

Research and Design of Road Intelligent Parking Based on IoT

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Abstract. Development of auto industry leads to parking difficulty and traffic jam in the city, which decreases operating efficiency of the city and happiness of people. Under the circumstances, parking space is planned on both sides of roads, by which the traffic jam is relieved to a certain extent. But some problem exists in management of the parking space as follows: Firstly, the management cost is high such as Human Resources investment. Secondly, rate of received fees (about 30 percent) is low because many car owners don't pay parking fees consciously. For the above problems, in this paper, the road intelligent parking request is firstly analyzed, and then an intelligent management and fee collecting solution for the road parking based on IoT is put forward. Besides, a management and control platform of road intelligent parking is designed. Finally key technologies for this system are analyzed. The purpose is to realize intelligent management, lower management cost, and higher fee collecting rate for the road parking.

1. Introduction

As rapid development of auto industry, population of private cars is larger and larger. So the parking difficulty is increasingly prominent. Because of lack of advanced managing method, traffic jam is becoming more and more serious, which decreases operating efficiency of the city and happiness of people [1][2][3][4][5][6]. Under the circumstances, parking space is planned on both sides of municipal roads, by which the traffic jam is relieved to a certain extent. But some problem exists during management for the parking space of municipal roads as follows: Firstly, the management cost is high such as Human Resources investment. Secondly, rate of received fees (about 30 percent) is low because many car owners don't pay parking fees consciously. Therefore, how to solve the above problems and improve management intelligence level is a problem faced in the management of municipal road parking space.

Fortunately, at present, the rapid development of Internet of Things (IoT) technology has become the technical support of intelligent parking in cities, which is the best way to solve the "parking difficulty". IoT is the third wave of information industry after computer and internet. IoT is a technology that connects all kinds of objects with the internet by information sensing device (such as RFID devices, sensors, cameras, etc.), various communication means (such as wireless, cable), and the agreed agreement. The purpose is to realize intelligent perception, identification, location, tracking and monitoring and management for the objects. The ultimate goal is to realize the communication between humans, humans and things, things and things^[3]. In terms of intelligent parking, the technical architecture of the IoT is shown in Figure 1.



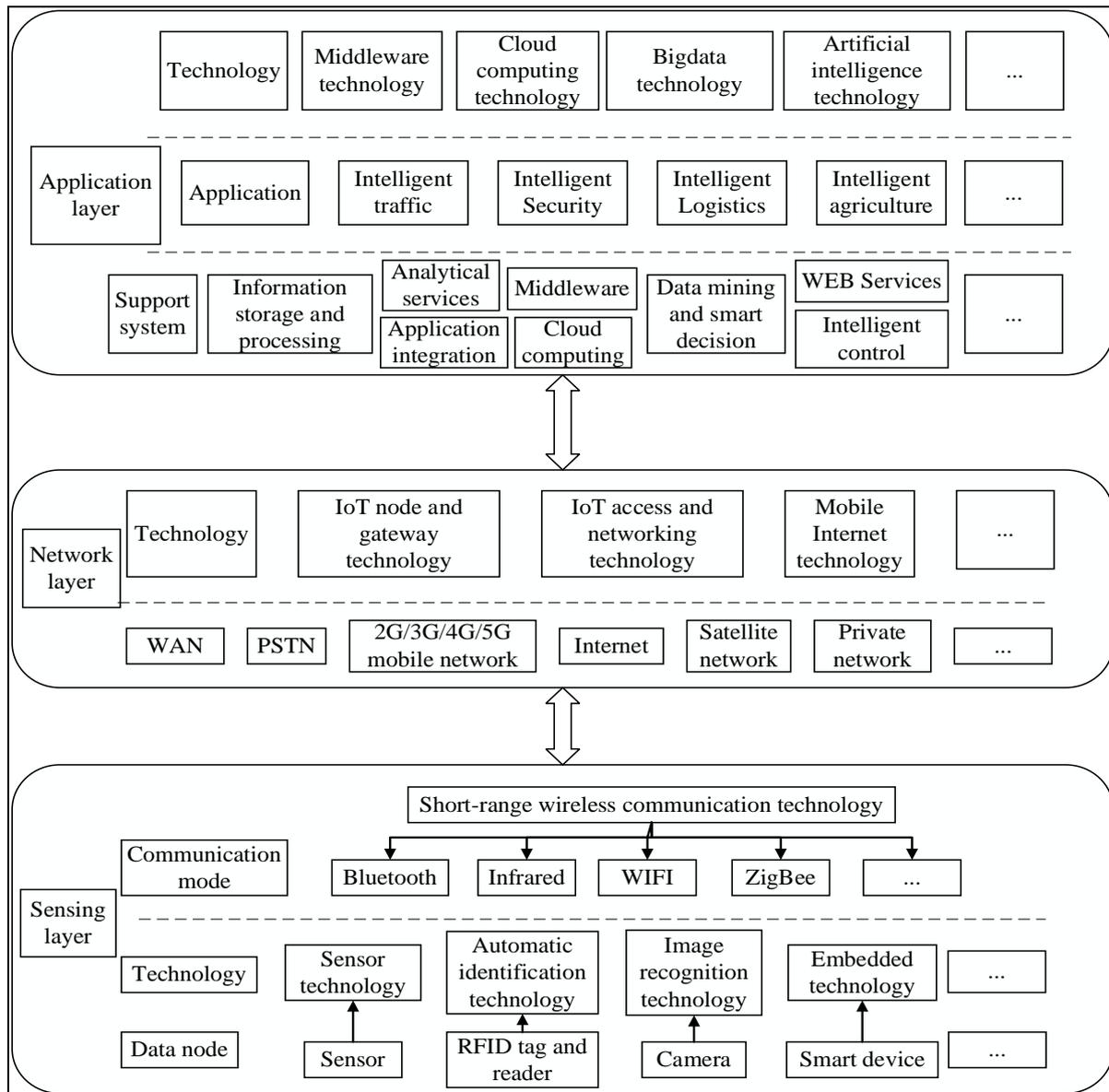


Figure 1. Technical architecture of the IoT

As shown in Figure 1, the function of the sensing layer is to comprehensively perceive and recognize cars and obtain the license plate information. The function of the network layer is to transfer information acquired by the sensing layer reliably to the application layer. Application layer is the deep integration of the IoT and industry professional technology, which can realize an intelligent parking industry.

2. Request Analysis of Road Intelligent Parking System

2.1. Market Size of Intelligent Parking

At present, there are more than 30 private cars for every 100 families, which accounts for about 92 percent of small passenger cars. In china, 49 cities had more than one million cars, 18 cities more than two million, and 6 cities more than three million by 2016. In Guizhou province, the car population is about 3.5 million by 2016. The above data is shown in Figure 2.

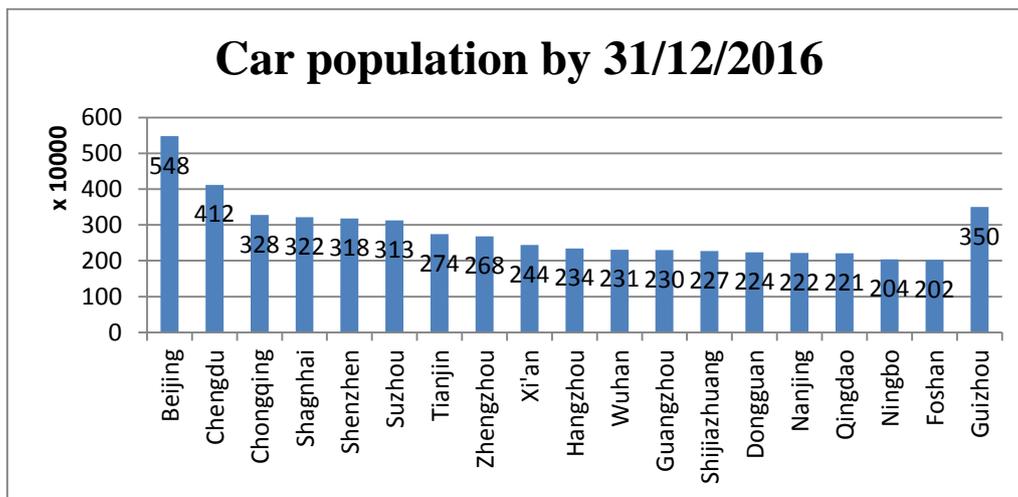


Figure 2. Car population by 2016

As shown in Figure 2, such a large car population means that a huge market size exists^[4], as shown in Figure 3.

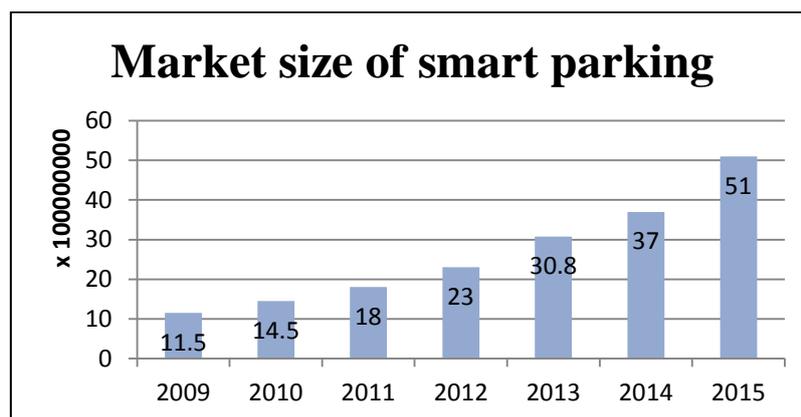


Figure 3. Market size of intelligent parking

As shown in Figure 3, with the development of economy and the improvement of people's living standard, the market size and request of intelligent parking increase year by year. So there will be a broad market prospect at the intelligent parking area.

On the other hand, in a city, new road infrastructure induces new traffic, but request tends to exceed supply. And parking lots are always in short supply in cities, especially in big cities[2][5][6]. So road parking space is planned in most streets of the city. Therefore, intelligent parking system for road parking space will have a broad market prospect.

2.2. Current Situation of Road Parking Management

At present, "intelligent parking" solution developed by "Songli group co. LTD" is widely used in municipal road parking management. The hardware is mainly composed of front-end video pile and mobile inspection end. Specific distribution of the front-end video piles is shown in Figure 4 [7].

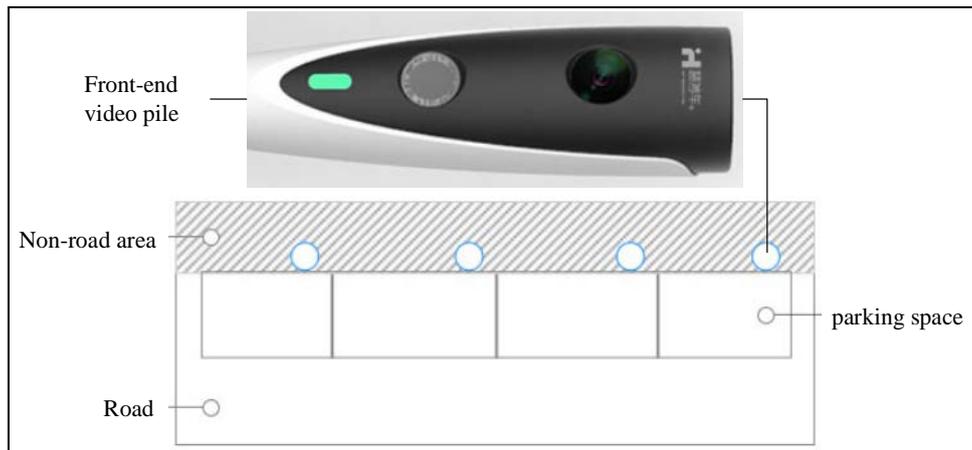


Figure 4. Distribution of the front-end video piles

As shown in Figure 4, the function of the front-end video pile is to take photos of license plate after a car entering parking space. Each video pile contains two cameras distributed at a certain angle, which can scan the license plates of two adjacent parking spaces through a certain layout method, so as to scan and identify all cars entering the parking spaces. The scanning mode is shown in Figure 5^[7].

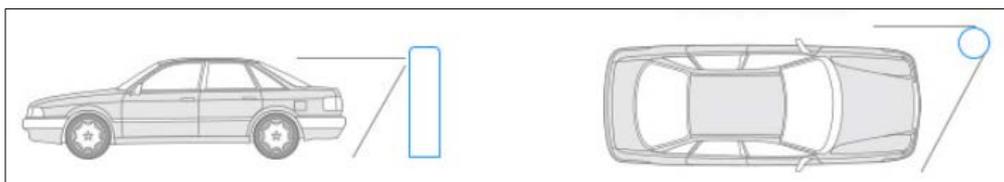


Figure 5. Scanning mode of the front-end video pile

As can be seen from Figure 5, in this solution, the lateral license plate recognition method is adopted, which can be used to recognize the license plate whether the car stops in the right direction or in the wrong direction [7].

Since there is no access restricting measures for the cars in this solution, manual management and charging are adopted at present. The specific implementation process is as follows: (1) each person is responsible for about 50 parking spaces; (2) the car enters freely. When the car leaves, the management personnel will hold the mobile inspection end and input the license plate for billing display. The owner can leave after paying the fee.

In this solution, there are the following problems: (1) high management cost. The annual management fee for each 50 parking spaces is about 30,000 yuan, so when the rate is low, the enterprise parking income is low; (2) when the owner leaves, if the manager does not find out, the charge will be delayed or missed, resulting in a low charging rate; (3) some car owners have a low consciousness of paying the fees. When managers collect fees, they refuse to pay for it, which will have a negative social impact and lead to a low charging rate.

3. Design of Intelligent Road Parking System

3.1. System Function

In view of the existing problems in the current municipal road parking management, a new solution is proposed in this paper, including some functions such as parking monitoring, parking guidance, cars identification, cars restriction, billing and payment and so on.

(1) Parking monitoring: Through the front video pile, the use of each parking space can be monitored and collected in real time in this system. It is convenient for parking space managers to know the details of parking space use in real time, and meanwhile provide the real-time parking space

remaining number for car owners to guide them to park smoothly.

(2) Parking guidance: On the basis of parking monitoring, statistical analysis of the remaining parking spaces will be made in real then released to the public. Before entering the road, the car owners will be informed of the number of remaining parking spaces in this section. They can independently choose appropriate parking space according to the prompt information of the system.

(3) Cars identification: After the car enters the parking space, the license plate can be imaged by the front-end video pile, and image data is transferred to the background computer through the network for calculation and processing. Finally license plate can be recognized by using a certain algorithm and character segmentation technology.

(4) Cars restriction: When the car enters the parking space, its license plate can be recognized by the system and then timed. After a certain period of time (free period stipulated by the system), the car will be restricted by controlling the actuator. When the owner needs to drive away, the actuator will automatically reset and release the car after paying the parking fee online.

(5) Billing and payment: When the car enters the parking space, the license plate is recognized, and the time and parking fee is automatically calculated. When the car owner needs to drive away, she can scan the QR code on the front-end video pile, input the license plate, or download the designated APP, bind the phone number and the license plate, after which the fee is billed. Car owners can pay and leave according to consumption.

In conclusion, this system aims to realize unattended intelligent municipal road parking management, standardize parking order, reduce enterprise management costs and increase the collecting rate.

3.2. Technical Solution of the System

STM32 is planned to be used as the control core to complete the automatic control and intelligent processing of the actuator motor in this system. The solution framework of the system is shown in Figure 6.

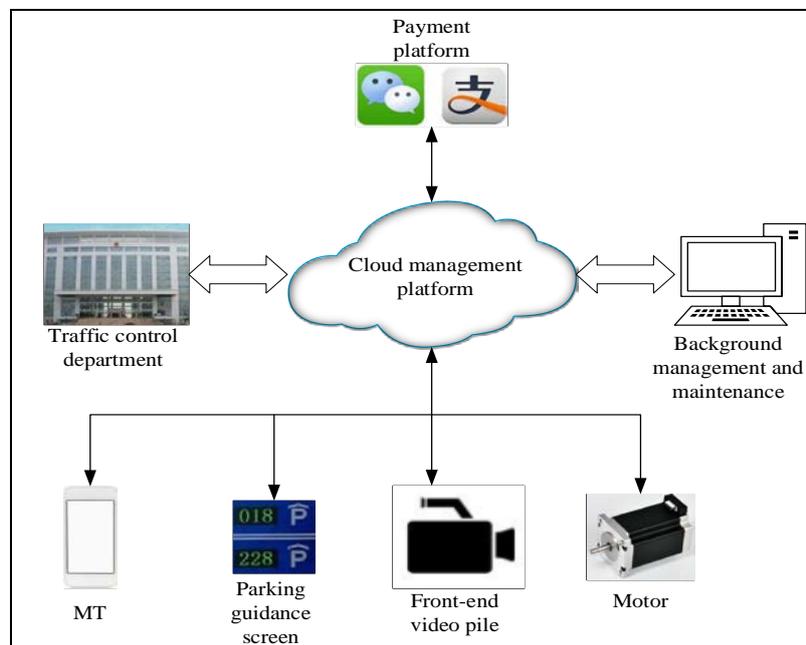


Figure 6. Solution framework of the system

As shown in Figure 6, the workflow of this system is as follows: (1) A parking guidance screen is placed near the road entrance to display the real-time remaining number of parking spaces; (2) When the car stops well, the license plate is imaged by the front-end video pile, and then transferred to data center for calculation and recognition, and start timing;(3) After a certain period of time (free time set),

the background computer sends control command to STM32 through the gateway to control the actuator to restrict the car;(4) When the car leaves, on one hand, the owners can download and install the corresponding intelligent parking management APP, bind mobile phone and license plate, then she can query the parking fee and pay for it in the APP. On the other hand, she can scan the QR code (WeChat or Alipay) on the front-end video pile, and then enter the license plate number to complete payment. After the payment finished, the background sends command to the STM32 through gateway to control the actuator are to reset and release the car.

3.3. Intelligent Parking Management Platform Design

According to the actual situation of intelligent parking on municipal roads designed in this paper, the following objectives should be satisfied in the design of the management platform :(1) the interface of the system should be beautiful and easy to be operated;(2) query function based on license plate and parking space should be supported;(3) the function of intelligent charging should be realized; (4) the platform should be simple to be maintained and later updating service should be supported. According to the system function in section 3.1 and solution framework in section 3.2, function and structure of the management platform is shown in Figure 7.

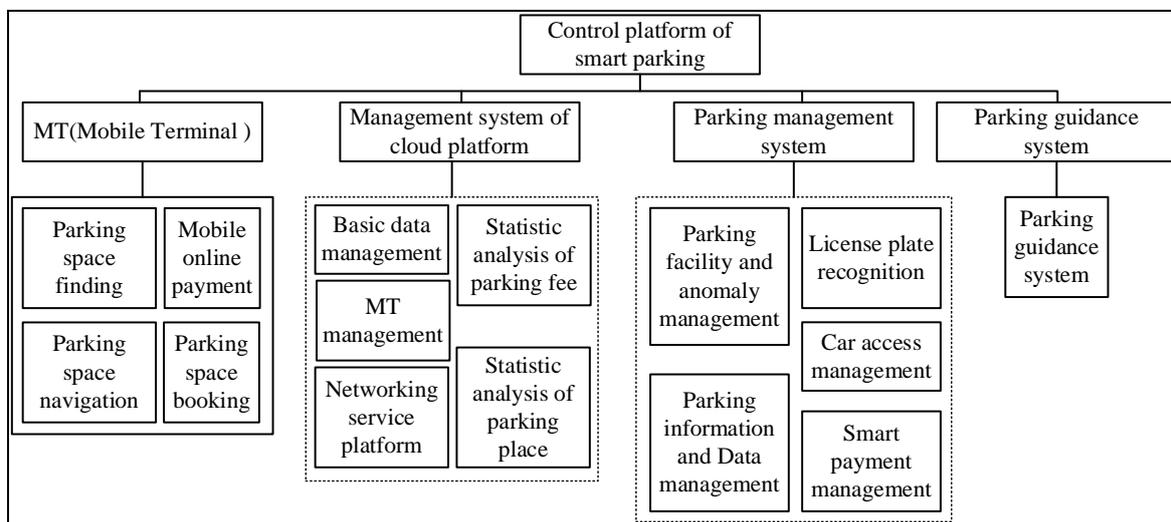


Figure 7. Function and structure of the management platform

4. Key Technologies of Road Intelligent Parking

According to the function and structure of the management platform, the required key technologies are introduced in the following section.

4.1. License Plate Recognition Technology

License plate recognition technology mainly consists of license plate location, character segmentation and character recognition. The recognition effect depend on the above three parts. The identification flow is shown in Figure 8.

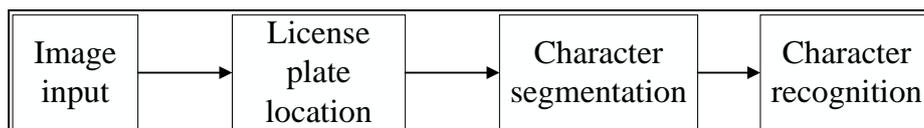


Figure 8. License plate identification flow

In Figure 8, the methods of license plate location mainly include the method based on the variation feature of horizontal gray scale, the method based on edge detection, the method based on the color feature of license plate, and the method based on mathematical morphology. Character segmentation

algorithms mainly include recognition based segmentation algorithm, direct segmentation algorithm and adaptive segmentation and clustering algorithm. The character recognition algorithms mainly include template matching, neural network, support vector machine, Bayes classifier and feature matching.

4.2. Information Transmission Technology

In intelligent parking, data of the sensing layer, such as the license plate number, entry time and image, are transmitted to the application layer through the network layer. The information transmission can be divided into wire transmission and wireless transmission (such as ZigBee, Bluetooth, Wi-Fi, etc.). According to the technical implementation, it can be divided into: fiber optic communication technology, Wi-Fi technology, WIMAX technology, 2G/3G/4G/5G communication technology, etc.

Among them, faced with more and larger data transmission volume in the future, 5G technology has great advantages due to its higher transmission rate and lower delay. The characteristics of 5G technology are as follows.

(1) Millimeter wave: with the millimeter wave, ultra-high speed transmission rate, narrow beam can be supported, and a large number of devices can be connected. Besides it can be controlled flexibly. (2) Micro base station: due to the small coverage of millimeter-wave, more base stations are needed, and the use of micro base station can reduce the cost. (3) Massive MIMO: the more antennas there are, the higher the spectrum efficiency and transmission reliability. (4) Beam forming: an antenna array is arranged on the base station. By controlling the phase of the radio frequency signal, the wave lobe of the electromagnetic wave after interaction becomes very narrow and points to the serviced mobile phone, and also the direction of it can change according to the mobile phone's movement. (5) D2D: in 5G era, if two users in the same base station communicate with each other, the data will no longer be forwarded through the base station, but directly from mobile phone to mobile phone.

4.3. Self-service Payment Technology

On one hand, the self-service payment of parking fee helps saving the time of entering and leaving the parking space and greatly alleviates the parking queue problem. On the other hand, it can help realizing the unattended parking, reducing the human cost, and realizing the intelligent management and operation of parking.

According to the system functions and workflow described in sections 3.1 and 3.2, the principle of self-service payment in this system is shown in Figure 9.

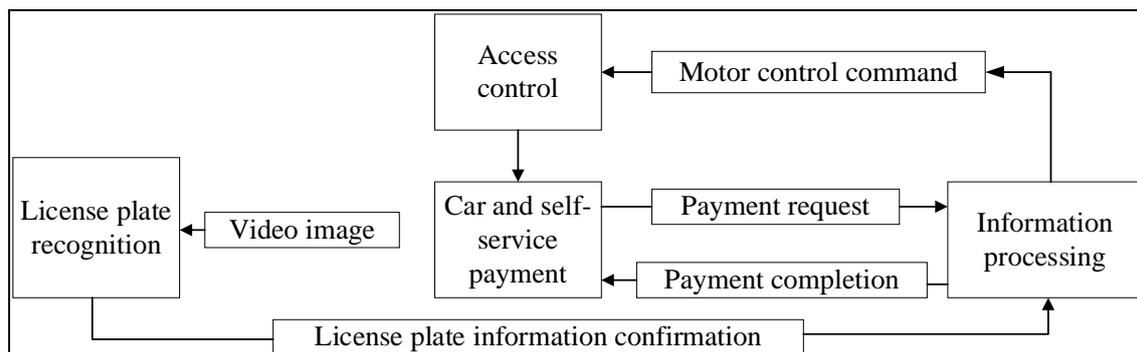


Figure 9. Self-service payment principle

5. Conclusion

In this paper, the existing problems of municipal road parking management and intelligent parking system architecture based on the IOT are firstly analyzed. Secondly, the market request of intelligent parking industry in China is analyzed, and also the current municipal road parking management system solution and the existing problems are introduced. Thirdly, a new solution is proposed, and its workflow and management platform are designed.

With the proposed solution, the following goals can be achieved :(1) to achieve intelligent management of municipal road parking space;(2) to save human resources and reduce management costs and Generate revenue for the management company;(3) to restrain car owners from not paying parking fees and increase the collecting rate;(4) to regulate the road parking order and alleviate urban traffic jam.

6. References

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