

## Research on 3\*3 Stereo Garage Control System Based on PLC

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### Abstract

Vehicle is parked problem is the city's social, economic and transportation development to a certain degree and the increase of population, personal vehicles all rate, the effects of the growing tension of urban land resources, with the rapid development of our country, the parking problem has increasingly become the urban development and management of major issues. The traditional parking method is not enough to meet the needs of the public, so the development of the stereo garage of the era is a rare and effective way to solve the parking problem[1]. In this paper, the storage and access of 7 parking Spaces in 3\*3 stereo garages are designed. This paper introduces the structure and working principle of the garage, expounds the structure and components of the garage control system, and designs and analyzes the control circuit of the garage motor. This system USES PLC and computer configuration screen monitor, the press of a button or control state images can complete car access process, simple operation, easy to access, control circuit part adopts ac contactor traditional way, make the safe and reliable running, adopting the combination of separable design modular installation, convenient and flexible, maintenance convenience, low cost etc. This paper introduces the specific application of s7-200 series PLC in the three-storey lifting and moving garage from the hardware selection and software design. In writing this thesis, there are some green place such as how to make more intelligent garage was slightly insufficient, in addition to more quickly and security access vehicles were in need of improvement.

### Keywords

Stereo garage; S7-200PLC; Configuration Monitoring.

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### 1. Introduction

The purpose of this paper design is: with the rapid development of China's urban economy and automobile industry, more and more individuals and families have private cars, which corresponds to the embarrassment of urban parking. How to use the limited land resources to solve the parking problem needs to be solved.

The significance of this paper for urban parking: parking problem is a static traffic (vehicle parking state) problem in a city, which is caused by the lack of urban parking space in the development process and the gradual increase of population. Static traffic is a kind of traffic form relative to dynamic traffic (vehicle driving state). Both of them are interrelated and interact with each other. Parking facilities are the main content of urban static traffic. With the continuous development of urban scale and building complex, as well as the continuous increase of various vehicles, residents' demand for parking facilities is also increasing. If there is a imbalance between them, There will be a series of problems in the city. According to the latest data, the average growth rate of motor vehicles in China's cities in recent years is between 15% and 20%, while the average growth rate of urban parking infrastructure in the same period is only 2% - 3%. In particular, the growth rate of vehicle ownership

in some super cities and first tier cities is far faster than that of parking infrastructure. Therefore, we must pay attention to it the problem of urban parking is difficult, and the measures to solve it are actively explored.

This paper is to solve the problem of urban parking, the design of the garage can use the least land area to store the most vehicles.

### **1.1 Research background and significance.**

With the rapid development of China's economy and automobile industry, there are more and more families with private cars, many of which are more than one. However, corresponding to this situation, the city is unable to meet the parking situation. The problem of urban static traffic (the vehicle is in the parking state) is the problem of parking in the process of rapid development of a city. Urban static traffic is another traffic form relative to urban dynamic traffic (the vehicle is in the driving state), and they are related to each other and affect each other [1] [2]. And parking facilities become the core of urban static traffic. With the continuous development of the city, the demand for parking equipment is also increasing. If the balance between the number of vehicles and the number of parking equipment is out of balance, the city will naturally have a series of problems such as difficult parking and difficult to pick up. All kinds of data show that in recent years, the average growth rate of the number of motor vehicles in China's major cities is 15% - 20%. However, compared with the rapid increase in the number of vehicles, the average growth rate of the number of urban parking infrastructure is only 2% - 3%, especially in China's first tier cities and second tier cities, the growth rate of vehicle ownership is far faster than the growth rate of parking infrastructure[2-3]. At the same time, the traditional parking methods in the past not only occupy land, but also affect the traffic operation and urban aesthetics. Therefore, we must pay more attention to the problem of urban parking difficulties, and actively cooperate with urban construction to explore solutions.

### **1.2 The goal of The control system of elevating and traversing stereoscopic garage needs to achieve.**

In the stereoscopic garage, many controls need to be realized, including speed, safety interlock, and positioning and sequential motion control. Simple, convenient, safe, easy to control, fast response and easy to maintain are the consistent requirements of the three-dimensional garage. The garage control system needs to achieve the following objectives:

Automatic operation: the access process of the car is automatic and intelligent. The user only needs to operate in the human-machine interface, and the system will immediately dispatch the program according to the situation of the garage, so as to facilitate the rapid access of the car to and from the garage.

Safety interlock control: safety guarantee is always needed in the garage. Therefore, many safety facilities must be installed in the garage to constantly monitor the condition of the garage and maintain the normal condition to ensure the safety of the vehicle.

High speed and stability: in order to quickly complete the access action of the car, there are more strict requirements for the transmission device. It is necessary to ensure that it can run at high speed, but also to ensure safety and stability, so as to achieve stable start and braking [4].

### **1.3 main research contents.**

This paper studies and analyzes the three-dimensional garage, aiming at the relatively backward situation of the automation level of the three-dimensional garage in China, designs the intelligent three-dimensional garage control system based on Siemens S7-200 PLC. At the same time, this paper introduces the types of stereo garage equipment, analyzes the operation principle of the lift and traverse garage, and puts forward the goal of the control system design, which provides the basis for the development and coupling of each module in the later system.

The main research contents are as follows:

- (1) This paper introduces the design background and research significance of the control system of the three-dimensional garage.
- (2) This paper introduces the definition, type and characteristics of three-dimensional garage. This paper introduces the overall frame structure and working principle of the lift and traverse type three-dimensional garage.
- (3) The overall design scheme and hardware design of the control system are introduced.
- (4) The software design of the control system is introduced.
- (5) This paper introduces the debugging and conclusion analysis of garage control system.

## **2. Overall design scheme of three-dimensional garage**

After a comprehensive comparison of all kinds of three-dimensional garages and their development at home and abroad, this paper chooses the three-story seven parking space type lift and traverse three-dimensional garage structure as the research object, and its overall structure can be divided into three parts: the mechanical structure part of the garage, the transmission mechanism part and the control system part.

In the three-dimensional garage, the lifting and moving control system is designed. Siemens S7-200 PLC is used as the three-dimensional garage control system, and its programming software is used for lifting and moving, debugging and running. As a stereo garage control system, PLC is very simple. Its stable, reliable, fast and economic characteristics make the control system more perfect. In order to use the three-dimensional garage more safely and effectively, according to the national general safety requirements for mechanical parking equipment standards and the actual situation, some safety equipment designs are added to the design [5].

### **2.1 Three dimensional garage structure frame.**

The frame of the three-dimensional garage is generally made of the reinforced concrete, so this material is also used in the design of the lift and traverse three-dimensional garage.

### **2.2 Carrier plate.**

Today's cars can be divided into: small hatchback, small hatchback, medium car, medium and large car, large car. In terms of the length of these cars, the shortest is 3600-4000mm, and the longest is 4700-5200mm. Therefore, the length of the carrier plate is 5500mm. In terms of width, the narrowest one is 1500-1700mm, and the widest one is 1800-2000mm. Therefore, the best width of the carrier plate is 2200mm.

### **2.3 Lifting mechanism and selection.**

In view of the application of stereo garage, the system should ensure its lifting speed and reliability. Because the starting, braking and normal operation performance of the lifting system is directly related to the operation condition of the driving motor. Many factors must be considered in the selection of lifting motor, including power, mechanical characteristics and the ability of the system to adapt to different loads.

Promotion mechanisms include:

- (1) Traction drive, reduction mechanism and brake.
- (2) Steel wire rope, pulley and other parts used for lifting.
- (3) Counterweight and balance chain.
- (4) Vehicle platform with vehicle lift when parking.
- (5) Lifting and balancing rails.

According to the actual requirements of garage application, the vehicle lifting time should not be too slow, and it needs to meet the requirements that the vehicle lifting time is less than seconds. The lifting time  $t$  of the designed vehicle in this garage is 17 seconds. For the sake of safety, in the

structural design of the garage, the vertical distance between the lifting carrier plate and the transverse carrier plate shall not be less than 1.8m. According to the above requirements, the vehicle lifting speed can be calculated:

$$v = \frac{s}{t} = \frac{1.8}{17} = 0.106 \text{ (m/s)} \quad (2-1)$$

In general, ordinary cars are parked in the garage, and the total weight of the car and the carrier plate is about 2 tons, that is,  $G = 2 \times 10^4 \text{ N}$ .

It can be concluded that the required lifting power  $P$  of the motor is:

$$P = G \times V = 2 \times 10^4 \times 0.106 = 2.12 \text{ (KW)} \quad (2-2)$$

## 2.4 Electrical control system design.

The circuit of the system includes motor circuit, lighting circuit, alarm circuit, photoelectric switch connection, limit switch connection, etc.

In the design of the garage, the spaces on the first floor and the third floor can only be moved and lifted respectively, so only one motor is needed for the spaces on the two floors, while the spaces on the second floor need two kinds of motion modes, i.e. moving and lifting, so one parking space needs two electric machines to meet the demand [6].

The hardware wiring diagram of the main circuit is shown in the following figure 1:

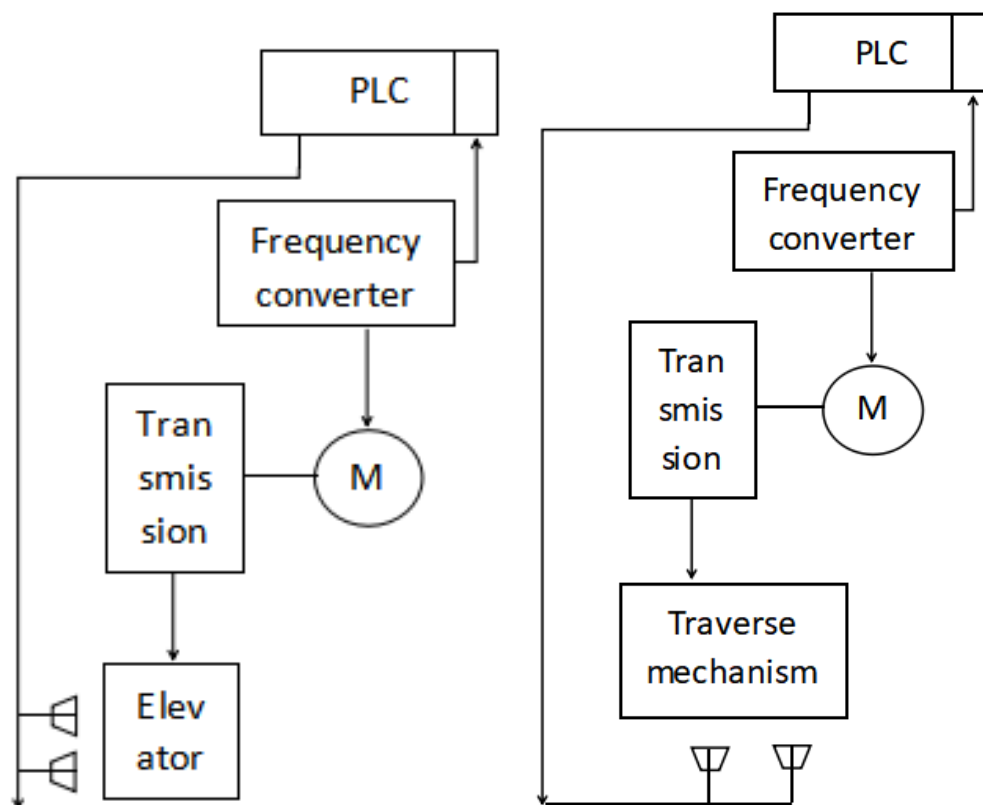


Figure 1 Schematic diagram of lifting and traverse motor

## 2.5 Summary of this chapter.

This chapter describes the structure of the lifting mechanism and the translation access mechanism in detail, and designs the lifting movement control scheme, the electrical control system design, the system control principle, the safety protection system, the selection of the proximity switch and the speed control method of the asynchronous motor. The list of hardware components is shown in Table 1:

Table 1 List of hardware components

Name of electrical components	Model of electrical components
Knife switch	HD11-100/3
Thermal relay	JRS1-D16321
Operation indicator	Red indicator AC220V
Alarm lamp	LTE-1101J
Photoelectric proximity switch	Omron's G18-3A30NA
PLC	PLC Siemens S7-200 series CPU226
Extension module	Mathematical quantity module EM223, 16 input / output DC / DC / DC
Three phase asynchronous motor (lifting)	Y90L-2
Three phase asynchronous motor (traverse)	Y801-2
Intermediate relay	Omron's MY2N-J
Button	Schneider XB2-B
Fuse	RT23-63
Inverter	Siemens MM440

### 3. Hardware design of stereo garage

In the research of this subject, the garage administrator manages the PC end, including the collection of user information and the use of buttons on the upper computer. Because the button operation is relatively simple and time-saving, this paper mainly focuses on the design of button type stereo garage, aiming at the stereo garage control system studied in this paper, according to the functional requirements of the system, the system is divided into two levels. One is the human-computer interaction control subsystem with single-chip microcomputer as the control core. It is responsible for the data acquisition and processing of single chip microcomputer. The system is also responsible for garage control, monitoring the real-time status of the garage at any time, including recording vehicle information, etc; the other is the field implementation system to control vehicle access, mainly including detection, drive equipment and PLC control subsystem, the system is responsible for vehicle access; The detection equipment adopts high-performance photoelectric sensor, which can accurately detect the moving position and parking status of the vehicle. The sensor sends the detected data to PLC as the control input. The control block diagram is shown in Figure 2. Test equipment and drive equipment are described above. Therefore, this chapter will design the main hardware of PLC control subsystem and human-computer interaction control subsystem.

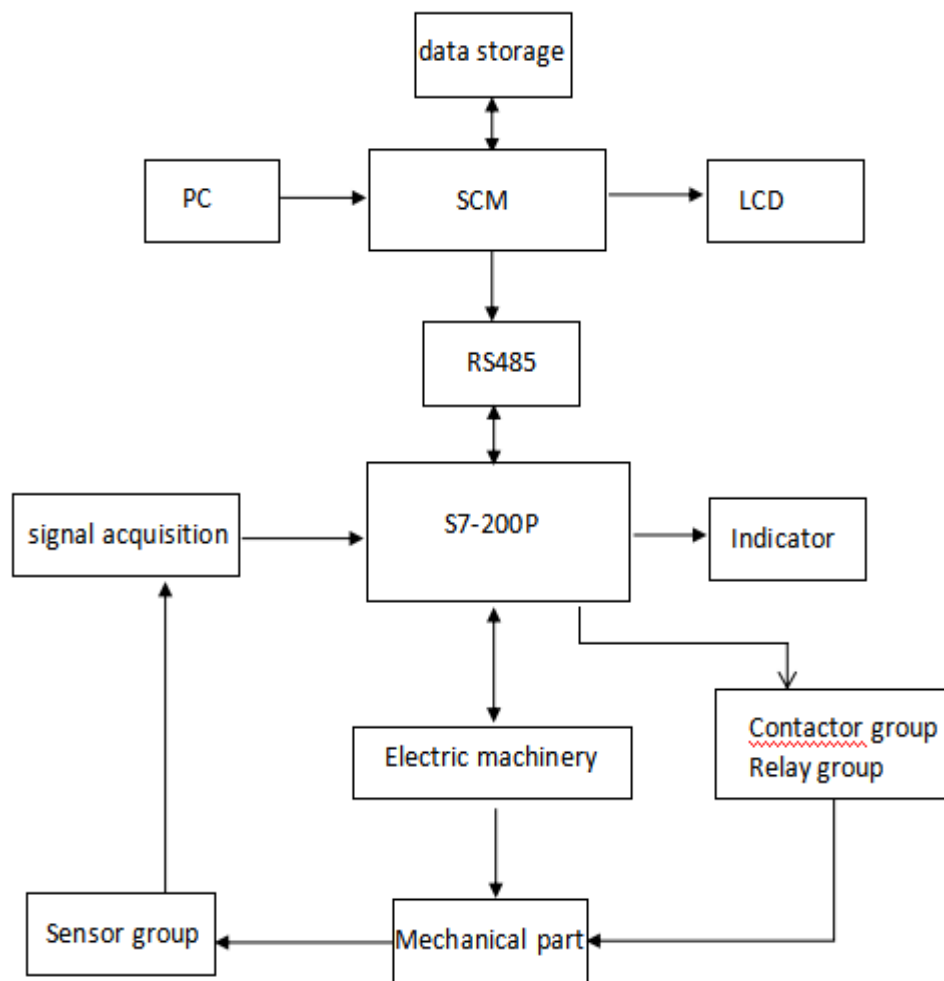


Figure 2 Control system diagram of stereo garage

## 4. Software design of stereo garage

With the increasing use of vehicles, the use of three-dimensional garage is more and more common, but it is produced by different manufacturers. Therefore, there is no unified standard for three-dimensional garage, which leads to the failure of products produced by different manufacturers and the inability to realize the standardized control of intelligent three-dimensional garage system, resulting in the overall low efficiency and high input operation of the garage. The parking space scheduling algorithm used in this paper is suitable for a. These small capacity devices greatly improve the efficiency of the system.

In this paper, the breadth first algorithm is used to control the garage scheduling, and the 3 \* 37 three-dimensional garage is studied in depth. Taking a parking lot with seven parking spaces as inventory, this paper solves the problem of intelligent vehicle access, and obtains the optimal storage through the algorithm, which improves the efficiency of the system.

### 4.1 Specific algorithm application scheduling vehicle.

In the 3 \* 3 three-dimensional garage, the initial state of vehicles in the garage is as shown in the figure. The garage is fully loaded with 7 vehicles. Among them, vehicle 5 is the target vehicle for pick-up, which is located on the left most side of the third floor.

Pick up vehicle 5. According to the specific parking space scheduling algorithm, the optimal path scheduling is carried out, and the mobile route is shown in Figure 4-6.

Through the set parking space scheduling algorithm, the vehicles of the target parking space arrive at the exit safely and stably, and the vehicle access is completed. The software programming to



achieve the above shift function will be described and designed in the software part.

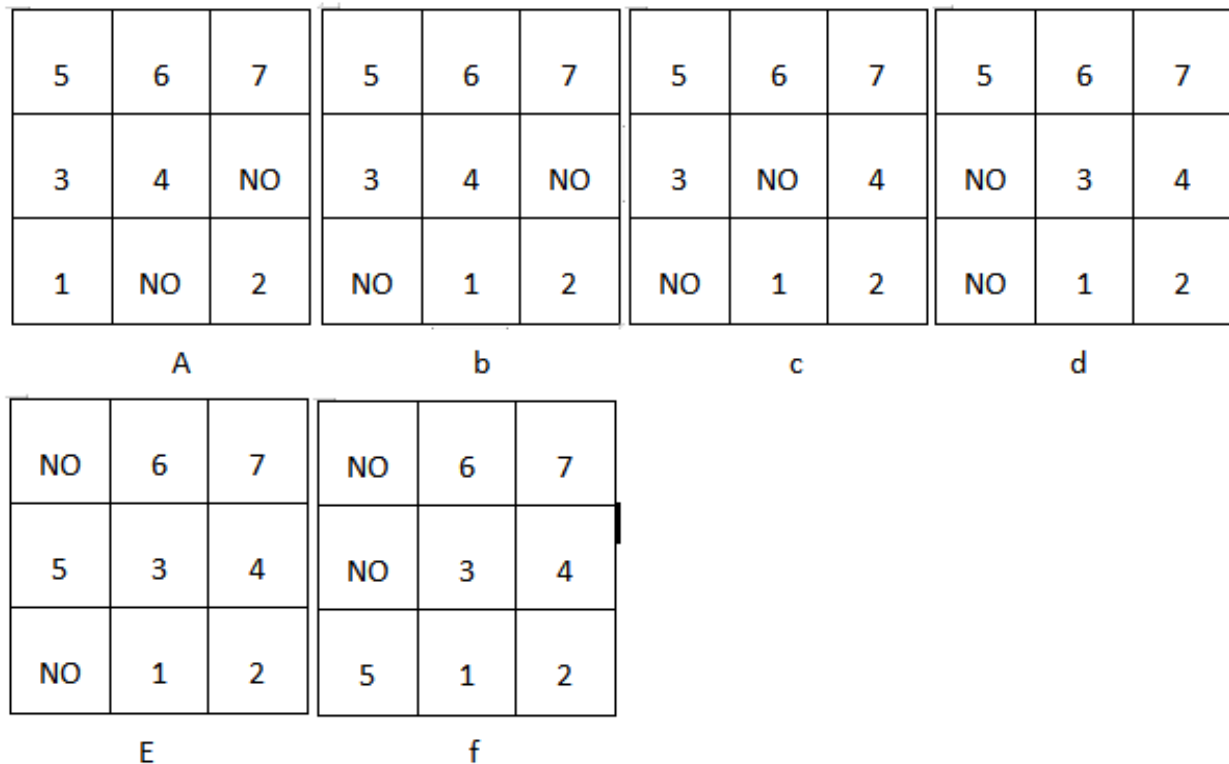


Figure 3 Scheduling moving path of target parking space

#### 4.2 Step-7 and its programming.

Siemens Company specially designed step-7 microwin V4.0 programming tool software for S7-200 series minicomputers. The advantage of this software is that it can compile different control programs according to different requirements of the control system, communicate with PLC in real time, download and upload the programs and monitor on-line, which greatly improves the work efficiency. At the same time, the modularization of the software in the process of programming greatly facilitates users.

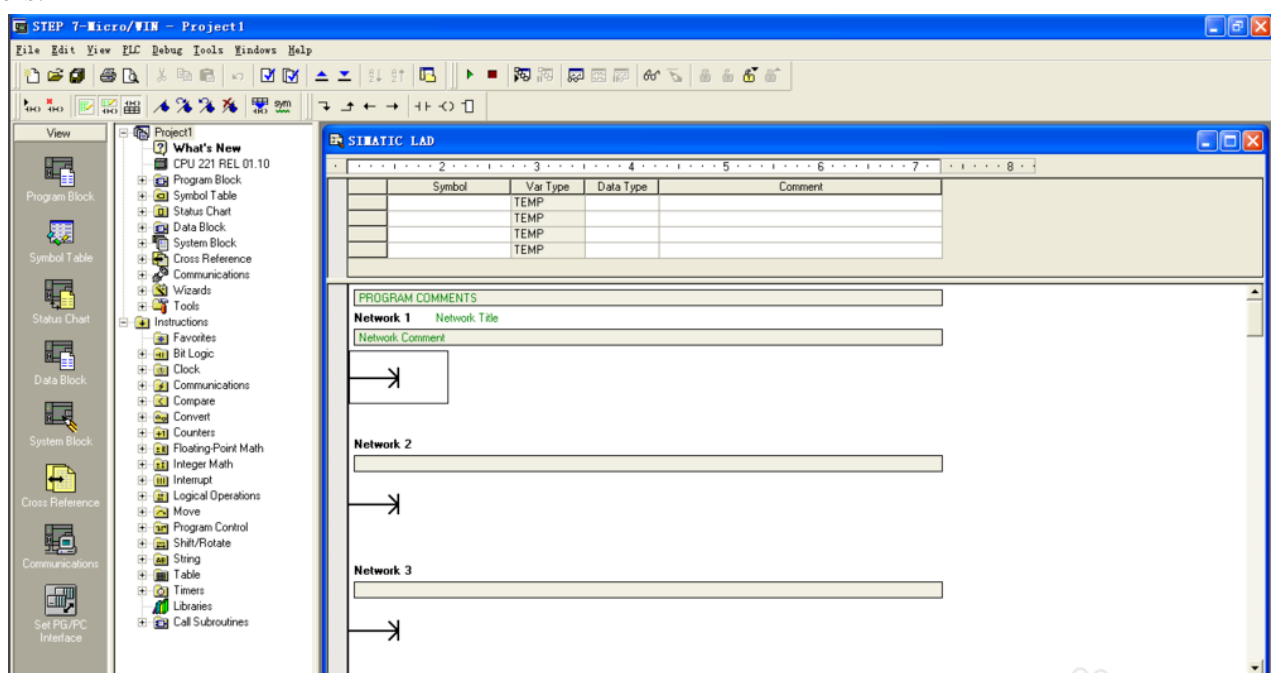


Figure 4 Step-7 microwin V4.0 Work interface

### 4.3 Kingview simulation.

In view of the current development trend of automation technology, and to meet the needs of low-end market and application, including the goal of enterprise integration, Asian control technology has developed a new product Kingview 6.55 and put it into the market.

## 5. Summary

Generally speaking, the design is successful, and the design scheme has also reached the expected goal. But there are still some flaws. Due to the reasons of personal level and the lack of time, the design of the three-dimensional garage scale is not so large, the practicality is not so high, but it can also be used. Because this design is designed by myself with reference to all aspects, there must be some imperfections. After all, as a student, there will always be some loopholes in some aspects, which makes the work not so perfect, but I will try my best to make myself not regret. The vertical and horizontal stereoscopic garage is a relatively simple type of stereoscopic garage, so I hope to have a chance to do other types of stereoscopic garage next time.

For the three-dimensional garage, I hope that the future three-dimensional garage can do the following:

1. The user can access the vehicle without wasting time to turn the front of the vehicle, and can access the vehicle in a short time, which is more convenient;
2. Practicability of three-dimensional garage. For example, the first floor of the three-dimensional garage is replaced by a coffee shop, a teahouse, etc., which is convenient for people to rest or have fun.

I hope that the future three-dimensional garage can be better and better, with more parking, more convenient and faster.

## References

- [1] Yong Zhang. Design of three-dimensional garage control system based on PLC [J]. Construction engineering technology and design, Vol.28(2017),p:456-456.
- [2] Haifeng Gong. Research on the lift and traverse parking garage and its control system [D]. Master's degree, Lanzhou University of technology, China 2003.p.3-7.
- [3] Huijuan Bian, Xiaohui Wang. Design of the control system of the elevating and traversing three-dimensional garage based on PLC [J]. Journal of Beijing University of information technology (NATURAL SCIENCE EDITION). Vol.31 (2016) No.5, p.73-77.
- [4] Kangkang Wang. Research on the design of lift and traverse three-dimensional garage [D]. Master's degree, Chang'an University, China 2015.p.30-36.
- [5] Liming Zhao. PLC based design of lift and traverse stereoscopic garage [D]. Master's degree, Inner Mongolia University, China 2014. p. 40-50.
- [6] Wei Liu. Development and implementation of the vertical and horizontal three-dimensional garage based on PLC control [D]. Master's degree, Chang'an University, China 2014. p. 44-55.