Design of an Intelligent Storage Cabinet System based on STM32

Jiahao Zheng[a], Mou Wu[*], Liangji Zhong[b], Guonian Jin[c], Zhiyong Wang[d]

School of Computer Science and Technology, Hubei University of Science and Technology, Xianning 437100, China

[a]2366508578@qq.com, *mou.wu@163.com, [b]41676637@qq.com, [c]750673745@qq.com, [d]99031054@qq.com
Corresponding author: Dr. Mou Wu (mou.wu@163.com)

Abstract. This paper proposes the detailed design of an intelligent storage cabinet system based on STM32. The system includes a control microcontroller, an electronic display screen, capacitive buttons, a temperature and humidity sensor, and a WIFI module, among other measurement and control components. To enhance the users' home living experience, the data system simultaneously uploads information to a cloud platform for real-time monitoring of the temperature and humidity conditions within the storage cabinet. This system design assists households in addressing issues such as the moisture and decay of important paper documents or other items. The system features real-time monitoring of the cabinet's environmental conditions and automatically ventilates and dehumidifies based on the situation. The system also includes remote control functionality through a mobile APP to activate or deactivate the dehumidification and sterilization processes of the storage cabinet. This device enables proper preservation of items and improves people's quality of life. The system incurs relatively low costs and provides a more reasonable solution for the improvement of smart homes.

Keywords: Internet of Things (IoT); sensor; STM32; cloud platform

1 Introduction

Currently, there are issues with moisture, mold contamination, and damage by pests when storing paper documents or other items in regular storage cabinets for a long time. Excessive humidity within the storage cabinet creates favorable conditions for the growth of harmful substances like mold, which can pose a threat to the items and people's health. In the past, people primarily addressed this problem by placing desiccants inside the storage cabinet to dehumidify the items. However, this approach has two inconveniences: the desiccants need regular replacement, and there is a risk of children mistakenly ingesting them. On the other hand, the evaporation of desiccants can also cause certain damage to the items. Prolonged exposure to these chemical agents can also harm people's health. To address this issue, providing people with an intelligent

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storage cabinet that can monitor the storage environment in real-time, automatically adjust conditions, and alert users to the current status is a reasonable solution.

With the rapid advancement of science and technology, there is an increasing demand for higher quality of life. Consequently, an array of intelligent cabinet products has emerged in society, serving various scenarios and providing convenience for storing personal belongings. As the most common household item, storage cabinets face challenges such as dampness, mold, and high temperatures that can damage important paper documents and other items. Therefore, an intelligent storage cabinet that can automatically detect internal factors like temperature and humidity and respond accordingly would meet these demands. The current implementation methods for storage cabinets mainly involve the functionality of temperature and humidity sensors, heating modules, ventilation modules, and communication modules. By connecting to smartphones via WiFi, the control of smart storage cabinets achieves a high degree of convenience and efficiency. This rational approach aims to improve the level of storage conditions and utilize technologies like the Internet of Things for monitoring and management of storage.

2 Related work

An intelligent storage cabinet is a device designed to protect and store items [1-2]. Through intelligent technology, it achieves functions such as automatic opening and closing, intelligent temperature monitoring, and automatic adjustment to ensure suitable environmental conditions inside the cabinet.

Currently, research on intelligent storage cabinets mainly focuses on the following aspects. Firstly, in terms of technological development, the research and development of intelligent storage cabinets center around mechanical design, control technology, and communication technology [3-5]. With the continuous advancement of intelligent capabilities, the development of intelligent storage cabinets has become more mature. For example, Huawei has developed intelligent storage cabinets that support 5G networks, and some manufacturers have also developed cloud platforms for intelligent storage cabinets, enabling remote control.

Secondly, in terms of application scenarios, intelligent storage cabinets are primarily used in industries such as express delivery, hospitals, enterprises, medicine and tobacco [6-8]. As the demand for intelligent living continues to rise, the application scenarios of intelligent storage cabinets are expanding.

Lastly, regarding security, ensuring the safety of intelligent storage cabinets has been a key focus of research because it directly concerns the users' property security [1][9]. At present, intelligent storage cabinet manufacturers employ multiple encryption technologies and security authentication techniques to ensure the security of the cabinets.

3 Relevant technologies and components

3.1 STM32 microprocessor

The main control module shown in Figure 1 uses the STM32F103C8T6 from the STM32 series [10], which is a microcontroller that combines high performance and affordability. It plays a crucial role in the entire system design. This chip features an ARM 32-bit Cortex-M3 CPU with a flash program memory ranging from 64K to 128K bytes. It operates at a clock frequency of 4 to 16MHz and includes a 32kHz RTC oscillator for precise timing. The STM32F103C8T6 offers advantages such as low cost, high performance, and low power consumption.

Within the microcontroller, upper limits for temperature and humidity detection data are set. When the real-time monitoring by the temperature and humidity sensors detects that the data exceeds the upper limits, the system activates the ventilation heating device and exhaust fan for dehumidification. Once the data returns to a safe and reasonable range, the heating and fan operations are automatically stopped to maintain suitable conditions inside the storage cabinet. Additionally, the temperature and humidity conditions inside the cabinet can be monitored in real-time. This enables proper storage, sterilization, and visualization of real-time data for the stored items.

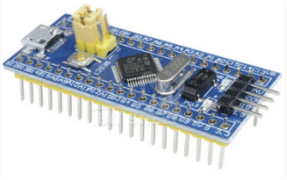

Fig. 1. STM32F103C8T6 module

Fig. 2. ESP8266WIFI communication module

3.2 ESP8266WIFI communication module

The ESP8266 WiFi module [11] has been proven to be the most widely used WiFi module in the market today. It is characterized by its extremely low power consumption and excellent performance. Its advantages include convenience, high efficiency, and reliability. It can effectively support serial connections with multiple mainboards, thus meeting the application requirements in different scenarios. The module also includes a TCP/IP protocol stack, allowing for the connection of experimental devices and external networks through serial interfaces, host computer interfaces, and WiFi interfaces,

thereby providing more reliable communication services. Figure 2 shows the ESP8266 module.

3.3 DHT11 temperature and humidity sensor module

The DHT11 digital temperature and humidity sensor shown in Figure 3 is widely used in environmental monitoring [12]. It has a complex structure, consisting of a set of polymer resistive humidity sensing elements and a set of NTC measurement units. It can monitor real-time changes in humidity indoors and outdoors, providing accurate environmental information. To ensure more accurate testing results, the sensor module is fixed on the inner wall of the storage cabinet.

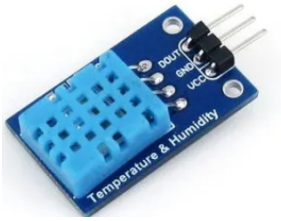

Fig. 3. DHT11 temperature and humidity sensor module

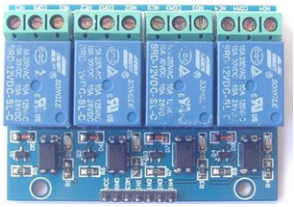

Fig. 4. Four-channel relay

3.4 Four-channel relay, heating, exhaust, and sterilization modules

A four-channel relay is a component used to achieve automatic control and protection of power devices. Its principle is to determine whether the input signal has changed in order to connect or disconnect the control circuit. The cooling function is achieved using a small fan, the heating function is achieved using a heating element, and the sterilization function is achieved using a UV light strip. Figure 4 shows the actual modules.

3.5 Buzzer

A buzzer is an integrated component that converts electrical signals into sound signals. It is widely used in electrical devices. Its principle is based on the periodic vibration of an electromagnetic coil and a magnet to generate sound. It has the advantages of easy installation and simple operation, making it widely used in applications such as alarm systems, computers, automotive electronics, and timers for generating keypress sounds

and alarm sounds. The buzzer used in this design is an active buzzer, as shown in Figure 5.

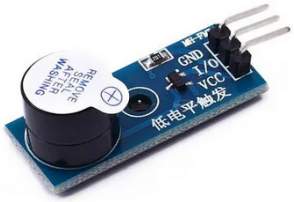

Fig. 5. Active buzzer

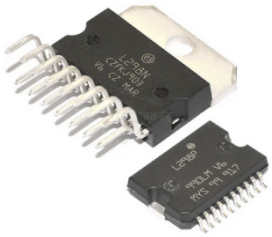

Fig. 6. The motor driver chip L298N

Fig. 7. The SG90 servo motor

3.6 The motor driver chip L298N

The L298N circuit [13] adopts a dual H-bridge configuration for motors, providing high current and voltage capabilities. It can handle currents up to 4A and voltages up to 50V, making it suitable for high-power DC motors, stepper motors, solenoids, and other electronic devices. The L298N chip has powerful functionality, allowing it to drive two bipolar stepper motors or one four-phase motor simultaneously. Its output terminals can be directly connected to a microcontroller, enabling easy control. Additionally, it can adjust the voltage for stepper motors based on different requirements, allowing for automatic forward and reverse movements. Figure 6 is referred for the physical appearance of the chip.

3.7 The SG90 servo motor

A servo motor, also known as a servo drive shown in Figure 7, is a precision positioning device that enables accurate adjustment of various angles or directions. It consists of three connecting devices: a ground wire, a power wire, and a PWM wire. These three connections transmit the PWM signal to the servo motor. The servo motor receives PWM wave signals from a microcontroller. This information is then transmitted to the control system, which adjusts the motor's torque and drives the operation of the potentiometer through a gear reduction mechanism.

4 Software and Environment Setup

To meet the design requirements, we conduct the system design on the One NET cloud platform [14]. This cloud platform offers a wide range of features, including various API interfaces, powerful hardware development tools, and support for multiple communication protocols. For this design, we have chosen to use the WIFI communication method. To make full use of these features, we have selected the ESP8266 WIFI module, and during development, we can directly operate it to connect to the cloud platform.

Moreover, we use App Inventor released by Google to achieve Android APP programming. Its development environment is very easy to build and does not require complex software installation and debugging. Because it uses the browser and cloud service mode, it does not need to download and install various software at all. This greatly facilitates the development of the first hand degree.

5 System design and implementation

The system structure is illustrated in Figure 8 and the main functions of the system are described as follows:

1. The first function is to use capacitive buttons to toggle the door of the smart storage cabinet.
2. The DHT11 temperature and humidity sensor can monitor the temperature and humidity inside the storage cabinet in real-time. If abnormal temperature or humidity is detected, the buzzer will sound an alarm as a notification.
3. The third function is to activate the heating and ventilation features when excessive humidity is detected. During the drying process, the humidity gradually decreases, and when it returns to a normal value, the heating and fan will automatically stop.
4. The fourth function allows for scheduled and manual sterilization using ultraviolet lamps.
5. The fifth function involves using WiFi to communicate with my mobile phone, enabling real-time data viewing and human-machine interaction through the WiFi module on the phone.

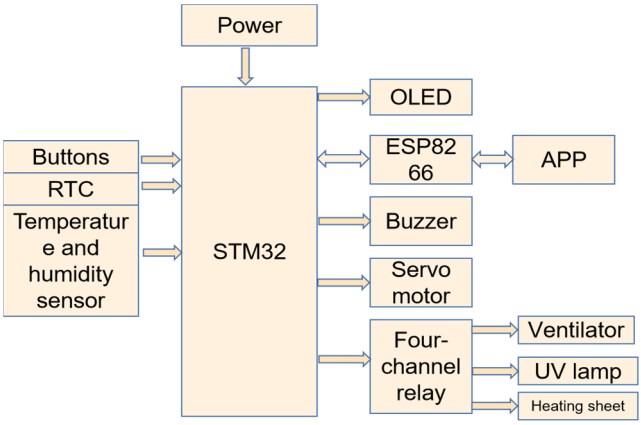

Fig. 8. System structure

6 Experimental results

Fig. 9. Touch button switch

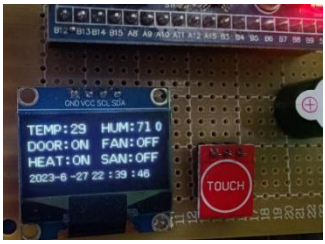

Fig. 10. Heating is activated when humidity is greater than 60

The test results are shown as follows. Firstly, the servo motor can be directly controlled through touch buttons. The display screen shows a '0' for the automatic mode and '1' for the manual mode. In the automatic mode, the system will perform control based on temperature and humidity changes. When the humidity exceeds 60, the heating will be automatically activated. If it exceeds 80, the fan will also be turned on. When the temperature exceeds 35 degrees or the humidity exceeds 80, the buzzer will sound an alarm. Once the temperature and humidity return to normal, the system will automatically turn

off these components. The UV lamp is programmed to automatically turn on at 8 AM and automatically turn off after 20 minutes. Figure 9 to Figure 12 show the experiment result of the automatic mode, while Figure 13 shows the overall system profile.

Fig. 11. Activated fan when humidity is greater than 80

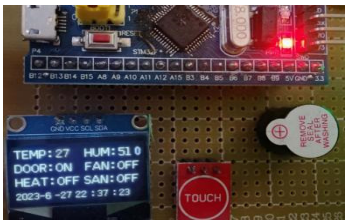

Fig. 12. Automatic shutdown in normal mode

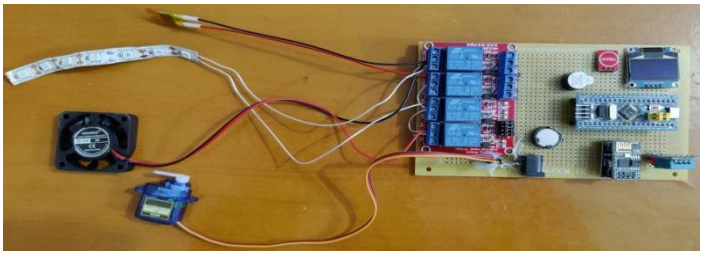

Fig. 13. The overall system profile

7 Conclusion and future work

This system design incorporates functions such as heating, disinfection, and environmental monitoring, demonstrating its intelligence and user-friendliness. However, there are still many shortcomings in this system design. For example, there is a lack of some practical features, which will be improved and updated in the future to address these deficiencies and enhance the system. With the continuous development of science and technology, smart homes are expected to become commonplace in the near future, and smart storage cabinets are a part of this smart home ecosystem. Moreover, people's acceptance of the concept of smart homes will also increase. This will lead to the introduction of more smart home products into ordinary households, providing convenience to people. Additionally, such smart products can also be utilized in public facilities, offering not only convenience but also a great user experience.

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References

1. Zheng, J., & Chen, Z. (2019, November). Research and development of intelligent safe storage cabinet management system. In Proceedings of the International Conference on Advanced Information Science and System (pp. 1-5).
2. Shen, Y., Ge, Y. (2023). Design and Research of a Tower Type Intelligent Storage Cabinet. In: Liang, Q., Wang, W., Liu, X., Na, Z., Zhang, B. (eds) Communications, Signal Processing, and Systems. CSPS 2022. Lecture Notes in Electrical Engineering, vol 872. Springer, Singapore. https://doi.org/10.1007/978-981-99-2653-4_42
3. Guo, P., Shao, J., Tu, J., & Xiong, X. (2021). Intelligent storage and washing integrated cabinet based on sine mechanism. In E3S Web of Conferences (Vol. 233, p. 04025). EDP Sciences.
4. Zheng, Z., Yang, F., Chen, Q., Lee, P., & Wang, W. (2017, December). Design and implementation of intelligent switch cabinet control device. In 2017 IEEE 2nd Information Technology, Networking, Electronic and Automation Control Conference (ITNEC) (pp. 1124-1128). IEEE.
5. Xin, L. I., Xiangfei, M. E. N. G., & Qiming, G. U. (2017, July). Design and Implementation of Intelligent Self Extracting Cabinet Control System. In 2017 International Conference on Electronic Industry and Automation (EIA 2017) (pp. 255-259). Atlantis Press.
6. Wei, B. (2020, January). Research on Current Application of Intelligent Express Cabinet and Its Development Countermeasure. In 5th International Conference on Economics, Management, Law and Education (EMLE 2019) (pp. 807-810). Atlantis Press.
7. Xu, X., & Qian, S. (2023, March). Research on the Design of Medicine Storage Cabinet. In Proceedings of the 2nd International Conference on Information, Control and Automation, ICICA 2022, December 2-4, 2022, Chongqing, China.
8. Han, S., Zhang, J., Wu, Y., Liu, Z., & Zheng, S. (2022, December). Design of a continuous and stable feeding system for cut tobacco storage cabinet. In Proceedings of the 2022 5th International Conference on Algorithms, Computing and Artificial Intelligence (pp. 1-6).
9. Kshash, A. H. (2019). A storage cabinet design for research chemicals for developing nations. Journal of Chemical Health and Safety, 26(4-5), 29-32.
10. Nishitha, K. R., & Vittal Bhat, M. (2022). IoT-based patient health monitoring system using STM32F103C8T6. In Advances in Renewable Energy and Electric Vehicles: Select Proceedings of AREEV 2020 (pp. 247-260). Springer Singapore.
11. Mesquita, J., Guimarães, D., Pereira, C., Santos, F., & Almeida, L. (2018, September). Assessing the ESP8266 WiFi module for the Internet of Things. In 2018 IEEE 23rd International Conference on Emerging Technologies and Factory Automation (ETFA) (Vol. 1, pp. 784-791). IEEE.

12. Novelan, M. S., & Amin, M. (2020). Monitoring System for Temperature and Humidity Measurements with DHT11 Sensor Using NodeMCU. International Journal of Innovative Science and Research Technology, 5(10), 123-128.
13. Yin, L., Wang, F., Han, S., Li, Y., Sun, H., Lu, Q., ... & Wang, Q. (2016, October). Application of drive circuit based on L298N in direct current motor speed control system. In Advanced laser manufacturing technology (Vol. 10153, pp. 163-169). SPIE.
14. Sun, Z., Pan, S., & Yang, L. (2018, November). Remote monitoring system for multiple mobile robot based on OneNet cloud platform. In 2018 Chinese automation congress (CAC) (pp. 3977-3980). IEEE.