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Internet of Things Based on Parking Lot System Design

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Abstract: With the rapid development of China's economy and the improvement of science and technology level, the continuous increase in car ownership leads to a serious shortage of parking space supply, and it is difficult to find a parking space and park a car, etc.; at the same time, the parking lot has a low capacity of information management, and there is no supporting parking space management system. To build a safe underground parking lot, carry out effective operations, and provide the public with high-quality parking lot management services, the establishment of a complete set of operation and management programs for the long-term development of the parking lot is essential. This thesis aims to deeply explore the application and development of IoT technology in the field of intelligent parking lots. This system adopts LoRa wireless communication technology to realize parking space control and collection of parking space detection information, which can realize automatic payment, automated parking management, improve parking lot management efficiency, reduce manual operation, and ensure the safety of parking lots and users.

1. Introduction

With the development of the national economy, the number of motor vehicles is increasing, and problems such as insufficient supply of parking spaces in traditional parking lots, difficulties in parking and finding parking spaces, lack of supporting parking management system[1], and frequent accidents are highlighted. The advantages and disadvantages of a parking lot system directly affect the efficiency of parking, the management cost of the parking lot, and the profit [2]. To build a safe underground parking lot, operate effectively, and provide quality parking management services for the public, we must establish a complete set of operation and management solutions to ensure the long-term development of underground parking lots [3]. To solve the challenges faced by underground parking lots today, the government has provided significant funding to support the development of emerging technologies of the Internet of Things (IoT), which are widely used in the field of intelligent parking lots to provide new solutions for parking management. Nowadays, IoT technology realizes the functions of parking space reservation, precise positioning of parking spaces, video guidance, and payment in advance by linking vehicles, equipment, and systems for real-time data collection, transmission, and analysis [4], which improves the operation efficiency of parking lots, provides smarter parking services, improves the quality of people's lives, and ensures the safety

of people's lives. In summary, it is very necessary to transform and upgrade the traditional parking lot in China. The parking lot system based on IoT established in this paper can solve the data sharing problem to a certain extent, reduce the probability of parking lot accidents through the monitoring video linkage system, and has the advantages of low system power consumption, strong data management, and scalability.

2. Main Research Contents and Innovative Points

2.1 Main Research Contents

This paper mainly focuses on parking difficulties and parking lot security problems and designs an intelligent parking lot management system based on the Internet of Things (IoT). The system uses intelligent road gates and RFID technology to manage vehicles, installs sensors in the parking space to determine the presence or absence of vehicles, uses ZigBee networking to upload and send data, displays and manages the parking space information through the management interface, and the owner can check the status of the parking space through the display screen to guide the parking. Through the self-organizing network function of LoRa nodes carrying geomagnetic sensors to complete the data collection of underground parking spaces, and uploaded to the main module of geomagnetic, the main module and Raspberry Pi direct connection, the Raspberry Pi as a data collector and controller, the data will be sent to the server; intelligent monitoring and control and access control, fire, etc., to reduce the occurrence of accidents; the design of the relevant rules of charging, the vehicle into the exit to realize the intelligent management and control. This research is a shallow attempt and exploration in this field to provide new ideas for the application and development of IoT-based intelligent parking lots in the future, and it is expected that it can be used in practice to further enhance the performance of IoT intelligent parking lot by improving and practicing the system.

2.2 Innovation Points

A monitoring system for automatically detecting the occurrence of an accident and alarming it is designed as a subsystem of a parking lot management system. Including video acquisition module, video acquisition module, and event detection module connection, the detection results will be uploaded to the event evaluation module, the accident emergency level processing; the evaluation module for the accident level processing will be uploaded to the alarm display module data; multimedia setup module and alarm module connection, the data will be shared with the multimedia equipment, and then the information will be conveyed to the management personnel; management personnel through the After the final audit, the management personnel will upload the judgment data to the control module, connect with the linkage response module, and link with the fire department, public security department, access control system, anti-theft system and so on by analyzing the data uploaded by the management personnel.

3. Parking System Requirements Analysis and Overall Design

3.1 Demand Analysis of Parking System

Traditional parking lots have problems such as unsearchable parking spaces, low utilization rate of parking spaces in parking lots, inconvenient and non-transparent payments and settlements, inefficient management of parking lots, and low security. It is necessary to realize automatic identification of entering and leaving vehicles, real-time recording of vehicle entry and exit time,

residence time, and other information, without manual intervention; provide real-time parking space navigation, guide drivers to quickly find available parking spaces, and monitor the occupancy of parking spaces; integrate mobile payment and electronic payment methods, so that users can pay for parking fees through cell phones; automatically calculate parking fees, and settle them according to the length of stay and the rate; Allow users to reserve parking spaces in advance to ensure that there are enough parking spaces available; monitor activities in the parking lot in real-time; automatically detect abnormalities and report to the police; generate real-time reports and statistical information, and use data analytics to optimize parking lot layouts and operational strategies. Take measures to protect the system from cyber-attacks and data leakage.

3.2 Parking System Overall Design and Analysis

This system uses LoRa wireless communication technology to realize parking space control and parking space detection information collection in the parking lot.LoRa is a reliable wireless transmission network, and each LoRa main module node is equivalent to an information relay station. The collected data is uploaded to the main module, which is directly connected to the Raspberry Pi to form a wireless sensing network for the parking lot. The Raspberry Pi connects to the public network to complete the communication with the server, which saves the sensor data of all the parking lot nodes in a database and maintains data consistency with the parking lot network. The control request from the administrator is parsed by the server as a specific instruction and sent to the Raspberry Pi, which parses it and then controls the geomagnetic module directly through the geomagnetic master module. The query requests of administrators and users are verified and then directly interact with the database to provide timely feedback to customers, which has a certain degree of real-time. The overall design structure of the system is shown in Figure 1.

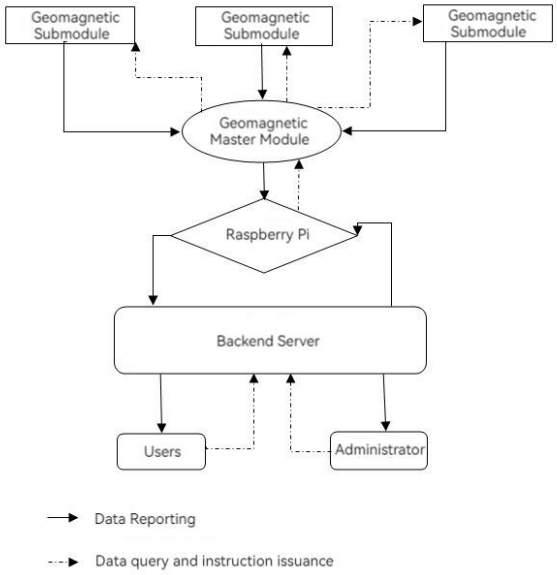

Figure 1: Schematic Diagram of the Overall Structure of the System

4. System Hardware and Software Design and Function Realization

4.1 Parking Lot Network Design

This system chooses LoRa, a widely used wireless network communication technology in IoT, to implement parking space detection and identification and parking space control in a parking lot. A

LoRa submodule node is placed in each parking space using a geomagnetic detection system to realize parking information detection [5]. When the layout of parking spaces in the parking lot is more concentrated, the star LoRa network structure is selected, and the master node is connected to the Raspberry Pi, but it has a limited transmission distance; if the parking lot has a large range, the mesh LoRa network structure is selected, which has strong environmental adaptability, and the nodes can be bridged to each other and are also able to be connected through the routing node. Since the distance between parking spaces and controllers in a typical parking lot is usually not too far apart, the star network structure can be adapted to most parking lot deployments [6]. Each node is installed in the parking space, using the LoRa self-organizing network function, component LAN, to link all the parking spaces, but each sub-node is independent of each others, one of the sub-nodes produces a failure, it will not affect the normal operation of other nodes, for this reason, the maintenance of the system has brought great convenience. The parking lot network structure is shown in Figure 2.

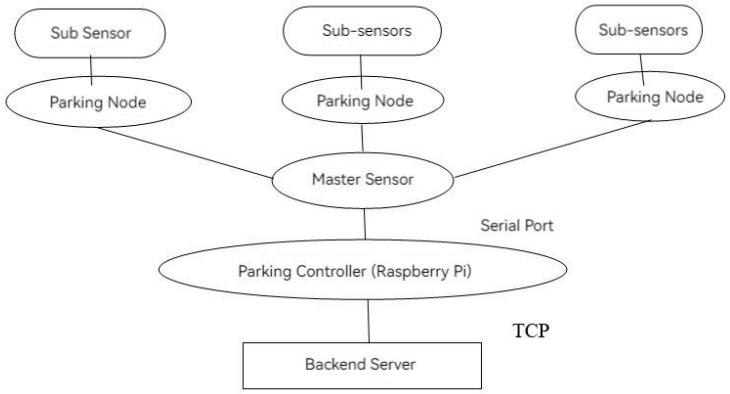

Figure 2: General Structure of Parking Lot Network

4.2 Hardware Design

4.2.1 SX1278 Hardware Circuit Design

This system adopts the LoRa long-distance wireless transmission geomagnetic detection module based on the SX1278 RF chip, which has strong anti-interference ability can minimize power consumption [7], and has a high sensitivity receiving ability to receive weaker signals, which makes it still able to maintain a reliable communication connection in low signal strength environments; it adopts advanced signal processing algorithms and spectrum expansion technology, which can effectively resist multipath fading and multipath interference and other wireless signal interference, and improve the reliability of communication. Expansion technology, can effectively resist multipath fading, multipath interference, and other wireless signal interference, and improve the reliability of communication. The hardware circuit design is shown in Figure 3.

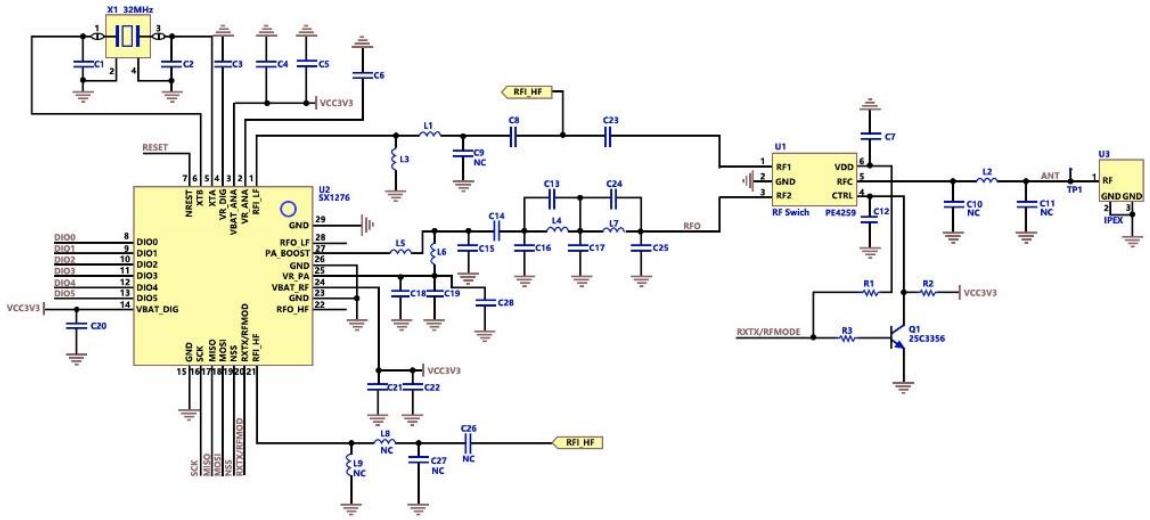

Figure 3: SX1278 Hardware Schematic

4.2.2 Extended Circuit Design

In this system, the parking node needs to mount the sensor detection module and power module, and the Raspberry Pi has its own RX-TX serial port transceiver format, the specific design is as follows: the anisotropic magnetoresistive (AMR) sensor is used to measure the magnetic field change, to determine whether there is a vehicle parked in the parking space. When a vehicle enters or leaves a parking space, the AMR sensor can quickly detect the magnetic field changes and provide the corresponding signals to the parking management system, the module includes a magnetic field change detection probe, an ultra-low-power MCU processor, and wireless transceiver module, battery module, etc. [8-9]; Serial module is used for the connection between the Raspberry Pi and the LoRa main module, and receives the data of the Raspberry Pi from the back-end server through the serial module.

4.3 Software design

This system is a network system built by computer, network equipment, and lane management equipment to manage vehicle access to the parking lot, vehicle flow guidance in the field, and collection of parking fees. The following will be a detailed introduction to this parking lot system into the field and out of the field and monitoring intelligent linkage alarm design.

4.3.1 Vehicle Approach Module

The vehicle admission process of this parking system is shown in Figure 4.

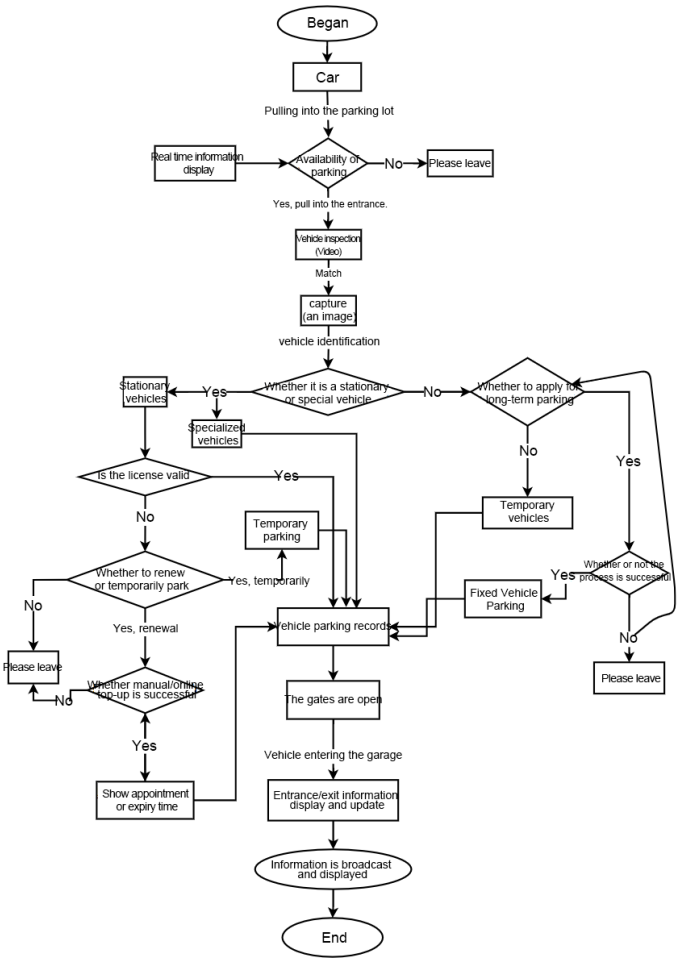

Figure 4: Admission flow chart

When there is spare space in the car park, the vehicle is allowed to enter, the vehicle is recognized by electronic equipment, the relevant information of the vehicle is recorded, compared with the background data, and the type of vehicle is judged (fixed vehicle/special vehicle/temporary vehicle). After judging the different types of vehicles, the corresponding operation is made (charging/renewing/recharging/directly releasing), and after the success of the vehicle is shown, the corresponding information of the vehicle is displayed to the display screen, and the voice broadcasting is made, and the information in the yard is updated at the same time. After successful operation, it displays the corresponding information of the vehicle to the display screen and makes a voice announcement, and at the same time, it updates the information of the field.

When the vehicle enters, the parking space management process is shown in Figure 5. The parking space management process includes allocation and release of parking spaces, real-time transfer of vehicle access information into the system database, and updating of parking space information. The parking space management process includes two phases, one is the allocation of parking space and updating of parking space information when vehicles enter, and the other is the updating of parking space information when vehicles leave.

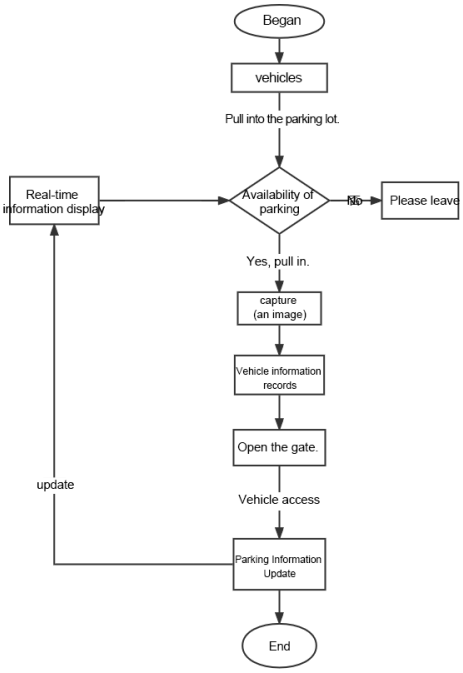

Figure 5: Flowchart of parking space management during vehicle entry

4.3.2 Vehicle Exit Module

The vehicle admission process of this parking system is shown in Figure 6.

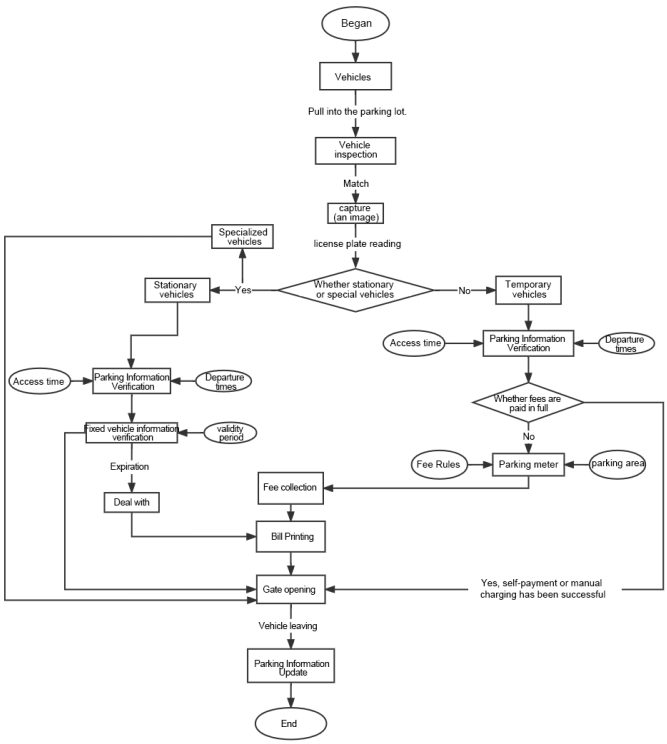

Figure 6: Exit Flow

When the vehicle is out of the field, the electronic equipment identifies and detects the vehicle,

calls the background data information for checking and comparing, judges the type of vehicle, makes the corresponding operation (direct release/payment release), gives the corresponding payment list according to the parking time, the number of times remaining in the parking or the expiration time of the parking, and makes the voice announcement.

When the vehicle leaves the field, the parking space management process is shown in Figure 7.

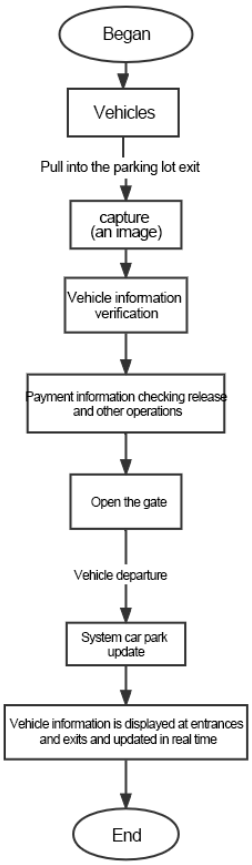

Figure 7: Parking Space Management Flowchart when Vehicle Leaves

4.3.3 Intelligent Detection of Incident Linkage Modules

Intelligent detection accident linkage system connects the video acquisition module with the event detection module, analyzes the detection through AI calculation, and uploads the detection result to the event evaluation module to grade the accident and emergency; the evaluation module uploads the data to the alarm display module after grading the accidents; the multimedia setup module connects with the alarm module to share the data with the multimedia equipment and convey the information to the multimedia setting module connects with the alarm module to share the data with the multimedia equipment and convey the information to the management personnel; after the management personnel passes the final audit, they upload the judgment data to the control module and connect with the linkage response module to link up with the fire department, the public security department, the access control system, the anti-theft system and so on through the data uploaded by management personnel.

4.4 Specific Functional Realization

The system introduced in this paper can realize the functions of automatic license plate recognition,

vehicle information recording, information prompting, remote assistance, gate control, parking space guidance, video monitoring management, report statistics, vehicle intelligent charge management, data uploading, and so on. Secondly, according to the different categories of vehicle parking, the vehicles are divided into temporary, fixed, and special categories, and different charging standards and rules are set up respectively, so that the special vehicles (official vehicles, collaborative unit vehicles, public security, fire trucks, ambulances, etc.) can pass through directly after the information recognition without paying fees, thus realizing the function of vehicle management. When the fire hydrant is damaged, the monitoring is blocked or the vehicle forcibly enters the parking lot, the system alarms; the intelligent monitoring linkage system detects the occurrence of the accident and alarms to the administrator for review, and then carries out the linkage alarms for the access control, fire fighting, public security, etc. to realize the alarm linkage management function.

5. Conclusions

Under the status quo of continuous increase in car ownership, the serious shortage of parking space supply leads to the situation of difficult parking gradually appearing. The system introduced in this paper realizes real-time monitoring of parking space occupancy, provides users with parking space navigation, convenient payment, automated parking management, and other functions to improve management efficiency and ensure parking lot safety and through LoRa wireless communication technology to achieve parking space control and parking space detection information collection. This management system can be a good solution to the problem of parking difficulties and parking lot safety.

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