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Smart Shoe Storage Controlled by One-Chip Computer

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Abstract. This product is a smart shoe cabinet, which is designed for domestic shoes storage and brings convenience for families to put shoes. Its mechanical structure mainly includes a drive module, a shoe rack module and a seat module. The electrical control part mainly includes 51 SCM, Raspberry Pi and various sensors. This shoe cabinet adopts a unitized module design. According to the demand of the residents for the shoe cabinet, this Smart Shoe Storage can be combined casually at the users' will and unitized to make it suitable for various apartment types.

1. Introduction

As a storage tool for shoes, the shoe cabinet is one of the most commonly used furniture in the home. During using shoe cabinets, because of traditional shoe cabinets are limited in their types, more and more problems are exposed. The low-type shoe cabinets have limited storage space and the space between its top and the ceiling cannot be used reasonably. The suspended ceiling shoe cabinets are not easy to put shoes due to the height. When the number of shoes becomes larger, it will be difficult for users to sort out them. Because the capacity of the shoe cabinet cannot meet the demand for storing shoes, the phenomenon of random stacking will occur, which will seriously affect indoor hygiene and indoor beauty, even lead to safety accidents.

In the context of home intelligence and automation [1], in order to solve the problems of traditional shoe cabinets and meet people's needs for shoe cabinets, intelligent shoe cabinets have become the best choice. The design and use of smart shoe cabinets has a huge potential market.

At present, most smart shoe cabinets on the market are expensive and have many drawbacks. For example, they just expand the room of shoe cases and use the automatic switch to open and close the door of shoe cases on the basis of the normal shoe cabinets. Also, their function is simple and single. They just design the ozone disinfection and deodorization shoe cabinets with automobile shoeshine because they find that sealed cabinets will result in peculiar smell and mold. However, their products cannot fundamentally solve people's urgent problems. Therefore, people's requirements for smart shoe cabinets are becoming more and more strict, and they hope to use convenient, intelligent and diversified smart shoe cabinets.

2. Function analysis

Based on the above background, a new type of intelligent shoe storage cabinet was designed to automatically pick, place and organize the shoes in the cabinet. The unitized and expandable structure can reasonably arrange the location according to the needs of residents and the actual environment,



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and use the fragmented space at the entrance to adapt to different user's demand to make the most of the shoe cabinet space. When the user returns home, he only needs to put the shoes on the storage platform, and the shoe cabinet can automatically store the shoes to complete its work. When the user goes out, he can choose the required shoes according to the weather and humidity displayed on the App, and then the intelligent shoe cabinet automatically take shoes for its master. Thus, the problem of inconvenience of taking shoes at high or low places is solved. Fig.1 is the model of the shoe cabinet.



Figure 1. Overall smart shoe storage.

3. Design

The smart shoe storage can be structurally divided into a driving module, a shoe rack module and a seat module. The driving module realizes the process of lifting and moving the shoes. The carry shoe board has a certain inclination angle, which saves the storage space of the shoes. The seat can be flipped upwards while opening the cabinet door, providing users with a seat when putting on and taking off shoes, which is convenient and quick.

In addition, the shoe cabinet can be freely combined with shoe rack modules based on the size of the existing family room, the complex layout environment, and the actual needs of the users. The working length of the drive module is matched with the power of the Appropriate power according to the residents' requirements for access efficiency. The device can reasonably use the location of the room and make accessing shoes more convenient.

3.1. The driving module

The movement of the device can be simply divided into two basic movements: the horizontal movement mechanism drives the entire row of carry shoe board to move in parallel, and the lifting mechanism drives the fetch shoes board to complete the lifting movement. The two movements are independent of each other, and the entire access process of the shoe is coordinated through the control module. The device operates simply and efficiently.

The device consists of two stepper motor 2 of the same power working simultaneously to complete the two actions of vertical movement. The two motors are connected by a pulley and a wedge-shaped belt 3. The carry shoe board 1 is consolidated with the belt 3. When moving in the same direction, the wedge-shaped belt 3 will move along the chute with the rotation of the stepper motor 2, thereby completing the vertical movement of the carry shoe board 1 in the vertical direction. When the two stepper motors 2 move in opposite directions, the length of the wedge-shaped belt 3 between the two motors will increase or decrease along the chute with the rotation of the stepper motors 2, thereby completing the left-right movement of the carry shoe board 1 in the horizontal direction. As shown in Fig. 2.

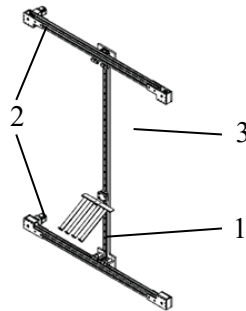


Figure 2. Dual motor drive mechanism.

3.2. The shoe rack module

For the purpose of safety, we check the shoe rack module with the shoe weight of 1kg, so that more shoes can be stably stored on the shoe rack module for a long time [2], and the horizontal and vertical expansion are designed according to actual needs.

3.2.1. The shoe carrier. The shoe carrier is mainly made of aluminum alloy plate [3]. The size is designed as 250mm × 300mm through market research and field measurements. Considering the different shoe sizes of each user, the width of the comb teeth can be adjusted, and comb teeth of different lengths can be replaced to adapt to a variety of shoes of different sizes to meet the requirements of different users.

The shoe carrier is divided into a carry shoe board and a fetch shoe board. The carry shoe board is fixed on the shoe rack, and the fetch shoe board can be freely moved. The carry shoe board and the fetch shoe board are meshed and staggered through the comb-tooth structure, which realizes the function of picking and placing shoes, improves the efficiency of accessing shoes, and saves space for storing shoes.

The left and right sides of the carry shoe board are symmetrical. The two long comb teeth in the middle are used as the main load-bearing connection members. The two short comb teeth on the left / right side provide auxiliary support. The spacing is set at a distance of 100mm to ensure that the shoes can be placed on the carry shoe board smoothly. The short comb length is set to 50mm, which can meet the necessary width range and improve the bending resistance of the outer comb teeth. Its specific structure is shown in Fig. 3.

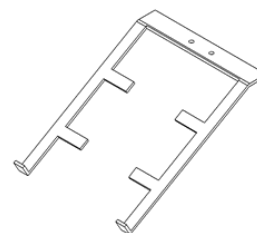
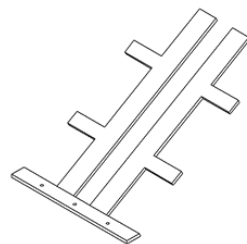


Figure 3. The carry shoe board. **Figure 4.** The fetch shoe board.

The fetch shoe board is a symmetrical structure that is engaged with the carry shoe board. The two comb teeth on both sides are longer as the main load-bearing connection member. The two shorter comb teeth in the middle part provide auxiliary support. The specific structure is shown in Fig. 4.

The surface of the shoe carrier has a certain inclination angle. After the shoes are put on, the shoes will self-locking on the inclined surface without sliding, because the friction angle is set too small. It can further protect the safety of the shoes that placed on the shoe carrier, and prevent the shoes from slipping off accidentally, which affects the normal operation of the shoe cabinet.

When using the shoe cabinet to store shoes, the user first places the shoes on the fetch shoe board. The lifting and moving mechanism drive the fetch shoe board to complete vertical and horizontal movement. After reaching the designated shoe storage position, the fetch shoe board moved in the vertical direction, and the algorithm is used to complete accurate landing. The combs meshed and fall, then the shoes stay on the carry shoe board and the fetch shoe board returned to the starting point.

3.2.2. Shoe rack structure. The shoe rack is mainly composed of aluminum profiles through a corner piece to form a frame structure. The frame structure is the basic load-bearing structure of the entire shoe cabinet, which needs to ensure high strength. The end of the column that touches the ground is fully constrained and is connected to the foundation by anchor bolts. The effective use space of the shoe cabinet is determined by the maximum external dimensions Applicable to the family apartment layout. Considering the display effect and processing cost, the size of this shoe cabinet is 1200mmx450mm, and the height of the column is 1500mm. A schematic diagram of the shoe cabinet frame structure is shown in Fig. 5.



Figure 5. Frame structure.

3.2.3. Combined shoe rack module. The combined shoe rack module uses a single carry shoe board as a basic unit, and can expand the shoe storage position according to the shoe storage needs of users. Considering the actual size of the room, the shoe rack can be extended horizontally or vertically, which can be placed directly in the room, or can be mosaiced in the wall. The entire combined shoe rack module has strong interchangeability, which can be removed and assembled at any time during design.

In order to ensure that each module can complete its functions effectively and with high quality, and is better adapted to various occasions, we adopt adjustable modes in multiple institutions. The process of lifting and moving is required in device. Considering the long lifting stroke of the device, large bearing capacity, and maintenance-free in the later period, we decided to move in a range, using the distance occupied by each grid as the base and take its integral multiple as the moving distance to improves the stability and working efficiency of the device. At the same time, all the motors are hidden inside the machine, which facilitates the protection of the motors and increases the aesthetics.

The device is designed with highly interchangeable parts: the lifting and moving mechanism can adjust its distance by replacing the belt of a certain length. Through changing the longitudinal support column profiles of different lengths, the number of longitudinal carry shoe boards can be adjusted. Replace the transverse support column profiles with different lengths to adjust the number of carry shoe boards in the transverse direction, thereby increasing the number of stored shoes. The installation parts of the device are all standard parts, with strong interchangeability, flexible and convenient use of the user's space.

3.3. The seat module

The seat module provides the convenience for users to wear shoes. It relies on a six-bar mechanism at the bottom to complete the movement with one degree of freedom, and provides the power source through the motor and other original moving parts to complete the switch between the cabinet door and the seat mode.

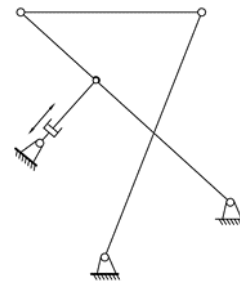
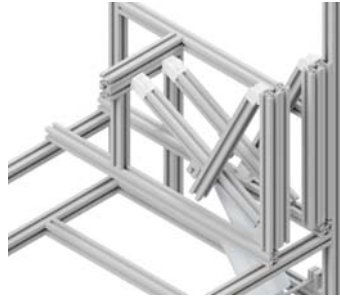


Figure 6. The seat module structure.

Figure 7. Six-bar mechanism diagram.

4. Control system design

This product mainly uses 51 SCM as the main control chip, uses the Raspberry Pi to realize the camera function, and realizes data transmission with the App through the wireless communication module. The power source of the driving device is two 2.8N 57 stepper motors. The TB6600 driver is used to drive the motor to rotate. The single chip computer sends control signals to the driver to control the motor's running direction. The control system is mainly composed of a shoe storage sensor module, an information acquisition module, an App interaction design module, a wireless communication module, a Raspberry Pi camera module [5], and a motor drive control module, as shown in Fig. 8.

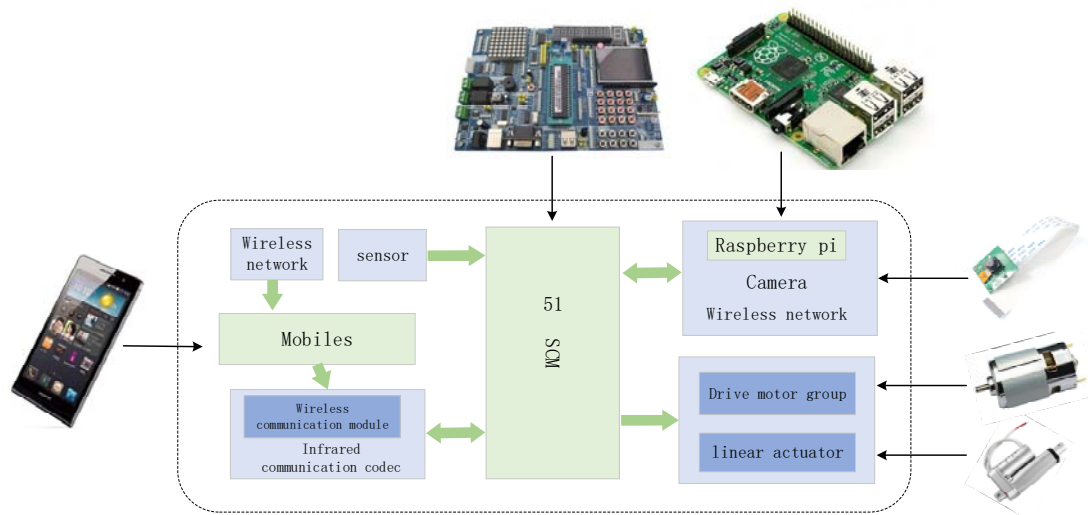


Figure 8. Overall flow chart of control part.

The mobile phone uses the App to communicate with the operator, and obtains weather-related information and real-time shoe cabinet storage information on the wireless network to facilitate the selection of a suitable shoe. The wireless communication module is used to establish a connection with the main controller, that is, the 51 SCM. The 51 SCM recognizes the information sent by the user through codec and performs the specified operation. Fig. 9 shows the homepage of the App.

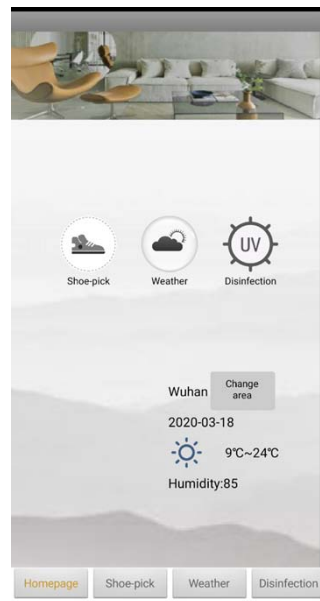


Figure 9. The homepage.

This product mainly involves three functions on the App:

1)Shoe taking: In the shoe taking interface, you need to display the shoe storage situation and corresponding thumbnails in the corresponding unit of the shoe cabinet in the table. When the user enters the shoe taking interface, it must first match the corresponding cell information and refresh, and show real-time shoe cabinet situation. After selecting the corresponding shoe picture, the mobile sends signal to the main controller through wireless communication to perform the shoe-taking operation. Using GitHub as an image storage intermediary, App establishes a web client to set the GitHub corresponding path API URL, extracts the named file stored in the GitHub fixed folder, and finds the corresponding shoe position by distinguishing the corresponding file name, so that the corresponding image can show the real-time shoes in the shoe cabinet. As shown in Fig.10.

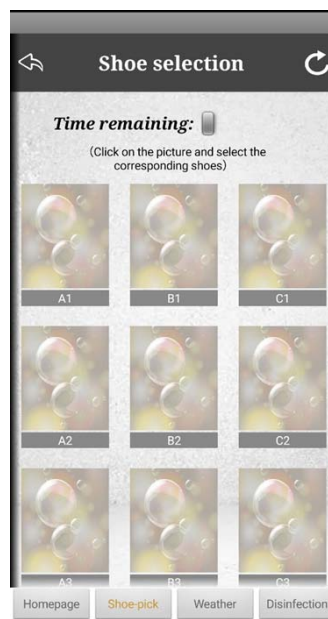


Figure 10. Shoe taking interface.

2) Disinfection: In the disinfection interface, two operations, immediate disinfection and regular disinfection, are designed for users to choose. After confirming the corresponding information, the signal is sent to the main controller through wireless communication to perform the disinfection operation. The device is equipped with an intelligent sterilization system and uses ultraviolet rays to sterilize, which can effectively kill bacteria on the surface and bottom of shoes. As shown in Fig. 11.

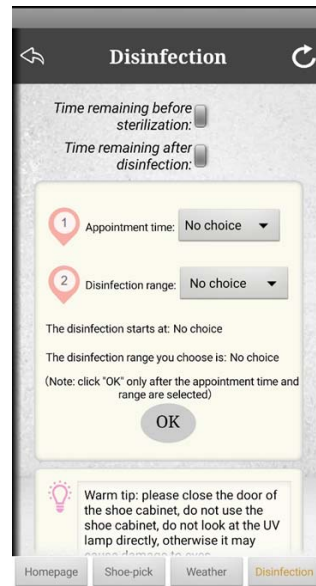


Figure 11. Disinfection interface.

3) Weather: When using the App, the initialization interface can refresh the information and choose the style of shoes according to the weather of the day. Obtain the weather information to be displayed through the API of the specified website, parse the returned JSON text, extract the required information from the list, and display the information at the designated location on the App design interface. As shown in Fig. 12.



Figure 12. Weather interface.

In order to improve the operation feasibility and safety of the shoe cabinet, these electromechanical equipment and control systems have been feasibly designed so that the shoe cabinet can still operate reliably and safely even when individual electromechanical equipment fails. Modular design of the operating electromechanical equipment and control system, taking into account the performance matching and high interchangeability in the design, can be quickly installed, replaced and debugged.

5. Conclusions

Shoe cabinets occupy a non-negligible position in smart homes, but the current realization of shoe cabinets obviously does not reach the ideal expectation. This design realizes the work automatically from putting, organizing and taking out shoes. Above all, it makes easier for the storage of shoes and effectively take advantage of the upper space. It is convenient to operate and is able to enhance the comfort of home life, and effectively solve the problem of messy shoes.

This product exactly corresponds with today's social needs and actually achieves the desired effect. The unique mechanical design mechanism can easily complete the corresponding action without consuming much energy. The precise control system reflects the highly intelligence and improves the user experience. Compared with the existing intelligent shoe cabinet, this device has the advantages of small size, low cost, simple operation and high degree of integration. At the same time, it has the functions of organizing and storing shoes that can be widely used in various families to improve the quality of family life and build a smart home. Therefore, the design has broad Application prospects.

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