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RESEARCH ARTICLE

Design and Implementation of an STM32-Based Smart Medicine Box Reminder System with Multiple Functionalities

Qiyuan Liu[1,*], **Xingdong Wang**[1] **and Yuhua Wang**[1]

[1] School of Information Science and Engineering, Henan University of Technology, Zhengzhou 450100, China

Abstract

Since the 21st century, with the acceleration of people's life rhythm and the increasing number of patients with chronic diseases, taking medicine has become a part of their daily life. This system is based on the design of the smart pill box reminder system based on the single-chip microcomputer, using STM32F103C8T6 as the core of the smart pill box reminder system, which is composed of a button module, an OLED display module, an infrared detection module, a servo module, a clock module and a Wi-Fi module. As a setting module, the user can set the reminder time and dosage of the three pill boxes according to their needs. When the set time for taking medicine is reached, the user will be reminded to take the medicine by voice, and the medicine box will be automatically opened so that the user can take the medicine on time. The system also monitors the amount of medicine taken by the user through the infrared detection module, and the system will send out a voice alarm to remind when taking less or taking more. Through OLED, the current time and the remaining amount of medicine in the medicine box can be displayed, and the user can be reminded to replenish the medicine in time. At the same time, the system can also send the user's medication status to the mobile phone through Wi-Fi for real-time monitoring and management. This design aims at the problem that it is easy to forget to take medication on time in life, and helps users develop the habit of taking medication on time and improve their quality of life through accurate reminders and intelligent management.

Keywords: smart pill box, microcontroller, automatic remind.

1 Introduction

The global aging population is intensifying, and the social pressure on young and middle-aged people is increasing, making it easy for people to neglect taking medication on time. The market for intelligent medical devices is expected to expand rapidly, and intelligent medication reminder systems based on microcontrollers have emerged. The system is based on the STM32F103C8T6 microcontroller and can achieve intelligent control. It has practical and developmental significance and can help patients take medication on time [1].

The current intelligent medical devices have different functions such as intelligent health monitoring,

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***Corresponding author:**
✉ Qiyuan Liu
1561027957@qq.com

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intelligent voice reminders, and intelligent assisted diagnosis and treatment. With the continuous development and progress of society, the proportion of intelligent medical devices in hospitals and family life is increasing. At the same time, people are paying more attention to health issues, and early detection and treatment of diseases are of paramount importance. The continuous advancement of modern technology has made tremendous contributions to the development of intelligent medical devices, especially in assisting doctors in medical diagnosis, point-to-point treatment, disease prevention, and other aspects. The scope of device use has also expanded to include the statistical and analytical analysis of family members' physical data, the integration and sorting of clinical patient teaching data in hospitals, and the teaching situation of medical colleges at home and abroad. Compared with traditional medical products, intelligent healthcare based on IoT technology has the advantages of timely perception, data analysis, and information recognition. Medical devices do not need to rely on traditional methods for diagnosis. Medical products that combine IoT technology can better serve people's health [2]. The intellectualization and modernization of medical equipment lies in the connection between ECG monitoring equipment, personal mobile phone terminals and hospital network system [3], but there are still shortcomings in the development of this field at present, such as less basic research on relevant intelligent medical equipment, lack of connection between home health status information and hospitals or health centers, insufficient evidence of human health data support, too difficult to judge, too large error in the detection of instruments, insufficient credibility, limitations in use and technology to keep pace with the times. Future research can be promoted from the aspect of human data standards. On the basis of this research, relevant human data indicators can be determined, a unified data platform that can be used together can be built according to the Internet, and research and development can be carried out from medical instrument design, product quality control, use and other fields, Research a reasonable and credible data foundation to expand the scope and functionality of product use. The research on intelligent voice medicine boxes in China started late and gradually emerged in big cities in the early 21st century [4]. The development trend of intelligent medical devices is to meet the needs of user groups and meet the increasing emphasis on health in social development. Most electronic medicine box circuits are often composed of discrete digital electrical components, which have fewer functions, but are heavier, larger in size, and consume more power [5]. The current user group hopes that the product's functions will be diversified, intelligent, and the operation will be simpler and more user-friendly. In addition, it is important to pay attention to the competitiveness of the product itself. Products that have made significant progress in human-computer interaction, energy efficiency, and personalized experience are more likely to be accepted by the public. As a bridge connecting the elderly and medication, medication boxes can have a significant impact on the health, medical, and medication experiences of the elderly [6]. For intelligent pill boxes, their functions can be classified into basic functions and subordinate functions according to their nature. Since the basic functions, through the decomposition and combination of the subordinate functions, the intelligent pill boxes can be made more practical and more in line with the needs of the population [7]. With the development of science and technology, the emergence and development of intelligent medical devices not only meet the needs of modern society, demonstrating their practicability and reliability, but also open up new possibilities for the design of future intelligent medical devices. They have huge development potential and broad market prospects.

The main purpose of this design is to implement a pillbox reminder system. A STM32 single-chip microcomputer is created as the core of the system, aiming to remind patients to take their medications on time, ensuring that users can follow the medication treatment more easily and accurately and avoid the aggravation of their conditions or adverse consequences. With the help of microcontroller technology, this system can customize usage details, such as setting the time of taking medications and giving warnings for taking too many pills. Most chronic diseases often require patients to take various medications every day to maintain their conditions, but taking medications can also bring some inconveniences, such as miscounting the number of pills, forgetting to take medications on time, and taking medications in the wrong order [8]. The pillbox reminder system mainly realizes the function of automatic voice reminder for taking medications when it's time. Meanwhile, to ensure that users can take medications more accurately and improve their user experience, functions such as the display of the remaining amount of medications, the function of taking medications on time, and the function of

checking the system status in real time on mobile phones have been expanded.

2 Related Work

The system adopts STM32F103C8T6. It is like a bridge connecting various modules, responsible for the sending, receiving and execution of all data, thus playing a role of linking the preceding and the following [9]. It is combined with the clock module, display module, Wi-Fi module, voice module, servo module, infrared module, key module and power module. The servo is used as an actuator, and it is controlled by the single-chip microcomputer to complete the opening and closing of the pillbox.

This design implements the following functions:

1. Display real-time time (hour, minute, second), timed opening of medication box and voice reminder.
2. By using an infrared module to detect the time for taking medication and combining it with a voice module for voice reminders, it is also possible to detect whether the user has taken medication at the time of taking it.
3. Users can manually rotate the servo to control the opening or closing of the medicine box.
4. Users can connect their mobile phones to the system Wi-Fi module to wirelessly observe the dynamics of the medication box and the remaining dosage.

The overall block diagram of the microcontroller-based medicine box reminder system design is shown in Figure 1, and the circuit schematic is shown in Figure 2.

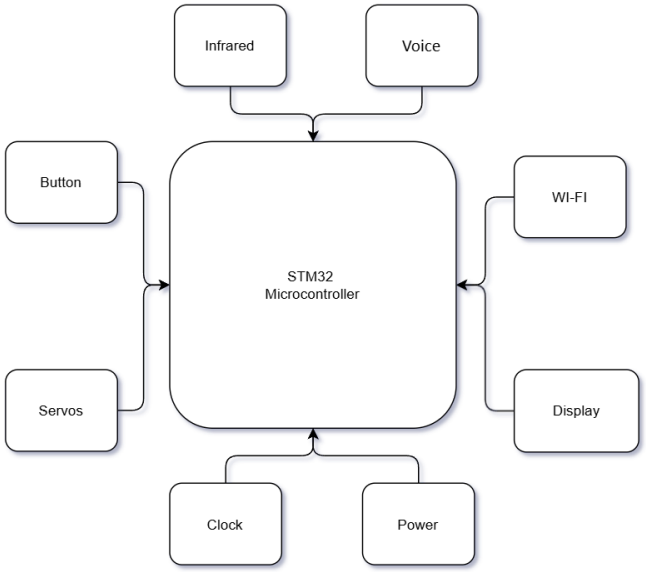

Figure 1. Overall block diagram.

3 System Software Design

3.1 Main Program Design

The design of the intelligent medicine box reminder system adopts modular programming, with the main program as the core, and seven subroutines including clock, buttons, display, Wi-Fi, infrared, etc. are used to assist in operation. The STM32F103C8T6 microcontroller features and optimization algorithms are fully utilized to ensure the perfect operation of system functions and smooth and fast response of the main program [10].When the main program starts, first initialize the OLED screen display function and DS1302 clock chip time function, and then drive the screen display information. The hour, minute and second are presented on the first line of the screen, and the remaining amount of medicine in the medicine box is displayed on the second line. The initial amount of medicine is 999 for each.Next, the STM32 microcontroller continuously scans the button module to determine whether the user has pressed the system button. If no button press is detected, continue scanning; Once the button press is detected, the main program enters the button subroutine and clock subroutine, which work together to set the real-time system time and medication reminder time for the medicine box. Up to three timers can be set.After setting the scheduled time, the system checks whether it is time to take the medicine. If it has not arrived yet, the infrared subroutine detects that the medicine has been taken, and the voice subroutine prompts the voice module to issue a "repeated medicine taking" reminder. In emergency situations, the servo can be manually rotated to open the box; If the scheduled time is reached, the voice subroutine prompts "It's time to take medicine", while the servo subroutine rotates the medicine box clockwise 90°to open.

The infrared subroutine is also responsible for detecting whether the medication retrieval is successful. When unsuccessful, the medication box cannot be closed and will continue to be tested; After success, the OLED display screen corresponds to a decrease in the dosage of the medication box. Press KEY_2 to close the box, and at the same time, the Wi-Fi subroutine sends the medication information to the mobile app. The main program ends running. The entire process is designed rigorously to ensure the accuracy and convenience of the medication reminder

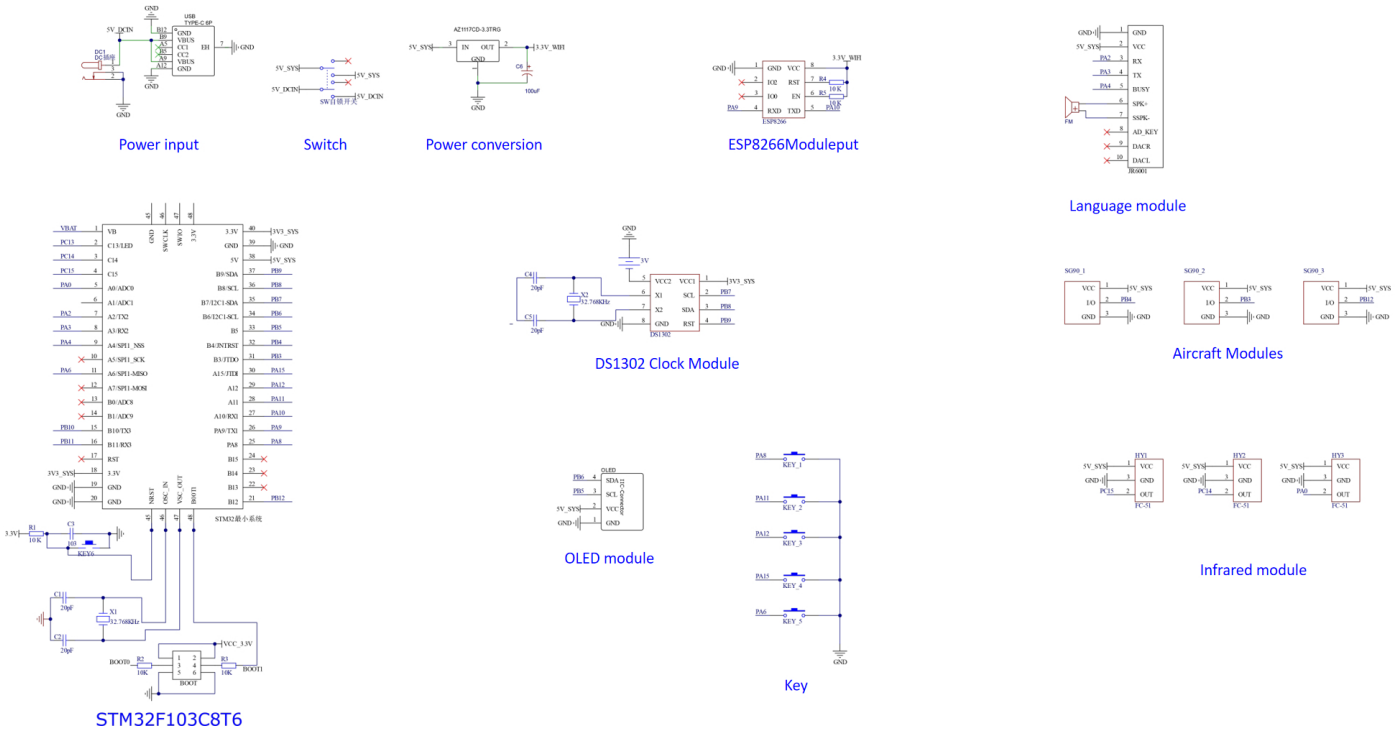

Figure 2. Circuit schematic diagram.

function, providing strong guarantees for users to use medication reasonably. The main program flowchart is shown in Figure 3.

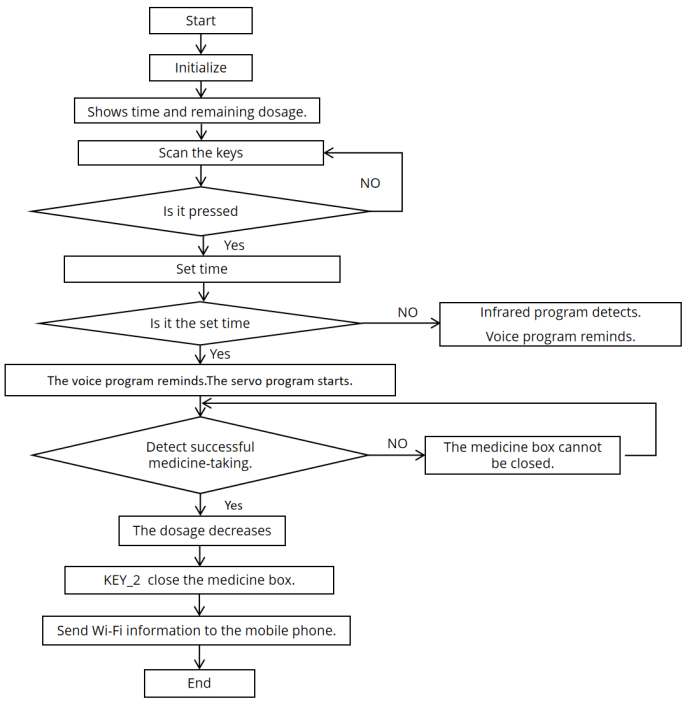

Figure 3. Main program flow chart.

4 System Commissioning

4.1 System function

The main functions of the intelligent medicine box reminder system based on STM32 microcontroller in this design are: setting the system time, and equipping the clock module with a 3.3V button dry battery to ensure that the time still runs when the system is powered off; Timer reminder for medication time, which can set three medication box medication times separately, and remind when the medication time is up; With the help of microcontroller technology, the steering of the servo is precisely controlled. Once the preset medication time is reached, the microcontroller will send instructions to the servo to open the medicine box; Voice reminders will be provided to users when the medication time is up, when the medication time is not up, or when there are too many times to collect medication; Medication amount display: The OLED screen can display the time and the remaining medication amount in the medicine box. When the OLED display screen shows that the remaining medication amount is 0, that is, the remaining medication amount in the medicine box is 0, the microcontroller will send a signal reminder to the voice module, and the voice module will sound "It's time to add medication"; Wi-Fi reminder, using the Wi-Fi module, the phone will automatically connect to the system when the hotspot is turned on, and send

the medication status updates to the mobile app for real-time query and monitoring of medication.

4.2 Initial State Debugging of Medication Box

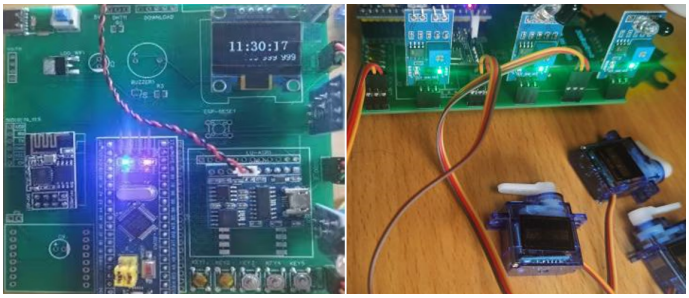

Figure 4. Initial state of medication box.

When the medicine box starts to operate, the power-on time is the current real-time time. The initial state diagram of the system is shown in Figure 4. The power-on lights of the three FC-51 infrared detection chips are lit, indicating that this module can work normally. Both lights on the single-chip microcomputer will light up when powered on. When the reset button is pressed, the real-time time will be paused. On the screen, it can be seen that the first line shows "11:30:17", indicating that the current time is 11:30:17; the second line "999 999 999" indicates that the remaining quantities of medicine in Medicine Box 1, Medicine Box 2 and Medicine Box 3 are all 999 pills. Click the button KEY_1 to enter the initial state time setting mode. Use the button KEY_2 to switch when debugging the hour, minute and second. Utilize the buttons KEY_4 and KEY_5 to add and subtract the time respectively. Click the button KEY_1 again to exit the setting mode, thus completing the setting of the real-time time. Even if the system is powered off, the current real-time time will run relying on the energy of the dry battery, which is convenient so that there is no need to adjust the real-time time again when opening the medicine box next time.

4.3 Setting Medication Timing and Debugging

When using the clock module to set the medication reminder time, during debugging, set the medication time for medication box 1 to "8:30 minutes and 30 seconds". First, press button KEY_3 to enter the medication reminder time setting mode for medication box 1. Use button KEY_2 to switch between hours, minutes, and seconds, and coordinate with buttons KEY_4 and KEY_5 to set the medication time for medication box 1.

The first line of the OLED screen displays the words "08:30:30", which means that the medication time for medicine box 1 is "8:30 minutes and 30 seconds". Then click the KEY_1 button to make the screen display an alarm clock like pattern, which completes the timing setting for medicine box 1. As shown in Figures 5 and 6.

Figure 5. Setting the Timing Time for Medication Box 1.

Figure 6. Completing the Timing Time Setting for Medication Box 1.

In the same way, the medication time for pill box 2 and pill box 3 can be set. During debugging, set the medication time for pill box 2 to "12:30" and the medication time for pill box 3 to "18:30". As shown in Figures 7 and 8.

Figure 7. Completed setting of timing for medication box 2.

Figure 8. Completed setting of timing for medication box 3.

4.4 Adjustment of Medication Reminder Time Upon Arrival

When debugging the system, the medication box 2 is set to 12:30 pm. When the system time reaches 12:30 pm, which is the same as the set medication reminder time, the microcontroller will send a signal to the voice module through the PA2 pin. The speaker connected to the voice module will emit a "It's time to take medication" sound to remind the user to take medication in a timely manner to avoid missing the time and causing adverse effects. Whenever the JR6001 chip emits a sound and works, the indicator light will light up. The status changes of the voice module are shown in Figures 9 and 10.

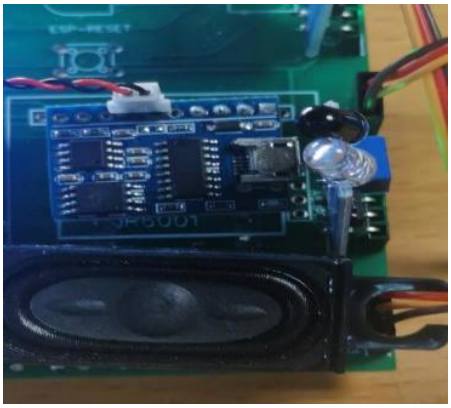

Figure 9. Completed setting of timing for medication box 2.

At the same time, the servo SG90_2 rotates clockwise by 90 ° to open the medicine box, and the servo state changes as shown in Figures 11 and 12.

4.4.1 Normal Medication Dispensing and Debugging

When debugging, set the dosage of each medication to 1. The FC-51 infrared detection chip detects that the user has taken medication through the detection wave emitted by the infrared tube. When one display light on the chip is constantly on, it indicates that

Figure 10. Completed setting of timing for medication box 3.

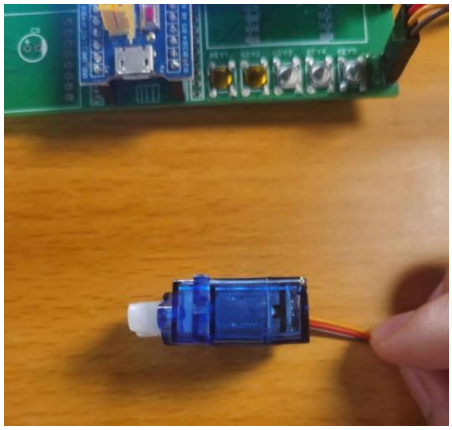

Figure 11. Initial state of servo motor.

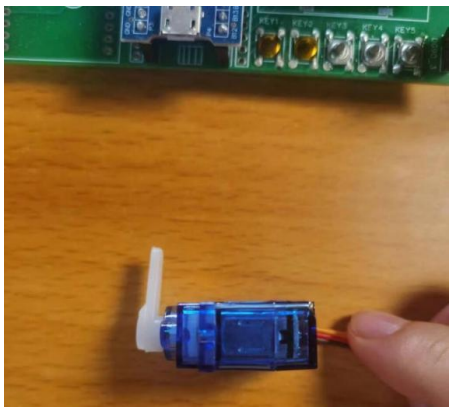

Figure 12. Servo motor drives the opening state of the medicine box.

the infrared detection chip has been powered on, and when the other display light is on, it indicates that the user has been detected. From Figure 13, both the on light and the detection light of medicine box 2 have been lit, indicating that the system has detected that a user is picking up medicine from medicine box 2. Box 1 and Box 3 only have the light on, indicating that the system has not detected the user taking medication.

When finishing the medication collection, press the KEY_2 button to close the medicine box, and the OLED

Figure 13. Medication box 2 detected to be taken.

screen will be as shown in Figure 14. The second line of the OLED screen displays "999 998 999", indicating that one pill has been taken from medicine box 2.

Figure 14. Reduce the remaining dosage of Medicine Box 2 by one.

After the medication is collected, the system will automatically send the medication information to the user's mobile phone through Wi-Fi, and the mobile app will display it as shown in Figure 15.

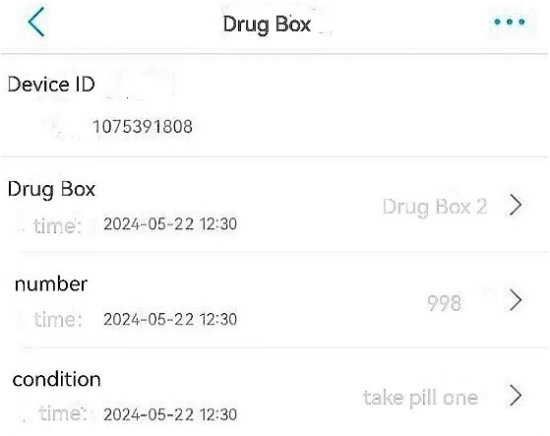

Figure 15. Reduce the remaining dosage of Medicine Box 2 by one.

4.4.2 Repeated Medication Dispensing and Debugging

When the FC-51 infrared detection chip detects that the prescribed number of times medication has been taken out has been exceeded, the voice module will broadcast a "repeat medication" sound to remind the user that the amount of medication taken out has exceeded the normal medication range. The status of the repeated dispensing system is shown in Figure 16. The visible light of the voice module is on, indicating that the voice module is issuing voice reminders.

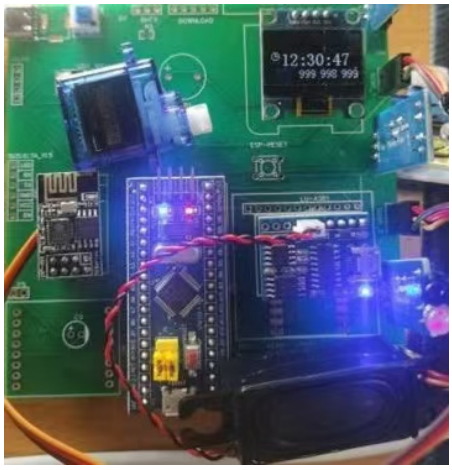

Figure 16. Reports the status of "repeated medication retrieval".

When the FC-51 infrared detection chip detects that the user has taken medication, if the set medication time has not yet arrived, the voice module will play a role by emitting a "repeat medication" sound through the speaker to remind the user that the set medication time has not yet arrived.

5 Conclusion

The medicine box reminder system has significant significance in the development of intelligent medical equipment in today's society. With the acceleration of the pace of life and the increase of life pressure, people's physical exhaustion often occurs, and health is increasingly valued. At the same time, topics related to health are being discussed by people of all ages, and smart medical devices such as smart bracelets and smart blood pressure monitors have emerged. At this stage, some chronic diseases require long-term, multi cycle, and accurate consumption of medication, and traditional medicine boxes that only store medication cannot meet people's needs for timely medication. Therefore, an intelligent medicine box with voice timing reminders to take medication, multiple medication reminders to ensure correct dosage, and mobile phone reception and recording of each medication situation has emerged. The intelligentization and domestication of medical equipment are the trend of the times. With the increasing demand for health, medical equipment will

inevitably begin to gradually move towards the path of intelligentization.

This design has good user experience. The dry battery connected to the DS1302 chip ensures accurate real-time time every time the system is turned on, without the need for further adjustments, reducing the user's workload; At the same time, this design will send the information of each medication, such as the medication box and time, to the mobile app through the Wi-Fi module for timely viewing, avoiding missing important information. Secondly, this design has good safety, and through the coordination of timing module, voice module, and infrared module, it achieves accurate and timely medication reminders, whether users should take medication now, and ensures that users will not consume medication at inappropriate times; When the medication time arrives, the infrared module will detect the number of times the user has taken medication. If the user takes more medication, it will trigger the voice module to remind them, avoiding the user taking more medication than the specified amount; When users need to take medication due to a sudden illness, they only need to rotate the servo to open the medicine box and retrieve the medication, ensuring the safety of users in case of emergencies.

Although the medicine box reminder system is innovative compared to the medicine boxes on the market, it still cannot avoid some limitations. Firstly, battery life is a major challenge at present, and multifunctional integration will inevitably lead to higher energy consumption. Optimizing energy management strategies will be the focus of future improvements. In addition, there is still room for improvement in energy efficiency, network adaptability, and user friendliness of the system.

Conflicts of Interest

The author declare no conflicts of interest.

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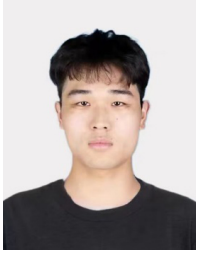

Qiyuan Liu Received the Bachelor of Engineering degree in Communication Engineering from Zhengzhou University of Industrial Technology in 2024. The university is located in Zhengzhou City, Henan Province, China, with the postal code 450100. (Email: 1561027957@qq.com)

Xingdong Wang Currently working at the School of Information Science and Engineering, Henan University of Technology. His current research interests include remote sensing, GIS(geographic information system). (Email: zkywxd@163.com)

Yuhua Wang urrently working at the School of Information Science and Engineering, Henan University of Technology. Her current research interests include Information security, data analysis. (Email: 9109348@qq.com)