Design of Cylindrical Three-dimensional Garage System

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Abstract. The increasing of car ownership makes the problem of parking difficult to become more and more prominent. The application of three-dimensional garage is one of the most effective solutions at present, which saves both cost and space. Based on the traditional three-dimensional garage, this paper designs a cylindrical three-dimensional garage system. The lifting device of the vehicle is composed of screw, parking platform, and transmission track. The control system of the garage is designed with the single-chip microcomputer as the control core. Finally, the control circuit of the software simulation system realizes the function of automatic exit storage of vehicles, which verifies the feasibility of the design.

1. Introduction

In recent years, with the continuous popularization of household cars, the traditional ground-based parking covers a large area, and the limited land resources lead to the result that the traditional parking methods can not meet the actual needs of life. The use of three-dimensional garage can well solve this problem.

Stereo parking system technology has been developed for many years, and its convenience and environmental protection have been widely recognized. There are mainly nine types of existing three-dimensional garages, namely lifting and traversing type, simple lifting type, vertical circulation type, plane translation type, vertical lifting type, roadway stacking type, horizontal circulation type, multilayer circulation type and automobile elevator. Among them, vertical lifting type can realize high-rise parking of cars, which is of great significance for areas with scarce land resources [1]. However, the traditional three-dimensional parking equipment has the problems of low space utilization rate, complex structure, high manufacturing cost, low system safety and so on. In this design, the vertical lifting type three-dimensional parking technology is combined with the plane translation type three-dimensional parking technology, and Cortex-M3 is adopted as its main control. A variety of automation technologies cooperate with each other to make the system have the advantages of high performance, low cost, low power consumption and the like, control the cost and improve the overall safety performance of the system.

2. Overall scheme design

2.1. Lifting device

The plan view of the lifting device of the cylindrical stereo garage is shown in figure 1. Rectangular squares on the left and right sides are parking spaces, and the middle part is a lifting mechanism. The mechanism comprises a support screw, a lifting platform, a falling prevention bayonet and a high-
precision stepping motor. The high precision stepping motor is the main power source of the device. The lifting platform is connected with the stepping motor through ropes, and the lifting platform is lifted and lowered through the forward rotation and reverse rotation of the stepping motor. The control signal of the stepping motor is directly sent by the central control equipment. Anti-falling bayonet is a safeguard measure. When the system is abnormal or the power is suddenly paralyzed, the lifting platform may suddenly fall. Whether there is a car on the platform at this time or not will have a serious impact on the equipment. The existence of anti-falling bayonet can block the platform during the falling process and avoid the occurrence of adverse conditions [2].

![Figure 1. Schematic plan of lifting device](image1.png)

![Figure 2. Principle block diagram of control system](image2.png)

In figure 1, 1- High precision stepping motor, 2- Lifting platform, 3- Support screw, 4- Anti-fall bayonet, 5- Garage unit.

2.2. Control system

The principle block diagram of the control system is shown in figure 2, in which the position detection module sends the data measured by the angle sensor to the single chip microcomputer. The single chip microcomputer is used to realize the control calculation, obtain the control quantity, drive the motor to move, and realize the intelligent control of the whole system.

3. Hardware design

This system uses STM32F103C8T6 as the main control of the system. In order to achieve system stability during control, the main control board is designed separately. The main control board includes TPS7333 voltage stabilizing circuit, sensor circuit composed of MS5611 and MPU6050, and interface circuit. The TPS7333 voltage stabilizing circuit converts the input voltage to 3.3V to supply power to the single-chip, so that the system is in a stable working state and the system works stably. The sensor circuit detects the actual state of the current platform, which is composed of MS5611 and MPU6050. It transmits the current platform state to the master control in real time through I2C bus [3]. The interface circuit is used as a control connection port for equipment such as motor drivers. It is the overall circuit diagram of the main control board [4] as shown in figure 3.
4. **Software design**

The overall program design flow chart of the system is shown in figure 4. Firstly, the system detects whether a user presses a card fetching button. If the condition is not met, the system continues to detect. If the conditions are met, the system will detect whether there are any vacant parking spaces. If the condition is met, the parking space is allocated and card ejection is carried out, and the corresponding parking space information and card ejection time are stored in the card. After spitting the card, move the door to open, light the red light indoors and prompt to stop the car correctly. Check whether the car is parked correctly, if yes, the system will prompt you to close the car door and leave, if no, the voice will prompt you to park correctly. After the user stops and leaves correctly, manually swipes the card to close the garage door, at the same time, the indoor green light is on, the vehicle is parked, and the task is finished.
After the vehicle enters the storage platform, the system reads the parking space storage information and controls the motor to drive the lifting platform. When the platform is lowered to the designated level, the offset angle between the platform and the designated vacancy is detected and sent back to the single-chip for operation. If the offset does not meet the preset value, control the motor to calibrate the rotation position. Otherwise, the translation vehicle is delivered to the parking space carrier plate, the lifting platform is retracted, and the vehicle storage operation is completed. The flow chart of the control subroutine of the lifting platform is shown in figure 5.

The system will initialize automatically after each parking. When someone swipes the card, the system reads the information, extracts the corresponding vehicle and opens the garage exit door. Then the system detects whether the vehicle has left. If the vehicle does not leave, the voice prompts you to drive away. If the vehicle has left, close the gate and end the mission. The procedure flow chart of taking the car is shown in figure 6.
5. System simulation

After the system design is completed, the control program is downloaded to the main control, which is connected to the computer through serial port. The upper computer is designed by Kingview software to simulate the actual use state. The upper computer is displayed as a man-machine interface. As shown in figure 7, the system is in its initial state. The entrance and exit doors are closed, and all indicators are red.

![Figure 7. Initial state of system](image)

When the car storage button is pressed, the system judges whether there is any free parking space. If the system has spare parking spaces, the system will control the entrance and exit doors to be opened and the door opening indicator lights up as shown in figure 8. The system waits for vehicles to enter and records vehicle information at the same time. On the contrary, it indicates that the parking space is full. After the system is set to open the door for 30 seconds, the vehicle is deemed to have been deposited successfully and the door is closed. The system controls the motor-driven platform to move downwards according to the vacancy situation of parking spaces, and the descending indicator light is green.

Press the platform alignment key, and when the platform reaches the designated position, the photoelectric tube assembly will be activated. At this time, the system starts the transfer motor to transfer the cars in the car box to the parking space as shown in figure 9. The system defaults to 30 seconds to complete the transfer. The system completes the parking process, and the motor drives the car box to move upward to reach the initial position, waiting for the next access command.
The process of picking up the car is the reverse process of storing the car. Firstly, the system judges to take out the vehicle information and find the parking space where the vehicle is located. Then start the motor to reach the corresponding position, transfer the motor to rotate, and take the car out of the parking space. Finally, the car rises and is transported to the exit to complete the car taking process. When the system encounters errors or emergencies, press the emergency stop button, the system ends the current action and returns to the original state to complete the system recovery.

6. Conclusion
The innovation of this system lies in its small footprint, large capacity, safety and environmental protection, which can effectively solve the problem of difficult parking in cities. The system can help people to improve parking speed, especially for novice drivers. It does not need to find parking spaces by itself and can optimize people's travel speed. Compared with the existing three-dimensional garages such as lifting and traversing type, multilayer horizontal circulation type, roadway stacking type and the like, the garage system greatly improves the utilization space, reduces the land occupation rate for the society and saves the land resources.

Acknowledgment
Fund Project: 2018 Teaching Research Project of Anhui Education Department (2018jyxm1082)
2018 "Xinhua-Huichen" Engineering Practice Education Center Project (2019xqjd02)
2017 Scientific Research Project of Anhui Xinhua University (2017zr002)

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