Design of An IoT based Smart Parking Lock

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Abstract. In recent years, the rapid growth of vehicles has led to a great increase in the demand for parking spaces, unmanaged car parks makes it difficult to efficiently utilize the limited parking resources. To solve this problem, an intelligent parking lock system based on the Internet of things (IoT) is designed and implemented in this paper. Our design incorporates the IoT technology, such as LORA wireless network, to carry out real-time monitoring of the parking space and offer remote control ability of the parking lock. The application of our smart parking lock includes time sharing rental of parking space. Our design can improve utilization of the parking space and help to ease the problem of parking space shortage.

Keywords: Parking lock, LORA, IoT.

1. Introduction
With the rapid growth of economy, the number of automobiles has an enormous boost in recent years. However, limit parking space cannot keep up with demand, especially in urban area, where parking space is limited [1]. Since the total amount of parking spaces cannot be increased, the parking problem can be alleviated by improving the utilization of parking spaces.

On the other hand, Internet of Things (IoT) [2] technology offers reliable interconnection of ubiquitous terminal devices through various wireless communication networks, and provides safe, controllable and customizable management and service functions such as real-time online monitoring, scheduling and command, and remote control [3].

In this paper, we incorporate IoT technology with parking lock design, to achieve real-time monitoring and remote controlling of parking lot. Our smart parking lock can be used in parking lot management, parking reservation and time sharing rental of parking lot, and can improve utilization of the parking space and help to ease the problem of parking space shortage.

2. Related Work
There have been several researches about intelligent parking lock design. S.V. rikanth et al. proposed an intelligent parking (Spark) management system based on wireless sensor network technology, which not only realized parking space management in the parking lot, but also realized parking reservation, parking guidance and other functions [4]. J. Vera-Gomez et al. proposed an urban intelligent parking
management system, which is based on the wireless network of photoelectric sensors. The system uses these sensors to detect vehicle entry and exit on these roads and transmits the information to the data center, so as to realize the prediction of the parking space in the region [5]. Yanfeng Geng et al. proposed a new intelligent parking system, in which different colors of lights were used to indicate the status of different parking spaces. The system also provides drivers with parking space allocation and reservation services, and strives to improve the overall utilization rate of parking spaces [6]. Wang Shian et al. develop a continuous-time stochastic dynamic model for the optimal parking management of connected autonomous vehicles (CAVs) in the presence of multiple parking lots within a given area [7]. Prabu A.V et al. considering the recent Internet of Things (IoT) technologies, effective parking management system can be developed with the use of efficient microprocessors and active camera units [8].

3. Design of IoT based smart parking lock

3.1. System architecture

The overall structure of smart parking system is shown in Figure 1, which is composed of cloud server, gateway and parking space parking lock. LoRa communication is used between the parking lock and the gateway, and 4G/5G/NB-IoT or network communication is used between the gateway and the background cloud server. In the real-time monitoring process, parking lock conducts vehicle detection on the parking space through the real-time operating system, uploads its detection information to the cloud server through the gateway, and the server updates the status of the parking space in real time. During the remote controlling process, the user can book a parking space in advance on the mobile terminal, and the server will lock the parking space after receiving the information. The background server can control the remote parking lock in real time.

![Figure 1: The architecture of the smart parking system](image)

The paper focuses on the smart parking lock design, as shown in Figure 2. The ultrasonic ranging module detects whether the current parking space is occupied by ranging the distance between parking lock and the object above it. The infrared emitting diode and photodiode pairs, together with the protrusions on the rotating shaft of the bar, are used to determine the lifting state of the parking locking bar. DC motor control the lifting of the lock bar to lock and release the parking space, Buzzer is for warning and alarm; The LoRa module realizes the wireless communication between parking lock and the gateway. An embedded real-time operating system is run on the microcontroller to realize the coordination and control among various modules.
3.2. Task design
The functional design of the system includes seven tasks: battery detection task, parking lock state detection task, motor control task, vehicle detection task, LoRa communication task, exception handling task and buzzer warning task, as shown in Figure. 3.

3.3. Software implementation
The other tasks in this design are pretty straightforward, here we mainly describe vehicle detection task and exception handling task.

(1) Vehicle detection task
The vehicle detection function mainly has two modes. The first mode is continuous active detection, which carries out vehicle detection every other period of time. The second is passive query detection, which is when the controller receives the query command sent by the background, it will conduct vehicle detection immediately. The continuous active testing process is as follows.
In the control process of the vehicle detection task, the system obtains the current time as CTime, when the interval between the current time and the initial time (STime) is less than CarDetectDuration, the distance of the ultrasonic wave is continuously measured as d. If d is less than the set distance Distance, the current parking space is determined to have a car. Otherwise, the current parking space is an empty parking space.

(2) Exception handling task

Exception handling in the system is mainly about the transition of parking lock state. LOCK_RAISED indicates that the parking lock is in the raised state, LOCK_DROPPED indicates that the parking lock is in the landing state. DROP_EXCEPTION indicates that an exception occurred when the lock was dropped, RAISED_EXCEPTION indicates that an exception occurred when the lock was raised, and FALL_EXCEPTION indicates that the system has problems and needs maintenance. The entire process is shown in Figure 4.

Firstly, if the parking lock fails to descend from the state of LOCK_RAISED, it will enter the DROP_EXCEPTION, at this time, the parking lock will first attempt to rise back to the original position and then make a second descent. If the drop succeeds, the system is back to normal, if it fails, it goes into FALL_EXCEPTION, inform the backstage to repair.

4. Implementation and Application

The design of smart parking lock using Windows 10 system development, the use of development software is Keil5 uVision5. In order to test and verify the functionality of our parking lock, the design is implemented as shown in Fig 5. The components used in implementation are listed in Tab 1.
Figure.5 Parking lock physical picture

| Experimental component | Tab. 1 |
|------------------------|--------|
| MCU                    | ARM STM32F103VET6 |
| LoRa                   | SX/JC1278A |
| Buzzer                 | AT3040 |
| Ultrasonic             | HC-SR04 |
| Motor                  | 12V DC motor |
| Motor driver           | L298N |

During the experiment, there is no car in the parking space. At this time, the parking lock is in the landing state. When the user applies to the server to reserve a parking space, the lock will be raised and the parking space will be locked. After the user arriving at the parking space, the control the lock lands, and the vehicle is parked to the parking space. Finally, when the user drives the car to leave the parking space, the parking lock will land automatically and the parking space will be released. The real-time system will update the parking space information and upload it to the server, and every- thing will be restored to the original state.

The smart parking lock designed to deploy in the parking lot of city, especially in some large shopping malls and playgrounds, parking space is hard to find, and by intelligently lock system based on Internet of things, all the available parking space in an area can be do a summary, will each parking space in real time information is stored in the server, the user can quickly find the free parking space.

5. Conclusion
In this paper, a smart parking lock design is proposed, the lock uses the Internet of Things technology, which can achieve real-time monitoring and remote control. The lock has a wide application prospect in the field of parking lot management, which can alleviate the problem of difficult parking.

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