Self-Parking management system based on geomagnetic detection and parking lock

Yingfang Zhang¹,*, Qi Zhang², Libin Zhang¹ and Jilong Shi¹

¹College of Computer Science, Jilin University, Jilin 130000, China
²College of Physics, Jilin University, Jilin 130000, China

*E-mail: zhangyf2116@mails.jlu.edu.cn

Abstract. With the increasing number of vehicles worldwide and the increasing demand for parking spaces, effective management methods are in urgent need to improve the utilization efficiency of parking spaces. In spite of many previous studies focusing on how to detect the status of parking spaces and guide vehicles, the schemes proposed by these studies can only provide certain parking information rather than effectively manage parking spaces. In this paper, a system based on intelligent parking lock is designed to realize functions of query, reservation and management, based on which, drivers can reserve the free parking space in advance. This system can ensure that the reserved parking space is not misoccupied, which can also automatically close the parking lock and perform functions such as billing after the vehicle leaves.

1. Introduction
With the rapid development of global economy and the acceleration of urbanization, the number of cars is also on the increase year by year.

As to large parking lots, traditional parking solutions, whether to use RFID technology or video recognition technology, are not only inseparable from the manual management at the entrance, but also unfavorable for drivers to quickly find suitable parking lots and idle parking spaces. Thus, It has become increasingly difficult to meet the existing demand.[1]

With the proposal and gradual development of the concept "smart city", how to make parking lots more efficient and realize intelligent management has become an urgent problem to be solved.

The intelligent parking lot management scheme based on geomagnetic detection and parking lock proposed in this paper is aimed at the large parking lots. It makes use of the parking lock and the geomagnetic wireless detection module to manage the usage rights of the parking space.

The way of putting up a rail at the entrance is abandoned, which may cause peak congestion, and instead, ZigBee technology is used, which has the characteristics of low power consumption and self-organizing network to form a local area network.

The unified management of the field coordinator and the exchange of information through GPRS technology and back-end server help to realize the grouping management of parking spaces, which, simultaneously, facilitates the later maintenance. Due to the fact that it is difficult to form a local area network for scattered parking spaces, a single parking lock is directly connected to the back-end server through GPRS. In addition, the driver can view the parking lot map in a visualized way through the
webpage, make parking reservation and realize unlocking, which greatly improves drivers’ efficiency of finding parking lots and idle parking spaces.

2. General description of the system
This self-service parking management system is mainly divided into three levels. As the picture shows, the top layer is the web page and web server for customer reservation, the second layer is the parking lot coordinator, and the third layer is the IoT parking lock.

The parking lot coordinator contains the GPRS module to communicate with the server. At the same time, there are ZigBee modules on the coordinator and parking locks to form a LAN to realize communication between them. Thereby, the coordinator can monitor the state of the parking spaces and control the opening and closing of the parking locks.

There is a Mysql database on the server, which stores the basic information of each parking lot and the parking space status in each parking lot. The reservation client displays the current parking lot information and the status of the parking spaces to users through the querying database, so that users can view and reserve an idle parking space (as shown in figure 1).

![Figure 1. Parking lot and ZigBee module.](image)

3. System software design
To simplify software design of the client, the whole software of the B/S structure is designed in the system. The user gets access to the system by firstly logging in the system on the browser. There are two types of servers supporting the system. One is the application server which provides not only interface between the server and users but also processing procedures, the other is the database server which saves information of users and all kinds of parking lots including the map of parking spaces.

To sum up, the website is mainly made up of 5 functions:
1) Querying a specific parking lot and displaying the state of all parking spaces, including occupied and idle ones;
2) Choosing and reserving an idle parking space;
3) Unlocking the parking lock on the program;
4) Payment;
5) Querying parking history.

The key is to send messages to the parking lot coordinator when unlocking the parking locks via this application and to receive messages from the coordinator to inform the application that the car has left. The following flow chart mainly describes the processing flow. First, users can login in the application, on which he or she can view the state of all parking spaces and reserve a proper one. Once arriving at the reserved parking space, he can unlock the parking lock and then drive into the parking
space. At the same time, the application will start timing. Once the car leaves, the parking coordinator will inform the application to stop timing and calculate the cost. After this, the application will update the parking status for next usage (as shown in figure 2). [3]

![Diagram](image)

**Figure 2.** Normal operations of the system.

Specific details of some main functions are as follows.

3.1. **Querying a parking space**
Users can search for information about nearby parking lots, including the parking rates. The system provides a map of the city, by means of which a user can query information of all parking lots that are saved on the database and updated in time. If a user specifies a parking lot, he can view the state of all parking spaces including the distribution of all parking spaces. Therefore, users can choose a suitable parking space according to positions of free parking spaces. What’s more, once users choose a free parking space, the system provides users a route to the parking space.

3.2. **Booking a parking space**
There is a button named special information of each parking space. Once you press the button named “free”, the system will deal with your booking request. The specific procedures are as follows. Firstly, our system will identify your booking information. If you have booked a parking space, you are not permitted to book another one and the system will return with a failure. After checking your legal request, the system will actually deal with your request. Secondly, the system will access the database to modify the information of the booked parking space. At the same time, the system will start to count the seconds immediately. Finally, the system will return with a successful booking including a tip that “if you can’t open the lock of the booked parking space in 15 minutes, the system will cancel your completed booking”. If users who have reserved parking space can not arrive at his reserved parking space in time, this parking space will be released by the system. If his parking space has been released, the user needs to make a new reservation if necessary.

3.3. **Unlocking the lock**
After you press the button named “unlock the lock”, the system will execute the final verification. If you unlock the lock after 15 minutes, the system will return with a failure. Under such a circumstance, you must book another free parking space again. Passing the checking of your request, the system will start to count the seconds immediately and return with a success. Then, the lock will be unlocked within a short time.
3.4. Exiting the parking space and payment
Once your car leaves the parking space, related sensor of the geomagnetic detection will send signal to the system server and the system will record the stop time and calculate the seconds of parking at the space. According to the length of seconds, the system will calculate accurate cost. The user can pay the cost through the third-party payment software such as wechat. Then the system modifies the parking space status to idle for next use. Besides, these information including cost will be recorded on the database. The service ends until you receive a message about the cost.

3.5. Querying parking history
Considering the mistake of the system and transparent service of increasing users’ cost, users can browse all histories of parking including the cost, the time of starting and ending as well as the location of the parking space. In addition, the system provides a interface to feedback to the administrator. Taking this measure, users can timely respond to the administrator. And the system can minimize the occurrence of accidents or losses.

4. System hardware design
The hardware of the system mainly includes intelligent parking lock and area coordinator. Intelligent parking lock is mainly responsible for vehicle detection and control of the car, and regularly sending messages to the regional coordinator. Regional coordinator is responsible for collecting management information within the scope of each parking lot, and sending it to the server. This design can facilitate the maintenance of the management system, which is easy to find out problems in time.[4]

4.1. Parking detection technology
At present, the commonly used technologies include RFID, photoelectric sensor, ultrasonic detection technology, geomagnetic detection and so on. RFID technology is currently widely used in parking lot management systems, but this technology requires each car to be equipped with radio frequency cards, which is of too much trouble. On the other hand, both photoelectric detection technology and ultrasonic detection technology are easily misjudged by environmental interference. Therefore, in this paper, geomagnetic detection technology is chosen, which can detect the uniform magnetic field generated by the earth within a certain range, and it is sensitive to any metal object. Moreover, it can detect the distortion or change of the geomagnetic field when the vehicle drives in and out. Through measurement in the experiment (as shown in figure 3), it is found that the most useful distance between magnetic field and metal object is -0.3m to 0.6m. Thus, we decide to install it in the center of the parking lot to detect the vehicle accurately (as shown in figure 4).[5]

![Figure 3. The relationship between intensity of magnetic field and distance (Z).](image)

AMR module for detecting geomagnetic changes is installed in the center of the parking lock. After detecting the change of the geomagnetic field, parking locks will judge whether the disturbance...
is from the vehicle. If a vehicle is judged to have entered or left, the MCU will judge the working state of the parking lock at that time and execute corresponding commands, such as controlling the lifting or falling of the parking lock, and then send information to the regional coordinator through the local area network.[6][7]

**Figure 4.** The geomagnetic sensor detects the parking condition.

4.2. **Parking lock control scheme for parking lock.**
Due to stepper motor has the advantages of simple drive control and no cumulative error, it is selected for the control of the mechanical arm, which has a high control accuracy, but also works stably and reliably. And because the lifting speed of the mechanical arm is required not to be high, it also avoids the problem that the torque of stepper motor reduces to too small with the acceleration of speed.[8]

4.3. **Local area network construction technology of parking lock**
Zigbee is used to build the parking lock network. Each parking lock will be equipped with a zigbee module to access the network. In areas where signal transmission is inconvenient, Zigbee modules can be placed separately in appropriate areas to ensure signal coverage.

**Figure 5.** Design of parking lock.

In order to realize these functions on the parking lock, STM32 MCU is taken as the control body of the parking lock, and besides, AMR sensor, stepper motor, zigbee network module and power module are added to achieve the design functions mentioned above (as shown in figure 5).

4.4. **Design of the regional coordinators**
The main components of the regional coordinators are STM32 MCU, Zigbee module, GPRS module, power module, and system management module (LED display). At regular intervals, the regional coordinator will collect information and working status of all parking locks from its zigbee network, and then send these messages to the server (as shown in figure 6). When the regional coordinator receives a message from the server, it will then send this message to the appropriate intelligent parking lock.[9] In order to facilitate the control of the parking lock, we add a LED screen on the parking lot coordinator, and managers can reset the status of parking locks or force the malfunctioning parking locks to open through simple interactions.
5. Conclusions
In this paper, an efficient parking management system design idea is put forward. The parking locks and coordinators are used to gather the required information, so that the drivers can find the parking information on the web page. Meanwhile, driver don’t need to install extra application because of B/S architecture. When it comes to the management of parking, every parking lot can be a smallest unit to manage, which benefits from the design of the parking lot coordinator. Besides, parking locks controlled by the embedded system will show different behaviors according to the requests of the drivers. It is likely to provide the driver with a suitable parking lot with a route guiding there. Finally, the driver can park the car in a short time without looking for a free parking lot under the guidance of embedded systems and servers.

Acknowledgement
Here and now, I would like to express my sincere thanks to all those who have helped us complete this project and make this thesis possible and better. First of all, I am deeply grateful to my alma mater, Jilin University, for providing us with an opportunity and a platform to exercise ourselves. Then thanks to my mentor for his instructive suggestions and patient guidance during the completion of the project and the thesis. Finally, I am very grateful to my lovely team members for their hard work and determination to overcome difficulties.

References
[1] Xu, X. L. Yun, and L. Song 2017. Design of Intelligent Stereo Parking Lot Management System Based on RFID. Journal of Electronic Design Engineering, 25(7), 119-122.
[2] S. Deese, and J. Daum 2018. Application of Zigbee-Based Internet of Things Technology to Demand Response in Smart Grids. Journal of IFAC PapersOnline, 51(28), 43-48
[3] J.H. Zheng, and J. X. Guo 2018. Design and Implementation of Parking lot Management System Based on ASP. Net. Journal of Scientific and Technological Innovation, 22(35), 86-87.
[4] Y. L. Xing, X. H. Wang, and J. Y. Li 2018. Research and Design of Wireless Parking Detector Based on Geomagnetism. Journal of Langfang Normal University (Natural Science Edition), 18(2), 18-24.
[5] X. S. Li, G. H. Yu 2006. Application of AMR sensors to vehicle detection. Journal of University of Science and Technology Beijing, 28(6), 587-590.
[6] Z. Y. Zhang, H. Y. Wang, L. Y. Zhu, and S. J. Deng 2016. Design of Geomagnetic Vehicles Detecting System Based on ZigBee Wireless Sensor Network. Journal of Electronic
Measurement Technology, 39(7), 110-15.

[7] H. H. Dong, X. Z. Wang, C. Zhang, R. S. He, L. M. Jia, Y. Qin 2018. Improved Robust Vehicle Detection and Identification Based on Single Magnetic Sensor. Journal of IEEE Access, 6(1), 5247-55.

[8] Z. C. Chen. Control Technology of Stepper Motor Driver and its Design for Application[D]. Xiamen University, 2008.

[9] L. Wang 2015. Based on the Network Technology of Car Parking Management System Design and Application Field. Journal of Logistics Engineering and Management, 37(2), 52-53.