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Research Article

Design and Implementation of Intelligent Vehicle Control System Based on Internet of Things and Intelligent Transportation

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With the improvement of urbanization and the continuous expansion of transportation scale, traffic problem has become an important problem in our life. How to ensure traffic safety has become the key issue for the government to implement social management. Nowadays, Internet of Things (IOT) technology is widely used in the industrial technology field. It will have a great impact on human production and life. Intelligent transportation system is a research field involving many high and new technologies. This paper proposes an intelligent transportation system based on Internet of Things technology. This paper presents the optimal design structure of intelligent transportation system based on Internet of Things technology. The experimental results show that the intelligent transportation system can effectively realize the information interaction between the vehicle and the control center and understand the road conditions in advance. At the same time, the intelligent transportation system can improve the driving speed of vehicles on the road, make effective use of resources, reduce economic losses during vehicle operation, and reduce air pollution caused by gasoline emission.

1. Introduction

With the development of urbanization, more and more vehicles have flooded into our life and work. In the process of social and economic development, people will pay more attention to traffic problems. At present, the number of motor vehicles in our country is as high as more than 200 million, and the traffic flow and the number of vehicles have a close relationship; how to avoid traffic congestion to ensure smooth traffic has become a hot topic [1]. In order to better control traffic problems, the emergence of intelligent system can be said to have a great significance. Intelligent traffic control system using Internet of Things technology can bring great benefits, such as reducing traffic pollution, easing traffic congestion, and reducing energy consumption [2].

As a newly proposed emerging technology, the Internet of Things (IoT) has experienced rapid development from its first appearance to the present. The emergence of WSN and RFID, two core technologies of the Internet of Things, has laid a foundation for realizing intelligent monitoring and remote intelligent identification by using them. Through the above technologies, the Internet of Things seamlessly connects the Internet, devices, and people together. Through the Internet of Things technology, we can effectively connect small smart devices and even personal computers to a variety of networks, so that anyone can enjoy high-quality information services, no matter where and when [3, 4]. Through the intelligent expert system, people can timely and effectively receive the status information of the goods they care about and make timely decisions, so as to achieve the effect of energy saving and emission reduction. It is becoming more and more urgent to introduce high technology to control traffic. Therefore, due to the emergence of the Internet of Things, intelligent identification and management can be realized through relevant technologies, so as to solve or alleviate the abovementioned social contradictions [5].

Intelligent transportation is another typical application of IOT. Because of the high social value of realizing intelligent transportation through Internet of Things technology, intelligent transportation can become one of the two typical applications of Internet of Things. Because of this, the research on the related technologies of intelligent transportation is particularly important [6]. It can promote the development of the whole social industrial chain, drive the relevant social and economic progress, and make a significant contribution to the realization of a harmonious society. Intelligent transportation is to apply many cutting-edge technologies to traffic management, so as to realize real-time, accurate and effective transportation management and integrated control system [7]. As an important branch of the Internet of Things, intelligent transportation can generate many related value-added services. The Internet of Vehicles is a new branch of the Internet of Things defined by Chinese people under such background. The so-called Internet of Vehicles refers to the application of the Internet of Things in intelligent transportation [8]. The main roads on Beijing are all clogged, so the government has issued the policy of limiting car license plate purchase and driving. This not only restricts the development of national economy but also seriously affects the normal life of ordinary people.

This paper fully investigated the key technologies of intelligent transportation in the Internet of Things environment, designed an intelligent system, and studied the two core technologies of intelligent transportation in view of the two core problems of transportation. It also summarizes the intelligent transportation system under the Internet of Things environment proposed in the paper and makes a summary for some of the problems and makes a plan and outlook for the existing related problems, puts forward improvement measures, and makes a work plan [9].

Internet of Things (IOT) refers to the real-time collection of any object or process that needs monitoring, connection, and interaction through various information sensors, radio frequency identification technology, global positioning system, and other devices and technologies, so as to realize the ubiquitous connection between things and people and realize the intelligent perception of things and processes through various possible network access identification and management [10]. The Internet of Things is an information carrier based on the Internet and traditional telecommunication networks. It allows all ordinary physical objects that can be independently addressed to form an interconnected network. The system also provides an adaptive cruise control system based on distance detection. At the same time, the system will give an audio and visual alarm if the distance detected by neighboring vehicles is less than the safe distance.

The main contributions of this paper can be described as follows:

(1) We deeply study the intelligent transportation technology, Internet of Things technology, and the main characteristics and application fields of these technologies. We have studied the main ways of the application of Internet of Things technology in the field of intelligent transportation.

(2) We introduce the Internet of Things technology into intelligent transportation filed, and we give the experiments which can verify the good performance of this method.

The structure of the rest of this paper is described as follows: Section 2 gives the overview for the Internet of Things. Section 3 gives the overview of intelligent transportation systems. Section 4 describes intelligent transportation system in the Internet of Things environment. Section 5 gives the conclusion.

2. Overview for the Internet of Things

The Internet of Things (IoT) is regarded as a major development and change opportunity in the field of information, and it will be widely used in many fields. Sensor network, transmission network, and application network constitute the Internet of Things system. In the sensor network, we arrange a large number of various sensors and related wireless communication nodes around the monitoring target regularly or irregularly [11]. The environmental parameters of the monitored target or its surroundings can be sensed through current, voltage, or digital sensors. In the transmission network, the perceived data are transmitted to the wireless communication device as the sink node through the wireless communication device as the terminal in a single hop or after multiple hops. Several sink nodes are combined to aggregate all the perceived data to the gateway device together [12, 13]. Data aggregated to a gateway device can be transmitted to a cluster server over multiple types of networks such as Internet, GSM, and 3G. In the application network, including many terminal devices, through the Internet and other external networks can read the data and status of the entire network, and according to the feedback information further reverse control of the operation of the entire network. Through intelligent decision-making and manual decision-making, information acquisition and reverse control can be carried out through terminals such as computers and mobile phones. The architecture diagram of the Internet of Things is shown in Figure 1.

Figure 2 shows a complex wireless sensor network, typically consisting of a data awareness network, a data transmission network, and a data processing and intelligent decision management center. In the wireless sensor network, the network topology is particularly important. So, we will take a comprehensive look at its properties. In a communication network, the main parameters to measure its performance are service packs and QoS for propagating messages. QoS refers to message delay, arrival time, bit error rate, packet loss rate, economic cost and transmission power, etc. Several basic network topologies is described in Figure 3. Generally speaking, the specific form of network topology is always in accordance with QoS considerations, combined with installation environment, economic considerations, and application applications. A communication network is composed of many nodes with computing power and bi-directional communication ability of sending and receiving data, as shown in Figure 3. A basic network topology has various forms of expression, such as star, ring, bus, tree, fully connected, and network [14]. A single network may consist of a number of interrelated subnets of different topologies. Networks can be further divided into local area networks (LANs) and wide area networks (WANs).

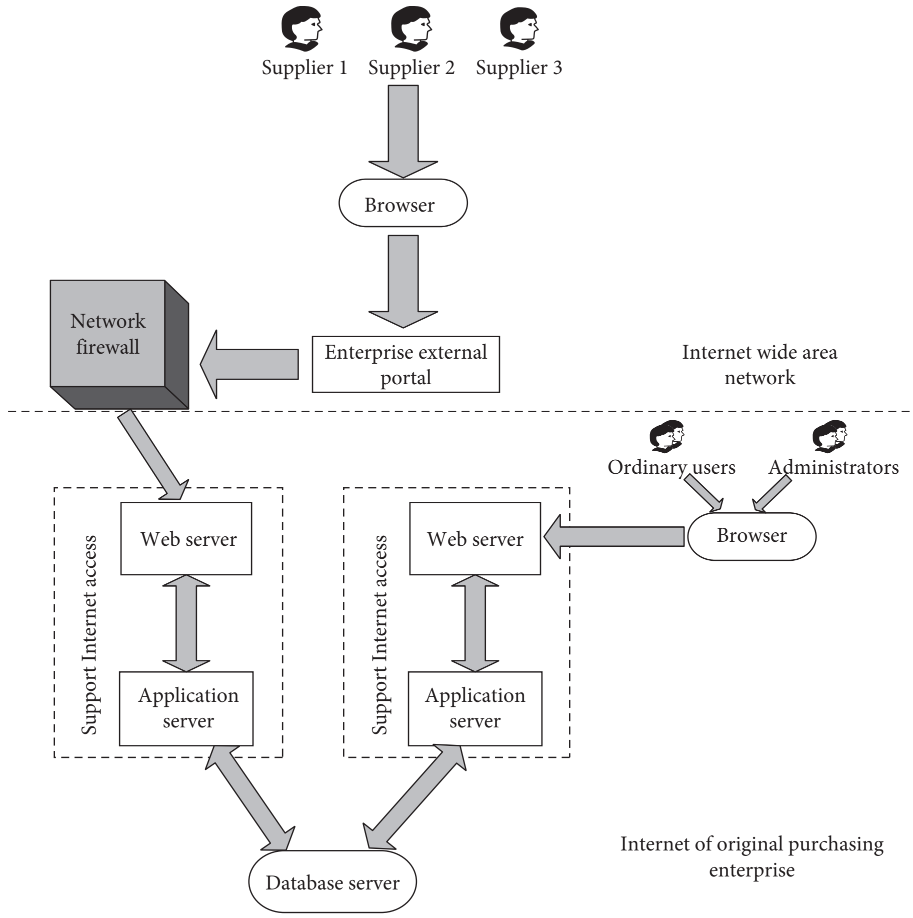

Figure 1: Architecture of the Internet of things.

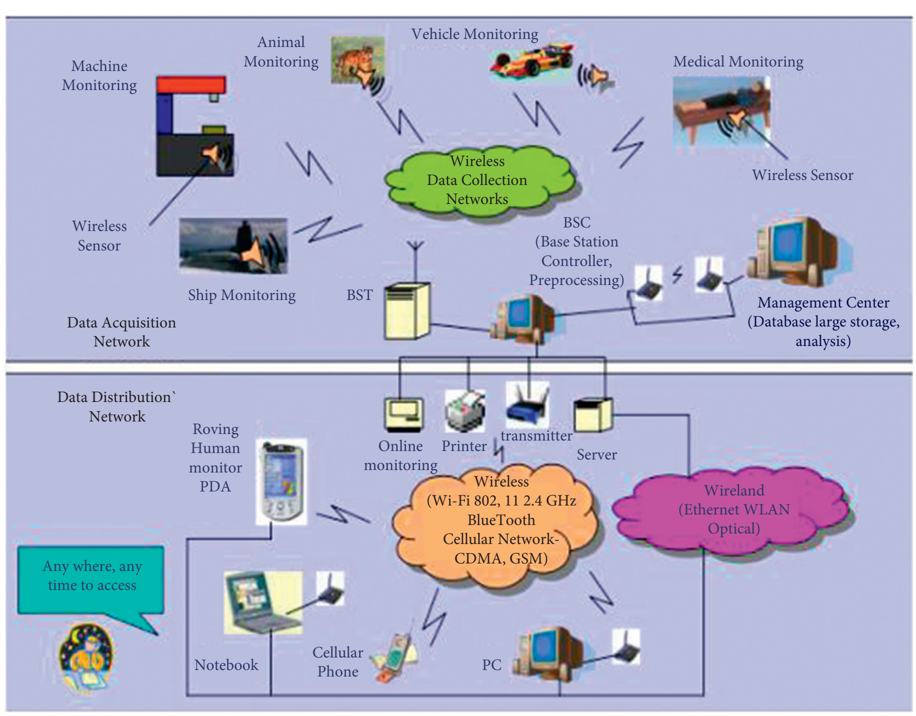

Figure 2: Structure of wireless sensor.

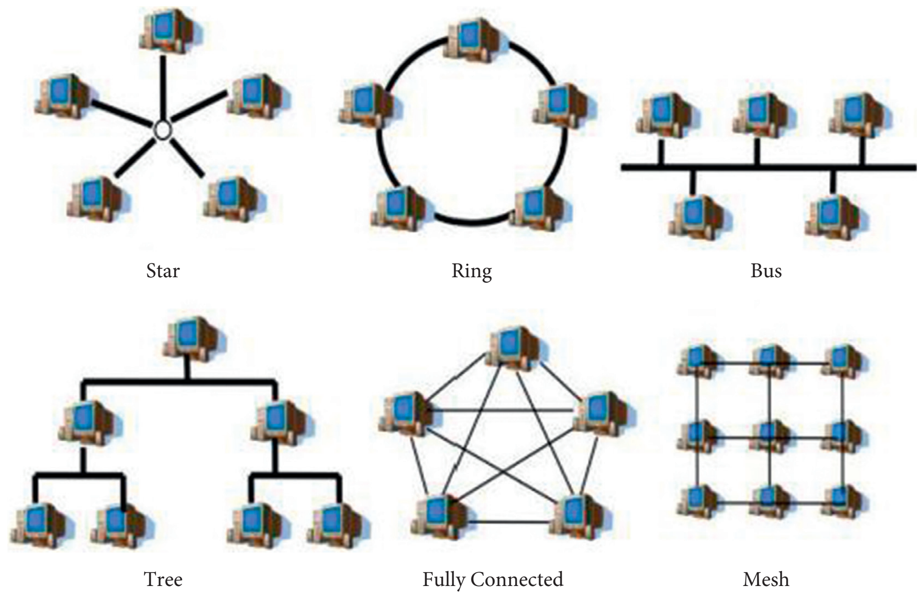

Figure 3: Structure network topology. (a) Star. (b) Ring. (c) Bus. (d) Tree. (e) Fully connected. (f) Mesh.

Radio frequency identification (RFID) is an integral part of our life, and its emergence has increased productivity and brought convenience to our life [15, 16]. It realizes digital information communication between a fixed position and a moveable object or a moveable object through short-range radio technology. The tag usually reads the stored data in its internal memory and changes the encoding loaded on the tag antenna so that it can be used to store the data. Figure 4 shows the main components of the new electronic tag, including the storage and memory function, display function, automatic reading function, positioning function, and input and output function of the new electronic tag.

The reason why the Internet of Things and the concept of Smart Earth can be realized is that the world has already stepped into the era of 3I, namely, instrumented, interconnected, and intelligent. We only need "a hundred steps on the road, one step further" enables the IoT world to be implemented anywhere, anytime and in any way [17]. Typical applications of the Internet of Things are reflected in the following aspects: urban management, such as intelligent transportation, intelligent energy conservation, intelligent buildings, cultural relics protection, digital museums, real-time monitoring of ancient trees, digital libraries and digital archives, digital home, positioning and navigation, modern logistics management, food safety management, retail, digital medical, and anti-intrusion system. From these typical applications of the Internet of Things, we can see that the intelligent transportation system is an application demonstration that can be used as a typical environment. At the same time, we can apply multiple intelligent transportation systems to public facilities and then form a community to form an intelligent community of information, thus paving the way for realizing the lofty goal of a smart city [18].

3. Overview of Intelligent Transportation Systems

Under the control of the Internet of Things, the intelligent transportation system realizes the interaction between people and information in the traffic system. Through various sensing technologies, the acquired object information is analyzed and processed, and the final conclusions are transmitted to the object, making it more convenient and fast for the object to travel in traffic [19, 20]. The intelligent transportation model of the Internet of Things includes three layers: the perception layer, the transmission layer, and the application layer. The sensing layer includes tools such as sensors and terminal devices [21]. FRID technology has been applied to the perceptual layer and has been successfully applied to the electronic nonstop toll collection system in China. The role of the transport layer is to transfer information, and there are communication networks and gateways. The role of the application layer is the application software at the receiver and publisher of the message. The structural model composed of three layers is called DCM three layers. Overall framework of the IOT is shown in Figure 5.

The occurrence of traffic accidents and the number of vehicles, the skills of the driver, has a great relationship, especially on the highway, and driving inexperience is easy to happen traffic accidents; traffic accidents once cannot be solved in time, will cause a second accident, threatening the lives and property of drivers and drivers [22]. Usually, video image processing technology is used to detect traffic accidents. Video technology can intuitively collect the vehicle information of the accident. However, video technology may be affected by weather conditions, and the monitoring may lose its function in serious cases. In addition to video image processing technology, acoustic technology can also be used

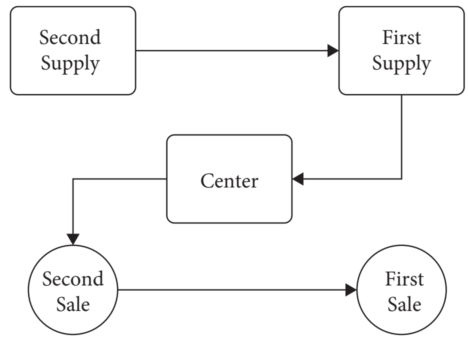

Figure 4: Overall framework of the new electronic tag.

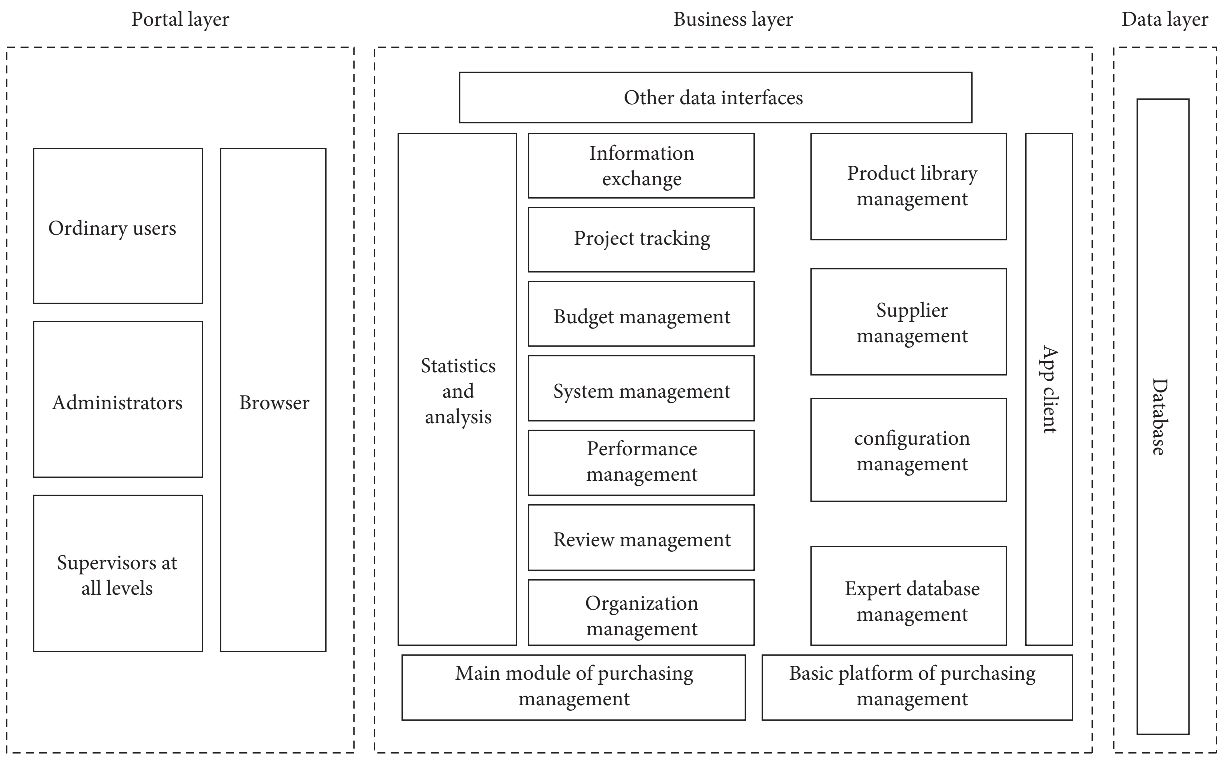

Figure 5: Overall framework of the IOT.

to detect vehicle accidents. When a collision occurs, the vehicle will emit impact noise, and its high frequency part has obvious characteristics. The frequency resolution of the wavelet transform decreases with the increase of the frequency in the time-frequency plane. Wavelet packet characteristics can be used to reflect the system state of the feature vector, using the method of pattern recognition to identify and classify the features, can be in the shortest time to seek help, reduce the occurrence of secondary accidents, effective detection, and treatment of vehicle accidents [23].

Each vehicle in the IoT intelligent transportation system is equipped with a FRID tag, which is designed to detect the vehicle in various aspects. The vehicle information collected by FRID is relayed to a reader, which decodes the data and relayed it to a data center. The reader can then identify the vehicle's origin, brand and traffic conditions, calculate the exact traffic flow, and develop management and control measures. FRID sensing detection can save the workload of vehicle inspection and improve the work efficiency. When FRID is used in conjunction with other automatic control systems, it can be used to organize vehicles that do not have permission to enter a certain area or vehicles with violation records to enter a certain road section. The efficient management improves the quality of service while greatly reducing labor costs [24].

Intelligent transportation systems can provide accurate and fast information through the Internet, facilitating travel. In addition, it can also be used to inform impending dangers and possible delays, while improving efficiency and reducing waste of fuel. Intelligent transportation systems can produce safer, more efficient, and more environmental friendly vehicle movements. Because of the rapid development of intelligent transportation, advanced intelligent transportation assistant

(ADAS) and intelligent vehicle type detection system have been promoted. Intelligent transportation assistant refers to the integration, such as cars, trucks, bus arrangement of sensors, and control systems, the aim is, through the collection of sensor technology and algorithm of vehicle network, to help the driver away or warning of potential risks better help driver to provide advice, effectively avoid the occurrence of traffic accidents, at the same time can get road vehicle information. It provides the basis for intelligent decision of traffic system.

4. Intelligent Transportation System in the Internet of Things Environment

Referring to the newly proposed Internet of Vehicles (IoV) technology, in this chapter, we realized the vehicle type identification based on the acoustic sound system by using the embedded technology and the integration of KPCA and SVM. The uniqueness of this algorithm is that it uses KPCA to identify vehicles. The outcomes indicated that it can accurately distinguish vehicle types.

In this chapter, based on the previous research, we put forward an innovative feature extraction algorithm: kernel complex discrimination algorithm, which can be widely used in the intelligent transportation assistant by combining with the embedded platform of low power consumption and high efficiency and verify its effectiveness. In the next step, more environmental factors (such as reflections, bad weather, and differences in light intensity at different times) will be taken into account to make the system more robust.

4.1. Brief Introduction of Intelligent Transportation System in the Environment of Internet of Things. Intelligent transportation combines many advanced technologies in today's world. Among them, there are not only low-level data awareness technology but also middleware data communication technology and network technology. There are not only the upper level of big data processing technology but also reverse automatic control technology and information release technology. In the course of establishing and perfecting the information and accurate transportation and management system, the integration of the abovementioned technologies has laid a solid foundation for the emergence of the system. It is the expansion of wireless sensor network in the field of transportation and the perception and processing ability of computer system to data. It can carry on the information monitoring and management and also can release the real-time traffic information to the drivers and passengers in the car and can carry on the emergency warning.

Internet of Vehicles, as an important part of intelligent transportation system, has been widely concerned by people since its appearance. From the rise of the Internet of Things in the late 1990s to the subsequent concept of smart city and smart Earth, these concepts are derived into the transportation system and hence the emergence of smart transportation and the Internet of Vehicles. The Internet of Things is transformed and evolved from the sensor network. The rapid development of IoT-related industries, especially the rapid integration in the field of transportation, promotes the emerging direction of intelligent transportation—Internet of Vehicles. A simple description of the Internet of Vehicles is that different types of sensors, such as temperature and humidity sensors, light sensors, or cameras, are arranged on the "car," or the abovementioned sensors are deployed in the surrounding environment of the "car," so as to realize the information interaction between cars and cars, and between cars and people. It is the expansion of wireless sensor network in the field of transportation and the perception and processing ability of computer system for the century. Through the Internet of Vehicles, it can effectively realize the rapid dispatch of cars and people, and at the same time, it can monitor and manage their information. In addition, through a powerful integrated information service system, real-time traffic information can be released to the drivers and passengers in the car, and the emergency warning can be carried out. In terms of policy, the Internet of Vehicles and related projects have also received strong support from governments around the world. A car will also be connected to the Internet and its related industry in China as a national major project research projects, car networking as breakthrough point of the Internet of things, and improve people's livelihood of major science and technology application, getting priority support in terms of economy; it provides capital for the vigorous development of car networking support, believe in the following the development of science and technology, will certainly come to the fore.

4.2. Two Key Technologies. The two core problems of traffic are traffic congestion and traffic safety. As the traffic system becomes more and more complex, the traffic management will develop to the precision, information, and intelligence. Experience-based traffic management will no longer fit the current needs, and there is an urgent need to introduce high technology to control traffic. The emergence of vehicle network and Internet of Things has laid a theoretical foundation for it. This paper studies the intelligent vehicle statistics system and the intelligent traffic assistant system in the intelligent transportation and provides solutions for the two core problems mentioned above in the traffic.

The occurrence of traffic accidents and the number of vehicles and the skills of the driver has a great relationship, especially on the highway; driving inexperience is easy to happen traffic accidents; traffic accidents once cannot be solved in time will cause a second accident, threatening the lives and property of drivers and drivers. Usually, video image processing technology is used to detect traffic accidents. Video technology can intuitively collect the vehicle information of the accident. However, video technology may be affected by weather conditions, and the monitoring may lose its function in serious cases. In addition to video image processing technology, acoustic technology can also be used to detect vehicle accidents. When a collision occurs, the vehicle will emit impact noise, and its high frequency part has obvious characteristics. Wavelet packet characteristics can be used to reflect the system state of the feature vector, using the method of pattern recognition to identify and classify the features, and can be in the shortest time to seek help and reduce the occurrence of secondary accidents, effective detection, and treatment of vehicle accidents.

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In this paper, we design and develop a signal processing system based on sound feature matching on an integrated module. The main hardware system includes an integrated processor and a wireless transmission module. In terms of software, we chose KPCA as the feature extraction method and support vector machine as the classifier because of its nonlinearity. This system can detect a moving car and determine its type. By building a test platform, we compare this method (KPCA + SVM) with other traditional methods and find that this method is more accurate than other methods. In this paper, we also designed an integrated signal processing embedded system, as the system can use image features to classify vehicles, better help drivers to provide driving advice, and effectively avoid traffic accidents. We choose the kernel identification method based on Fourier transform (FKD) as the feature extraction algorithm; because of its high-precision nonlinear ability, we can realize the image preprocessing by selecting the best frequency band and then choose the nearest neighbor classifier (NNC) to identify the image. The system also uses embedded devices to detect the distance between vehicles, effectively helping vehicles avoid collisions.

4.3. Designing Systems. With the development of transportation industry, the length of roads is increasing. We can detect different information on different roads by using the intelligent transportation system. Static information refers to the object information of vehicles or detection points, while dynamic information refers to the road traffic conditions, abnormal traffic events, and environmental information. Collecting dynamic information is the basis of traffic control and management. The main information collected includes density, flow, vehicle type, vehicle speed, and other traffic environment information. In the process of building an intelligent transportation system, it is not only necessary to collect traffic operation information in a timely manner but also to transmit information in a timely manner. Intelligent transportation should learn to use advanced technology to transform and connect the wireless access network and the core network to meet the requirements of power consumption of the sensing layer. Now, we should pay more attention to FRID, 4G networks, and sensor networks, and closely integrate wired networks and wireless networks to address each other's shortcomings and effectively improve the standardization and compatibility of network transmission.

At present, the traffic management and dispatching system in China can timely and accurately collect and process information. IoT Intelligent transportation system is a combination of multiple traffic management subsystem, such as video monitoring system and traffic detection system, as well as the good visual interface, which can realize the control center and information to accept good interaction between objects, effectively improve the efficiency of work, and eventually reach good scheduling results. Intelligent traffic management and scheduling system based on Web GIS has a wide range of access, which can manage and collect data sources. Users in the system can access the database through web browser at any time and realize remote data sharing, which is conducive to drivers' timely understanding of traffic conditions. At the same time, the intelligent traffic management and scheduling system based on web GIS also makes full use of the network resources, the server side distributes the basic work, the client side completes the operation with small data volume, effectively balances the computing load, and seamlessly integrates other information services, which is conducive to the addition and upgrading of the following sequence modules and functions.

One of the core problems to be solved is traffic congestion, so the acquisition of vehicle information on the road is particularly important. By using the data of vehicle type, speed and basic information of vehicle and people in operation, reasonable postregulation, and road information analysis can be carried out, so as to solve or alleviate the traffic congestion problem. Therefore, the statistics of vehicle types has become a hot topic in the research of the Internet of Vehicles. There are many ways to identify different types of vehicles by identifying different types of signals, such as vehicle detection and identification using magnetic fields, images, and sounds. To sum up, we choose to transmit acoustic signals through wireless sensor network for vehicle identification. The movement of vehicles on the ground affects the environment in different ways. Suppose similar vehicles under the same operating conditions produce the same sound. In view of this, we can classify vehicles according to their sound. This has led to research on how best to obtain the sound of each type of vehicle and extract the best feature description. In this chapter, a novel sound signal acquisition and feature extraction method based on KPCA is proposed, and the method is compared with other techniques. Support vector machine (SVM) is used as a classifier to detect recognition rate.

Compared with the traditional sound perception system, the embedded speech perception system has the advantages of greater amplification, faster processing speed, and higher recognition rate than the ordinary sound perception system. With a perceived CC2430 voice transmission system and a ARM11 processing system

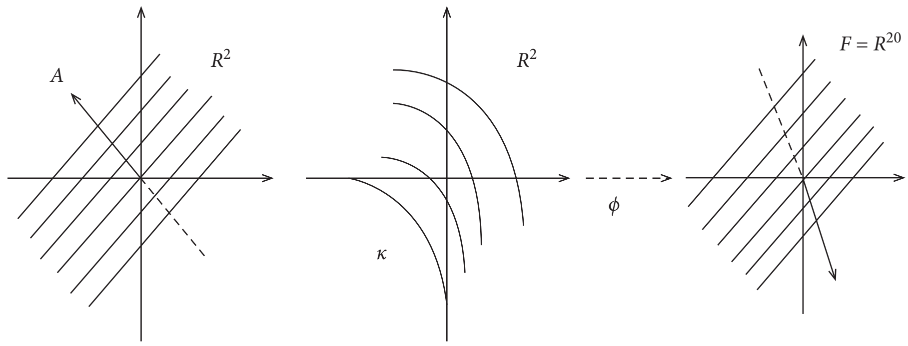

Figure 6: PCA.

composed of voice identification system is compared, we found that more than sound perception transmission system, a sound perception transmission system consisting of two sensors and a signal transmission components) compared with a single voice transmission system perception, collected a better and more full of voice. It provides an accurate signal source for the subsequent feature extraction system, thus obviously improving the sound recognition rate. Multisensor system can identify the sound perceived by each sensor.

Vehicle characteristics refer to the process of developing a vehicle's characteristics for use in classification. Usually, the processing of this feature is done using a general-purpose computer. Suppose there are M cars, all of which are target classification systems, and let V_j, $j = 1, \ldots, K$ is the sound of the JTH car. A collection of sound samples is called a training group. The training set classifier is then used to tag each vehicle generated. The V_j training sample refers to the sound sample collected from the jth vehicle. The training samples are used as classifier training and will generate a marker for each vehicle. Through the nonlinear mapping, the KPCA algorithm converts the sound signal from the data space to the feature space, in the feature space, and then using the principal component analysis, we can calculate the best projection direction and get the nonlinear feature. PCA is shown in Figure 6.

In the higher dimensional feature space, we do the kernel PCA transformation of the sound signal, just as we do the PCA transformation in the input space. So, it becomes nonlinear when the input space is projected onto the main eigenvector. More importantly, for KPCA, it does not actually map into F space, but performs kernel function K calculations in the input space. To sum up, we carry out the KPCA transformation by introducing the nonlinear transformation function, and each sound sample vector X_k is projected from the input space onto the higher dimensional feature space F. Then, from the feature space F, combined with the existing PCA algorithm, we can obtain the main features of the target.

4.4. Analysis of System Experiment Results. In our experimental platform, we induced RRS from a number of experiments. All experiments are carried out in a quiet area, where there is no abnormal noise such as wind noise. Because we do not know if there is an effective algorithm for mixed sound recognition, this case was not included in our experiment. Because the different sound samples of training vehicles will affect the recognition rate, we adjust the number of training samples appropriately. Our sound database includes 40 samples from six different types of cars. First of all, under the condition of using ML classifier, we conducted relevant experiments on the influence of different training samples on the recognition rate. Then, we change the classifier type, using KNN classifier and SVM classifier to do relevant experiments. The number of training samples increased from 4 to 12, with a step of 1. Figures 7–10 show the recognition rate distribution diagrams of different feature extraction methods and different classifier combinations. In order to verify the performance, we give the comparison of the methods of FFT, PSD, PCA, and FPCA.

Fourier transform was carried out on the collected car images, and the related points' location can be shown in Figure 11.

The image resolution ($800 * 640$) is 30 frames per second. As shown in Figure 11, the intranet system for crude oil trade procurement is grouped into three major components, namely, portal, business, and data layer. The portal layer is mainly responsible for accessing registered users to the system. All administrators with authority may access the enterprise internal network through any browser, and before entering the intranet, the web server shall process the access request, encapsulate the request, and send the request to the server. The main task of the business layer is to handle the requests from the web server and support the whole business layer by using the APP terminal. Function layer used to realize the functions of the intranet system, including the basic part of procurement management, the main part of procurement management, and the interface function with other systems.

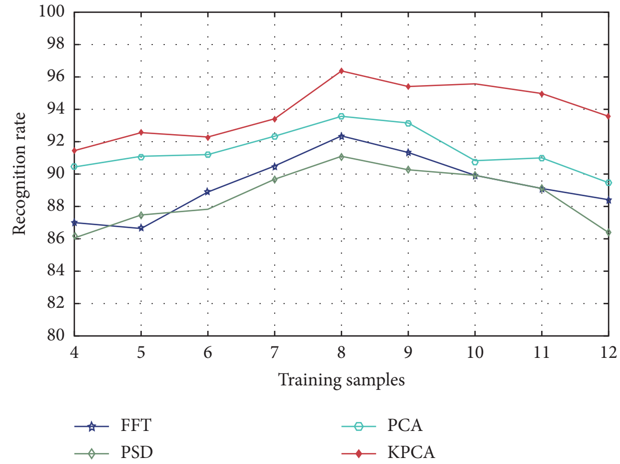

Figure 7: ML classifier.

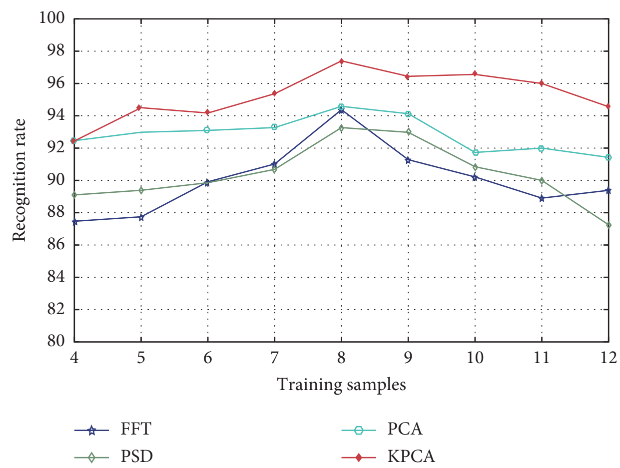

Figure 8: KNN classifier.

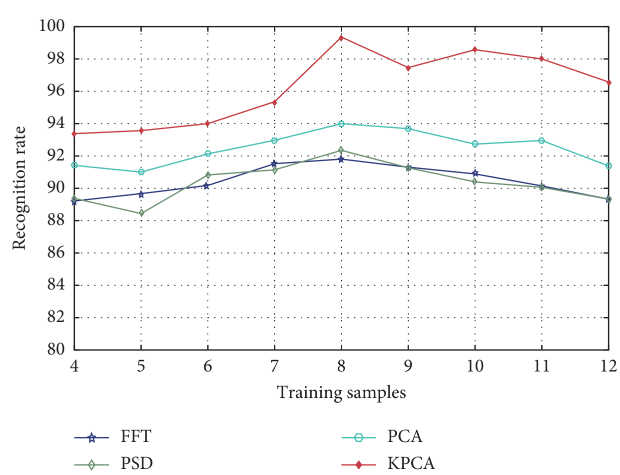

Figure 9: SVM classifier.

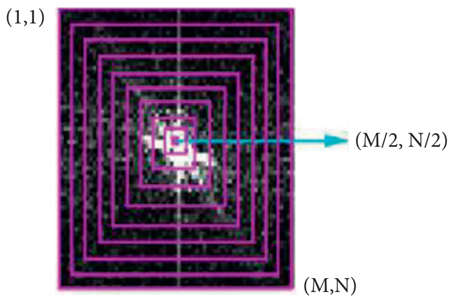

FIGURE 10: The case of F Translation.

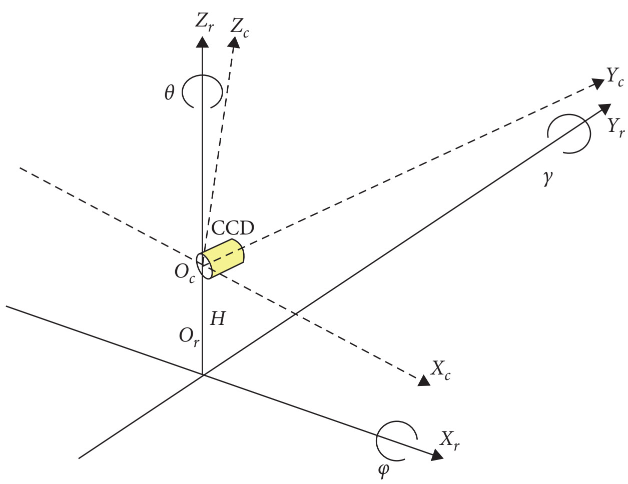

FIGURE 11: The camera corresponds to the coordinate system.

5. Conclusion

In this paper, a novel feature extraction algorithm, kernel complex discrimination algorithm, is proposed, which can be widely used in intelligent transportation assistant by combining with embedded platform with low power consumption and high efficiency. The system also provides an adaptive cruise control system based on distance detection. At the same time, the system will give an audio and visual alarm if the distance detected by neighboring vehicles is less than the safe distance. According to the method proposed in this paper, the amount and cost of calculation will be large. So, in the future, we will conduct further research mainly in the following aspects:

(1) The intelligent energy saving system under the environment of the Internet of Things proposed in this paper is only running in a single test environment. If it is promoted, how to realize big data processing and distributed computing is a challenge and requires in-depth study.

(2) The test environment of the intelligent vehicle statistics system based on voice recognition and kernel principal component analysis proposed in this paper is in the absence of other noise interference, while the real environment is far worse than this, so how to eliminate interference is the focus of the following research of this topic.

(3) The test environment of intelligent traffic assistant system based on verification authentication proposed in this paper is completed on the basis of no light interference. However, in the real operation, there are often many light interferences, and how to solve the light interference is the core of the following research of this topic.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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