to a higher level.

6 Conclusion

This paper introduces the development of the IOT transportation, from the concept of applying the IOT to transportation to the initial attempt and application of the concept, and then to the development of various technologies such as RFID, sensors and other technologies. This paper introduces and summarizes the current frontier research on Road traffic projections method based on IOT. At the same time, through the case analysis method, the advantages brought by the use of IOT technology compared with traditional transportation are discussed in detail. Based on the findings of this paper, the possible problems and challenges in the future are proposed. Suggestions for future research are also presented, and further research can explore the optimization and construction of IOT system network layer protocols. The method of combining Edge Computing (EC) with cloud computing (CC) was used to reduce the network dependence and robustness brought by cloud computing and improve the efficiency of operation.

Overall, this study provides insights into the Internet of Things system in traffic flow forecasting and provides a brief overview of Current research status, providing a foundation for possibilities for future research directions and practice. Finally, it hopes that this research can make some contribution to the development of related neighborhoods and can trigger more meaningful discussions

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