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Intelligent Parking System Based on Big Data and Internet of Things

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Abstract. Nowadays, the parking problem has seriously affected people's life. Aiming at the causes of parking problems, this paper proposes an intelligent parking system based on big data and the Internet of Things, and adopts a floating parking fee model to realize the reasonable allocation of parking resources. This paper obtains parking space and vehicle information through the deployment of iot terminal infrastructure equipment, adopts Zigbee technology for wireless short-range communication, NB-LoT technology for wide-area communication, transmits the information to the background database, and then makes statistical analysis of the information through Hadoop big data algorithm. The floating parking fee model is constructed according to the road and parking space information, and the real-time parking space price is determined. Big data algorithm is used to screen and recommend parking lot information for users. Based on the impact of distance and price on users, users can decide the choice of parking lot by themselves. The parking reservation system ensures the realization of user selection and facilitates users to obtain parking resources faster. In this process, the reasonable allocation of parking resources in time and space is realized.

Key words. Floating parking fee,NB-LoT,Parking,reservation**.**

I. Introduction

With the continuous improvement of economic level, the continuous development of science and technology and industry, the number of private cars is growing rapidly, and parking Spaces are in short supply. At present, there are widespread problems such as slow parking efficiency, difficult access, and traffic congestion, which lead to low utilization rate of parking Spaces, inconvenience for people to travel, increased energy consumption and environmental pollution, and have a great impact on the development of urban traffic in China. The problem of urban traffic congestion is becoming more and more serious, and the difficulty of parking not only affects the quality of life of citizens, but also further affects the process of urbanization construction in our country, and becomes a stubborn disease that hinders the development of cities. Its main manifestations are few berths, zombie vehicles, asymmetric berth information, and disorderly parking.

The reasons for this problem include: low turnover rate of parking space, dislocation of population distribution and increment of allocated parking space, increase of parking space supply leading to the rise of total motorized travel, and little effect of current

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parking fee standard on guiding and regulating vehicle use. The traditional parking management method is inefficient and can not meet the demand of efficient utilization of parking resources in modern cities.

2. Research status

The problem of parking has been discussed for a long time, and the existing intelligent parking system can not fully meet the needs of people.

Traditional parking lots have problems such as parking information not sharing, and vehicles cannot quickly reach the parking space. Drivers spend a lot of time and fuel in the process of looking for parking Spaces, which reduces the efficiency of urban operation and causes a lot of environmental pollution.

A large amount of data is difficult to deal with, and it is impossible to provide personalized services for individual users, which makes the use of the process of problems and difficulties.

At present, the pricing design of parking fees is mostly from the perspective of parking management. Although regional differentiation and progressive system are adopted, that is, to control vehicles entering the central area or improve the turnover rate of parking Spaces, it has not yet realized the coordination with road traffic operation, and cannot realize the joint adjustment effect of dynamic traffic and parking supply and demand balance of the road network. The application of floating parking fee in intelligent parking system is less, and there is still a lot of exploration space for the regulation of parking problem with floating parking price.

To solve the above problems, this paper uses the reservation system, allocates information through big data technology, realizes personalized management, and improves the macro turnover rate of parking space by relying on floating charges. Based on these, a complete intelligent parking system is established.

3. Overview of parking system

Aiming at the problem of parking difficulties caused by urban road congestion, this paper builds an intelligent parking system based on big data and the Internet of Things. The system consists of three parts: perception layer, network layer and application layer. Realize real-time monitoring and control of parking Spaces, monitor behaviors such as deviation from parking areas, and realize the integration of functions such as parking reservation, intelligent navigation, parking lot management, and system supervision.

The vehicle perception terminal and ZigBee node, as the main components of the system perception layer, are used to identify objects and collect information. With the support of ZigBee wireless sensing, NB-LoT and other technologies, information will be stored in the database through the network layer. Big data technology is applied to the APP for users to use through the mining and analysis of these massive data. According to the different identity of the user, the APP provides three modes: user, manager and traffic management department to realize the optimal allocation of parking resources, improve the efficiency and accuracy of parking management, and ensure the stable operation of the parking system. This paper also uses intelligent parking lock to manage parking Spaces to ensure the safety and effectiveness of parking reservation services;

The floating parking charging mode is used to improve the utilization rate of parking Spaces, alleviate road congestion, and make the system more intelligent, efficient and humanized.

4. Parking system structure

4.1 Perception layer

In the intelligent parking management system, the perception layer is the "antenna" that interacts with the outside world, which is composed of the vehicle perception terminal and ZigBee nodes, and the main function is to identify objects and collect information.

The vehicle perception terminal includes STM32 processor, camera module, memory module, power supply module and other components. Among them, because STM32 is easy to learn and use, and has a strong processing power, the vehicle perception terminal mainly uses the STM32F103VET6 chip as the processor. The camera module is used to sense whether the parking space is free and record the license plate image, and then the image recognition system of the STM32 processor recognizes the license plate number of the vehicle in the parking space. The memory is used to store relevant information collected by the Internet of Things such as parking space occupancy status and vehicle license plates. The power supply module is responsible for powering the electronic components of the vehicle perception terminal. Because ZigBee technology has the advantages of short distance, low complexity, low power consumption, low speed and low cost, this paper applies to the data transmission in various devices with short distance, low power consumption and low transmission rate in the parking area.

Here are some system iot terminal device names and their functions:

Table 1. Basic equipment

Device Name	Function
STM32 processor	Using the image recognition system to identify the license plate number of vehicles on the parking space
Photography module	Sensing whether the parking space is idle and taking and recording license plate images
Storage	Storing the occupancy status of parking spaces and relevant information collected by the Internet of Things such as vehicle license plates
Power supply module	Power the electronic components of the vehicle perception terminal
Parking lock	Prevent reserved parking spaces from being occupied by non reserved vehicles
Bluetooth communication	Enable interaction between individual users and parking lock

The perception layer includes license plate image recognition module, parking space information collection module, Bluetooth communication transmission module and intelligent parking lock management module for user perception.

4.1.1 License plate image recognition

As the image recognition technology has been relatively mature, it has the ability to complete the information recognition and collection independently. In this paper, the camera is selected to complete the image recognition and integrate the parking space information.

On the basis of differentiation method and gradient operator to sharpen license plate image, license plate image recognition uses Radon integral transform to solve the license plate tilt, so as to locate the license plate under complex background and correct the inclined license plate. After further processing, the corrected license plate can provide a clear license plate image for the segmentation and recognition of license plates.

4.1.2 Parking space information collection

Based on the above license plate image recognition content, the system can collect real-time video of each parking space, vehicle license plate and parking space occupation information and store it through the front end camera. At the same time, the platform can store the structured and unstructured information of vehicles after filter extraction and intelligent analysis, view the status of each parking space in real time, as well as the parking situation of vehicles on site, record the parking status of each parking space, and provide a basis for follow-up parking responsibility traceability and cost recovery.

4.1.3 Bluetooth Communication module

In order to realize the communication between STM32 and mobile APP, this paper introduces Bluetooth communication to realize the interaction between individual users and parking lock. HC06 Bluetooth module with low cost and high reliability is selected. At the same time, considering the characteristics of high-frequency signal transmission, the onboard antenna is designed in the HC06 Bluetooth module to facilitate the reception and transmission of Bluetooth signals, and the impedance in the loop is optimized through the supporting circuit to filter out unnecessary clutter and interference signals. Thus to realize the efficient transmission of information.

4.1.4 Intelligent parking lock management design

Smart parking locks are used to manage parking Spaces. Installing smart parking locks for parking Spaces can effectively prevent reserved parking Spaces from being occupied by non-reserved vehicles.

The specific application principle is as follows:

(1) The user makes a nearby parking reservation through the mobile APP.

(2) When the vehicle is near the parking space, the user turns on the Bluetooth of the mobile phone to interact with the parking lock.

(3) If the match is successful, the parking lock will be opened, and if it is not successful, it will not be opened.

(4) When the camera screen detects that the vehicle completely leaves the parking space, it automatically locks.

The intelligent parking lock is mainly composed of hardware design and software design. The hardware design includes Bluetooth communication module circuit and parking lock control circuit. It can accurately complete the automatic lock and realize intelligent parking in combination with the APP.

4.2 Network Layer

The network layer mainly consists of information transmission module and information processing module, the main function is to collect, transmit and process the information of the perception layer.

4.2.1 Information Transmission Module

The information transmission module, as the data information connection bridge between other subsystems and the central management system, is mainly divided into wired data communication transmission and wireless data communication transmission. Due to the more and more mature wireless communication technology at this stage, the current network transmission system technology is based on wireless communication technology, and supplemented by wired communication technology, to ensure the efficient, reliable and stable transmission of data information. In the field of wireless communication, we choose ZigBee wireless sensing technology to be responsible for short-area communication, and NB-LoT technology to be responsible for wide-area communication. Traditional cellular network solutions such as LTE typically consume too much power and are not suitable for applications that transmit data infrequently and in small amounts. The Internet of Things needs a solution that can provide low power consumption and wide coverage, which generally needs to meet the following four points: low technical cost, low power consumption, wide coverage, and high connection capacity. The NB-LoT technology uses the mobile Internet to connect, is to achieve efficient communication and long battery life of large-scale distributed devices, with improved indoor coverage (with stronger penetration), support for a large number of low-throughput devices, low delay sensitivity, ultra-low equipment cost, low device power consumption and optimized network structure and other advantages. It is a good choice for iot applications in parking systems.

The wireless sensor network covers the parking space area set in the parking lot. The vehicle perception terminal in the area collects parking space usage and license plate number from the Internet of Things, converges to the fixed deployment ZigBee node through specific wireless sensor network routing planning, and then adopts a specific routing path and adopts multi-hop mode, and finally transmits to the aggregation node. The sink node collects all node data, and through NB-LoT technology, the sensor data will be sent directly to the master server and stored in the database.

The process is shown in figure 1.

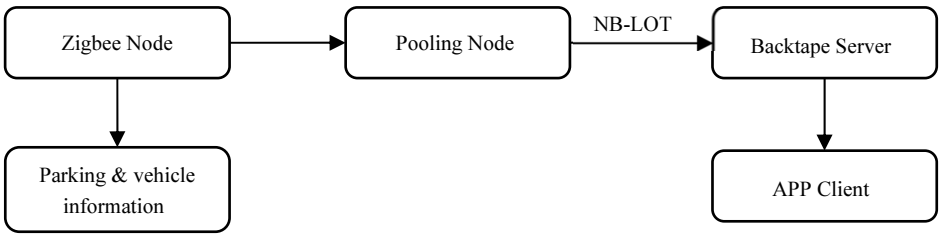

Figure 1. Network layer architecture diagram

4.2.2 Information Processing module

The main function of the information processing module is to analyze and process the information collected by the Internet of Things using big data technology. Hadoop is an important technology of distributed system, which realizes the efficient processing of data information through the hierarchical principle, and has the advantages of strong stability, high fault tolerance and low cost. A large amount of data collected in the wireless sensor network is stored and managed in a database in the background server. The big data analysis software of the background server uses Hadoop technology to carry out statistical analysis, online query and data analysis of the data, thus providing data services, such as convenient access to parking lot information and utility comparison for users; Administrators can obtain relevant information efficiently, which facilitates dynamic monitoring and visual operation management; The traffic management department conducts safety checks and so on.

4.3 Application Layer

The application layer is mainly composed of application software, which is divided into client and server. According to different user identities, the client is set to three modes: user mode, manager mode, and traffic management department mode, which has comprehensive functions and is convenient to use.

4.3.1 Client

(1) User mode

For individual users, the main functions of the client include: parking space search, intelligent navigation, parking reservation, parking lot information query, parking lot navigation, intelligent recommendation, etc.

The design of the APP client includes several modules, such as personal center, parking space search, interface display, data communication, log management, and customer service center. The Personal center is mainly responsible for user login software, identity confirmation, personal information collection and management, software rights management, individual user wallets, etc. The parking space search module includes inquiring the geographical location of the surrounding or destination parking lot from the background server and searching the parking lot information and intelligent recommendation; The interface display module displays the user's surrounding map information to the APP interface, including the parking lot information (the number and location of free parking Spaces) and the specific floating price of the parking lot; The data communication module is responsible for the data communication between APP client and background server; Log management records APP running status and user usage information, and saves it to the background database.

The organization chart of the APP client is shown in Figure 2.

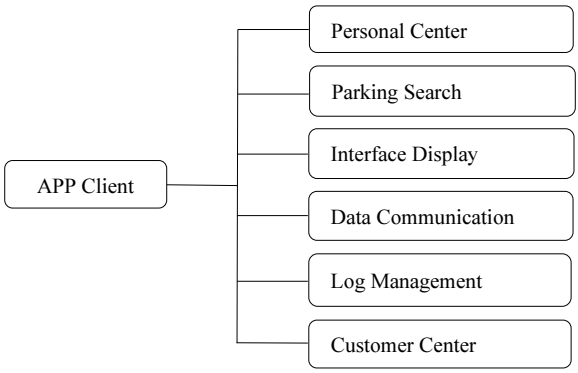

Figure 2. Client organization chart

The application view can refer to the research of Amara Aditya et al [10].

The use process is:

1. Enter the APP registration or login account, enter the destination, and after the APP obtains the positioning permission from the user or the user manually enters the origin, the APP predicts or plans the user's travel route on the map according to the navigation system.

2. After the user confirms, the system recommends the parking lot and parking space within two kilometers of the destination for the user through data analysis, and then the user chooses the appropriate parking time according to their own needs, and then views the parking information and the floating price of the current time.

3. Confirm the reservation information and wait for a successful reservation notification. The reserved parking space will be held for 30 minutes after the notification message is sent.

4. The APP provides intelligent navigation services and multiple paths for users to choose. After arriving at the parking lot, users can open the APP, scan the QR code or input the license plate number to enter the parking lot, and the camera at the entrance of the parking lot will recognize the license plate at the vehicle stopper and start charging.

5. After entering the parking lot, the user plans the path through the navigation system inside the parking lot to guide the vehicle to the reserved parking space.

6. When the user approaches the parking space, turn on the Bluetooth of the mobile phone to match the parking lock. When the match is successful, the parking lock is lowered. The user pulls into the parking space.

7. After the activity, when returning to the parking lot, guide the user to find a parking space through the navigation system again.

8. Leave the parking lot and scan the license plate again at the exit of the parking lot to stop charging.

9. Complete online payment through wechat, Alipay, Palm Bank and other software interfaces.

(2) Management model

For parking lot managers, the APP provides a manager mode, whose main functions include parking lot management and operation management. Parking management includes determining the management scope and quantity of parking lots or parking Spaces; Design and publish information about parking lots or Spaces, such as location, prices, availability, etc.; Monitor the operating status of intelligent parking reservation system equipment, such as license plate recognition, toll collection machine, etc., and

monitor the internal environment of the parking lot. Operation management includes setting pricing strategies and preferential policies for parking or parking Spaces, analyzing revenue and financial data, and providing customer service support, such as online consultation and complaint handling.

(3) Traffic management mode

The traffic management mode is a special mode set for the traffic management department to manage traffic safety and supervise the operation of the platform. In this mode, the traffic management department supervises the operation of the platform, such as pricing rules, and also accepts feedback from users. In the process of road driving, the regulatory department can issue the latest road traffic rules, such as speed limit, ban and other regulations, use the convenience of the platform to provide users with the most efficient way to travel, and regulate the user side and the manager side.

4.3.2 Server Side

The background server uses database technology to store and manage the collected data such as the number of parking Spaces, location, status, order data, vehicle entry and exit records. Using big data technologies such as Hadoop, MySQL, PostgreSQL, MongoDB, etc., in the user mode, after the user selects the parking lot, the user conducts a correlation search of the parking space near the vehicle to find a suitable free parking space. The server side processes the business logic and data requests of the application program, and communicates with the client side. The client runs in the user's mobile phone, is responsible for obtaining the user's location, and displays the free parking information queried by the background server in the APP interface. For managers, the information in the database is processed and stored, and then the data is visualized for real-time display, such as order transactions, car flow, parking space usage, etc. The traffic management department can call the data for supervision and management, thus realizing the normal operation of the APP under the three modes and the high efficiency of the intelligent parking system.

5.floating parking fees

5.1 Floating parking charges

The parking fee required for the parking space is adjusted according to the actual utilization rate of the parking space and other relevant information during the daily peak hours. The parking space with high utilization rate will increase correspondingly, and the parking space with low utilization rate will decrease correspondingly.

In order to realize a more reasonable cooperative utilization of parking space resources and road resources, the intelligent parking system adopts floating parking rate to replace the traditional billing method. Through the adjustment of the market through the optimization of billing, the limited parking space resources are allocated to more needy consumers in exchange for greater economic benefits.

5.2 Floating parking fee model

According to the research of YanHai et al[4], a floating parking billing model based on system optimization balance is established. The model takes the maximum parking

choice utility as the objective function, the parking rate, parking demand, parking lot utilization rate and road saturation as constraints, and the social benefit of parking fee as the evaluation index. The economic benefit of parking charge, road driving benefit and parking search benefit are considered comprehensively. SQP method is used to calculate and solve the objective function, and the model is applied to a concrete example.

6. Conclusion

In the study of intelligent parking system, this paper uses big data and Internet of Things technology to achieve a deeper integration of big data and Internet of Things technology for parking lot and user information processing; To realize the combined application of big data and Internet of Things in intelligent parking system, and realize the innovation of intelligent parking system design; This paper innovates the theoretical research of floating parking charging, provides a template for the application of floating parking charging, puts forward new solutions and ideas to solve the problem, and realizes innovation in solving the problem of user parking.

This paper puts forward a set of innovative parking service application system, which provides a reference for parking management. In the actual application of the intelligent parking system, the floating parking fee, parking reservation, route optimization and other functions of the Internet of Things and big data technology are combined to provide a customized solution to the causes of parking difficulties. At the same time, through big data and Internet of Things technology, to achieve the overall management of parking lot resources, so that "parking space - parking lot - users" mutual perception. Intelligent parking systems based on big data and the Internet of Things help the construction of smart cities and improve the efficiency of urban traffic operation.

With the acceleration of urbanization, parking difficulty has become an important factor restricting urban development. Intelligent parking system based on big data and Internet of Things technology provides an effective way to solve this problem. This paper introduces the intelligent parking system from the aspects of technical principle, structural logic and practical application. It is believed that driven by technological innovation, policy support and industry cooperation, intelligent parking systems based on big data and the Internet of Things will be more intelligent and personalized, providing people with a more convenient and comfortable travel experience.

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