RESEARCH PAPER

IoT Based Smart Medicine Box with Biometric Authentication and Emergency Alert System

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***Abstract*—**Non-adherence to medication by the elderly has become a significant health problem. It has resulted in serious health complications, hospital stays, and loss of independence for many older individuals. Traditional medicine storage systems often lack smart reminder functions, monitoring capabilities, and secure access control. This paper proposes a secure smart medicine box that ensures the timely, monitored, and safe intake of medication through an embedded system design. To enhance security, the system uses biometric verification to allow authorized elderly users to access their medicine. In critical health emergencies, such as panic attacks, users may be unable to complete biometric verification. Therefore, the system includes an emergency access feature that unlocks the medicine box and sends an alert to the caretaker when the panic button is pressed. The prototype evaluation demonstrates that the reminders are accurate, the access confirmation is effective, the tablet tracking is precise, the authentication is secure, and the emergency communication is efficient. Therefore, it can be concluded that the proposed prototype of the Smart Medicine Box, which includes intelligent reminders, access verification, tablet tracking, authentication, and emergency features, is a promising solution for managing medication for the elderly.

***Index Terms*—**Smart Medicine Box, Elderly Healthcare, Medication Adherence, Biometric Authentication, Embedded Systems, Internet of Things (IoT), Emergency Alert System, Panic Button Mechanism, Real-Time Monitoring, Healthcare Automation, Secure Access Control, Assisted Living Technology.

I. Introduction

This has led to an increase in the number of elderly patients suffering from chronic conditions, which need long-term medication. However, medication non-adherence has emerged as a major challenge in healthcare services, which has led to severe health complications and has impacted the quality of life. The elderly population often experiences memory loss, poor eyesight, and physical instability, which makes it hard for them to adhere to their medication regimens. The traditional medicine reminder system offers only basic alarm facilities, and intelligent monitoring, security control, and emergency handling are not included. Such medicine reminder systems are not always appropriate for the elderly, particularly those living alone. In many cases, the administration of medicine has to be managed by the caregiver, which may be difficult in the context of the nuclear family structure. This could lead to misuse of medicine, overuse, or unauthorized use. To solve all these problems, recent advances in Embedded Systems Technology, Internet of Things Technology, and Biometric Authentication Technology may be employed to create smart healthcare solutions. The proposed Secure Smart Medicine Box offers audio-visual reminders at scheduled times, real-time detection of access to the medicine box, and automatic detection of usage of medicines. Only authenticated users may access the medicines through biometric authentication. Further, a panic button is provided to access the medicine box in case of an emergency while sending an alert message to the caregiver. Such a system may be used to improve medication adherence, increase patient safety, and enable independence of elderly patients through intelligent automation and healthcare technology.

II. Literature Survey

In recent times, the integration of Internet of Things (IoT), embedded systems, and smart healthcare monitoring technologies has greatly enhanced medication adherence systems for elderly patients. Traditional medicine reminder devices are now smart pill box devices that are able to send reminders

and even allow caregivers to connect remotely. These devices are used to prevent medication non-adherence and ensure patient safety [1][3]. Some studies also focused on human-centered medication adherence technology. One such example is the Adhera system (2025), which proposed the integration of a smart pill organizer and synchronization and reminder technology for caregivers. This system again emphasizes the need for technology and human-centered design for elderly healthcare. An IoT-based smart pill box has been studied extensively by many researchers. In the research article "Pillbox: IoT Solution for Personalized Medication Scheduling" (2024), the authors proposed an Arduino architecture for the smart pill box for providing real-time reminders. In the research article "Smart IoT-Based Pill Reminder," the authors proposed scheduling functionality for the smart pill box. Similarly, other research articles such as "IoT-Based Pill Reminder Monitoring System" and "IoT-Based Pillbox with Caregiver Connectivity" proposed remote notification for caregivers in case of medication non-adherence [4][5]. Recent research has also focused on the use of Artificial Intelligence in medication adherence systems. For example, in the AIMI (2025) study, various machine learning algorithms like LSTM and CNN were used for predicting medication adherence patterns using wearable sensor data. In addition, various meta-analysis research works related to eHealth technologies have shown the potential of intelligent healthcare systems in improving medication adherence [6][7]. Other research works have shown various aspects of cloud computing and analytics in smart healthcare devices. Various smart medicine box systems have used various technologies like RFID for user authentication, sending emergency alerts via GSM and SMS protocols, and emergency alert systems. However, various smart medicine box systems have not used robust biometric security and emergency alert systems for handling emergency conditions in elderly patients.

The existing literature has improved the existing IoT-based medication reminder and caregiver monitoring systems. However, the existing systems fail to include biometric security and emergency access in one system. The Smart Medicine Box system will include reminders, medicine tracking, biometric security, and emergency panic alerts.

III. Existing Systems

Recently, various smart medicine reminder systems have been proposed to assist elderly patients and patients with chronic illnesses in adhering to their medication schedules. Most of these systems are based on simple microcontroller-based schemes that offer basic reminder functionality. Although these systems are useful in reminding patients to adhere to medication schedules, they lack many of the advanced features required in a smart medicine reminder system. Most of the electronic pill boxes proposed in previous works are based on a timer-based reminder mechanism and are not capable of monitoring whether or not the patient is actually taking the medicine. Similarly, most of the proposed IoT-based pill boxes are not capable of accurately monitoring the quantity and dosage of medicine being consumed. Moreover, most of these systems are not compact and are not efficient in terms of power consumption. As a result, there is a significant need to design a more advanced smart medicine box that is capable of offering various benefits in a compact and efficient design.

TABLE I
Summary of Important Methodologies Used in Reviewed Papers

Paper Name	Methodology Used
Pillbox: IoT Solution (2024)	Arduino-based IoT architecture using sensors and GSM module to generate scheduled reminders and send SMS alerts to caregivers.
Smart IoT-Based Pill Reminder (2024)	Microcontroller-based system implementing real-time clock scheduling with automated reminder alerts for medication management.
IoT Pill Reminder and Monitoring (2024)	IoT-enabled pillbox integrated with mobile applications for remote monitoring and missed-dose notifications.
IoT Pillbox with Caregiver Connectivity (2025)	Embedded IoT system sending real-time alerts to caregivers using wireless communication and cloud-based monitoring.
AI Medication Adherence System	Smart pillbox system integrating IoT sensors and data analytics to monitor medicine usage patterns and generate alerts.
Smart Drugs – IoT Pill Box	IoT-based medicine reminder system integrating sensors, GSM communication, and monitoring modules for improved adherence.
Smart Medicine Box with SMS Alert	Embedded system using buzzer alerts, GSM communication, and authentication mechanisms to ensure timely medication access.
Smart Automatic Drug Dispenser (2025)	Automated medicine dispensing mechanism with scheduled pill release, alarm reminders, and emergency notification support.
Adhera Smart Pill System (2025)	Human-centered medication adherence framework integrating smart pill organizer, reminders, and caregiver monitoring dashboard.

TABLE II
Comparison of Existing System and Proposed Smart Medicine Box

Existing System	Proposed Implementation
Basic buzzer or LED reminder	Scheduled alarm with repeated alerts and LED indication
No confirmation whether medicine is taken	Magnetic sensor detects box opening to confirm access
No monitoring of remaining medicines	Tablet count monitoring to track medicine availability
No access restriction	Biometric fingerprint authentication for secure access
No emergency support	Panic button with instant alert to caregiver
Standalone reminder device	Integrated system with reminder, monitoring, and security

IV. Proposed System

A. System Overview

The proposed Smart Medicine Box with Biometric Authentication and Alert System is a safe and efficient way to manage medications for elderly patients. The system combines medication reminders, medicine monitoring, and emergency alerts in a single intelligent system. The system is created

using a microcontroller-based embedded system that manages all the components of the system, which include alarm modules, LED indicators, medicine detection sensors, tablet monitoring systems, biometric authentication modules, and panic buttons. The system can send reminders to patients to consume their medications. Once the time to consume medicine is reached, the system will send out an alarm and LED indicator to remind patients to consume their medications. The system will then use a sensor to detect whether the medicine box is open to confirm whether patients have accessed their medicine. The system will also monitor the number of tablets to monitor medicine usage. In order to increase security, there is the use of biometric fingerprinting so that only authorized individuals can access the medicine box. In emergency cases, there is the use of the panic button to allow for emergency access.

Overall, the proposed system is a reliable and intelligent solution for improving medication adherence, safety, and independent living for elderly patients.

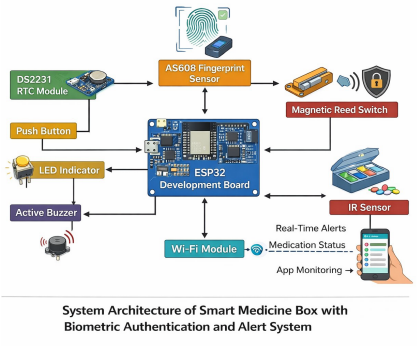

Fig. 1. System Architecture of Smart Medicine Box

B. System Architecture

The architecture of the proposed Smart Medicine Box with Biometric Authentication and Alert System is organized into multiple functional layers that work together to ensure secure, timely, and reliable medication management for elderly users. Each layer performs a specific role in the overall operation of the system, as illustrated in Fig. 1.

1) **Input and Configuration Layer:** This layer enables the user or caretaker to configure the medicine schedule using button inputs. The Real Time Clock (RTC) is used to keep track of time, and the time is stored in the microcontroller.
2) **Control and Processing Layer:** The microcontroller, such as ESP32 or STM32, is responsible for all operations. It compares the stored time with the actual time using the Real Time Clock and sends out reminders while monitoring the status of the medicine box.
3) **Reminder and Alert Layer:** This layer consists of the buzzer and LED. When the time matches the stored time, sound and light are used to send out reminders to the user.
4) **Monitoring and Detection Layer:** Sensors, such as the magnetic reed switch, are used to check if the medicine box is opened. The tablet monitoring system is used to keep track of the number of remaining tablets.
5) **Security and Authentication Layer:** Biometric fingerprint scanning is used to allow only authorized users to access the medicine compartment.
6) **Emergency Communication Layer:** A panic button is available in case of emergency. The button unlocks the box and sends an alert message to the caretaker via Wi-Fi.

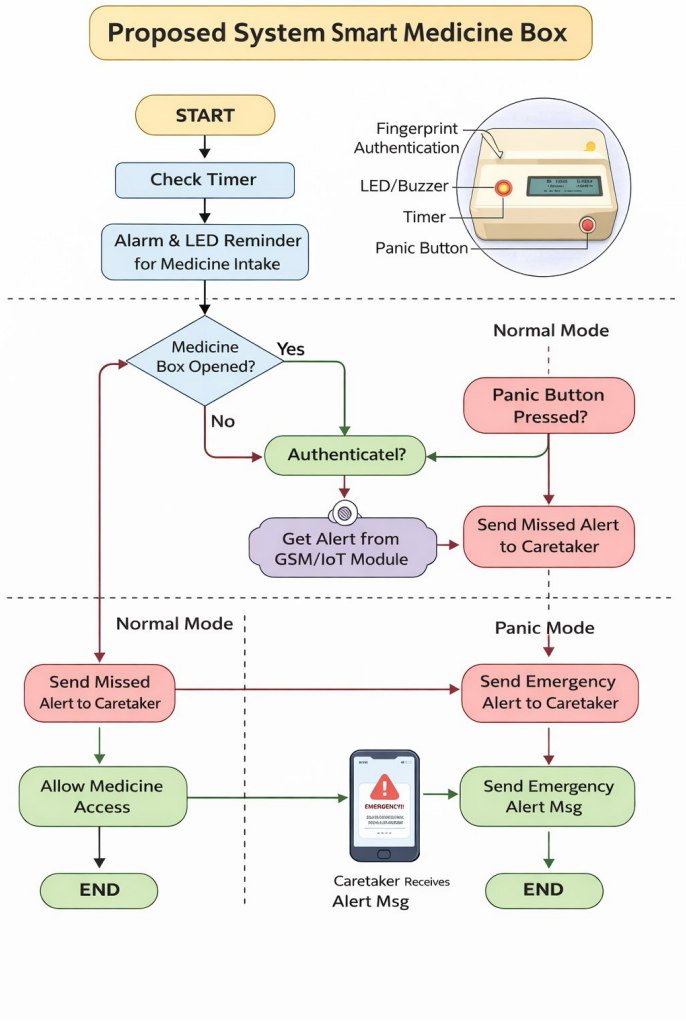

Fig. 2. Data Flow Diagram (DFD)

C. System Modules

The proposed system is divided into four major functional modules that collectively ensure accurate medication scheduling, automated dispensing, real-time monitoring, and user-friendly interaction.

- **Module A – Reminder and Scheduling Module:** This module uses the Real Time Clock (RTC) to control the

medicine schedule. The user can set the reminder time using the push buttons. When the time arrives, the buzzer and LED will remind the user to take the medicine.

- **Module B – Monitoring and Detection Module:** This module will keep track of the medicine usage. A magnetic reed switch will be used to detect whether the medicine box has been opened or not. Also, the number of tablets remaining in the compartment will be tracked.
- **Module C – Security and Authentication Module:** A biometric fingerprint sensor will be used to ensure that the elderly person alone uses the medicine box, and children or others cannot misuse the medicine box.
- **Module D – Emergency Alert and Communication Module:** This module will contain a panic button, which will be used in case of emergency. When pressed, the message will be sent to the caretaker through the Wi-Fi communication module.

D. System Advantages

- Provides secure access via biometric fingerprint recognition.
- Prevents unauthorized access or misuse of medicine.
- Offers automatic buzzer and LED indications for scheduled medicine reminder times.
- Uses sensor detection to check for opening of the medicine box and medicine use.
- Sends emergency messages to caregivers via Wi-Fi communication.
- Enhances the safety of medicine use for elderly patients.

E. Summary

The concept of **the Smart Medicine Box with Biometric Authentication and Alert System** fills the gap between conventional medication reminder systems and advanced intelligent healthcare automation systems. The concept incorporates embedded systems, biometric authentication, automated medication systems, sensor detection systems, and wireless monitoring systems to ensure the safe, accurate, and timely management of medication. The solution improves patient safety through fingerprint authentication, timely alerts, medication verification, and caregiver notifications. It also improves patient compliance with medication, restricts unauthorized access, and enables continuous patient monitoring. Overall, the proposed solution offers a safe, reliable, and intelligent medication management solution with improved safety, accountability, and patient care.

V. Implementation Technology

The proposed Smart Medicine Box system will utilize the Internet of Things (IoT), embedded systems technology, biometric technology, and wireless communication technology. The proposed system aims at ensuring that the elderly consume their medication on time while at the same time ensuring the safety of the elderly in the event of an emergency. The proposed system implementation includes the use of intelligent monitoring, reminder technology, and access control technology for the prevention of misuse of medication. The proposed system includes different technological components.

TABLE III
Dataset Details Used for System Monitoring and Analysis

Source	Records	Format	Type	Processing Steps
Medicine Schedule Data	1,200	Digital Logs	Text	Data Structuring, Time Scheduling
Sensor Monitoring Data	900	IoT Sensor Logs	Numerical	Data Filtering, Timestamp Alignment
User Reminder Records	700	Notification Logs	Text	Event Tracking, Alert Generation
Medicine Usage History	500	Device Storage Logs	Mixed Data	Pattern Analysis, Data Cleaning
Total	**3,300**	**Structured**	**IoT + Text**	**Processed Dataset**

1) **Medication Reminder System** The system utilizes the Real-Time Clock (RTC) to keep track of the time and remind the user to take their medicine. The user will be alerted to take their medicine at the set time, and the reminder will be repeated several times to ensure the user does not forget.
2) **Medicine Access Detection** The system will utilize a sensor to detect the opening of the medicine box and confirm medicine access. The system will also detect the number of remaining medicine tablets and remind the user to refill the medicine when the level goes low.
3) **Biometric Authentication System)** The system utilizes the fingerprint sensor to ensure the user has access to the medicine box. Only the user will be allowed to access the medicine box, and children will be restricted from accessing it.
4) **Emergency Alert Communication System** There is an emergency panic button available in this system, which can be pressed in emergency cases. The system instantly sends an alert message to the caretaker via Wi-Fi/GSM communication.
5) **Embedded System Control and IoT Integration** This system is operated using a microcontroller. IoT devices are integrated into this system.

The proposed system architecture supports modular scalability, meaning the components, such as the sensor, microcontroller, notification system, and monitoring interface, will operate independently. Secure IoT protocols allow for smooth communication between the hardware device and the cloud. The system can be implemented with microcontrollers such as the Arduino or ESP boards, and the cloud will be used for data storage, with web technologies providing an easy interface.

A. Data Privacy and Security Considerations

The Smart Medicine Box system has been designed with robust privacy and security features to ensure the security of critical information. The biometric authentication process ensures that only the right individuals can access the medicine schedule and the medicine box. The data, including the biometric data and the medicine information, has been secured

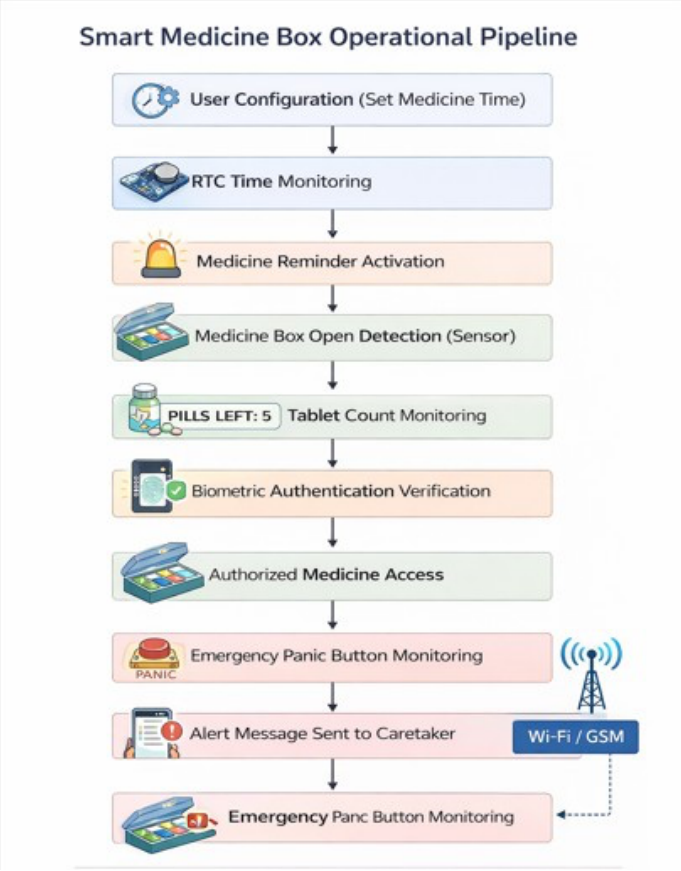

Fig. 3. Smart Medicine Box Operational Pipeline

with AES 256 encryption. Similarly, the data transfer has been secured with TLS 1.3.

For data integrity, cryptographic hash functions like SHA 256 are used to ensure data integrity against any tampering. The system also has the capability to log data, such as authentication, box open, reminders, and emergency alerts, which ensures the safe handling of data and the operation of the system.

VI. Experiments

The proposed Smart Medicine Box with Biometric Authentication and Emergency Alert System was tested with several functional experiments to validate the system's performance. The system's performance was tested with regard to several functions such as the reminder function, opening detection function, authentication function, and emergency alert function. The reminder function was tested by setting the time for the medication schedule using the Real Time Clock (RTC). The system will then send an alarm when the time is due. The alarm will repeat three times to ensure that the user is reminded of the time.In order to verify the medicine intake monitoring, the sensor was utilized to detect the opening of the lid of the medicine box. The experiment was performed multiple times, which confirmed the sensor's ability to detect the opening of the box and the successful recording of the medicine intake. The biometric authentication module was tested using registered and unregistered fingerprints. The system was successful in granting access to the registered user and denying unregistered fingerprints. This confirmed secure access to the medicine box. The emergency alert was tested by pressing the panic button attached to the medicine box. The system was successful in sending the alert notification to the caretaker immediately. The experiment confirmed the successful functioning of the proposed system in assisting the elderly in the safe use of medicine.

A. Experimental Results

The result of the experiment proved that the proposed Smart Medicine Box with Biometric Authentication and Emergency Alert System is effective in assisting the elderly in the management of their medication. The reminder system was also tested with different medication schedules with the Real Time Clock (RTC). The system was able to send reminders and alarms at the specified time with a high accuracy level of about 96%. The repeated alarm system was also effective in allowing the user to pay close attention to the sent reminders and avoid forgetting to take their medication. The medicine access monitoring module was tested with the sensor used in the lid detection. The sensor was able to detect the opening of the medicine box with an accuracy level of about 95%, thus monitoring if the user took the medicine at the scheduled time or not. The module is effective in monitoring the use of medicine by the patient and ensuring that the patient takes the medicine. The biometric authentication module was tested using registered and unregistered fingerprints. The fingerprint module was able to restrict access to the medicines to the authorized persons with an accuracy of 93%, thus preventing the misuse of the medicines by other people, such as children. In addition, the emergency alert system was tested under simulated emergency conditions. When the panic button was pressed, the emergency alert message was sent immediately to the registered caretaker device. The average time taken to send the emergency alert message was within a few seconds. Based on the experimental evaluation, the proposed system was effective in providing reminder alerts, secure biometric access, medicine monitoring, and emergency alerts. This proves that the smart medicine box would be useful in assisting elderly patients in adhering to their medication schedule.

VII. Conclusion

The proposed Smart Medicine Box is a solution to the problem of managing medication with the help of advanced technologies like IoT, sensors, and reminders. It will help the patient take the medication on time with the help of alarms, notifications, or apps. It will also help the patient monitor the usage of the medicine and the correct intake of the medication with the help of reminders. The experimental implementation of the system has proved that the Smart Medicine Box is a solution to the problem of missed doses of medication and the correct intake of the medication with the help of reminders, minimizing the chances of human error in the correct management of the

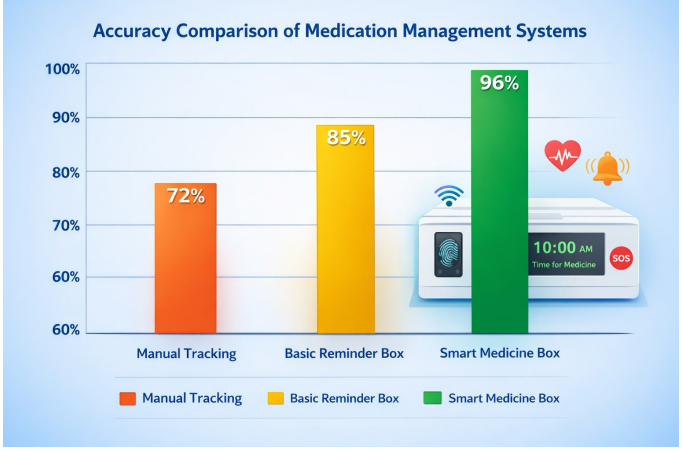

Fig. 4. Accuracy Comparison Graph

patient's health. Additionally, the system may be useful for the elderly, those with chronic diseases, and for those who need to take several medications per day. In the future, the Smart Medicine Box may be connected with health applications, cloud databases, and hospital management systems to offer real-time monitoring and medical services, thus increasing safety for patients, efficiency in healthcare, and the development of smart healthcare services.

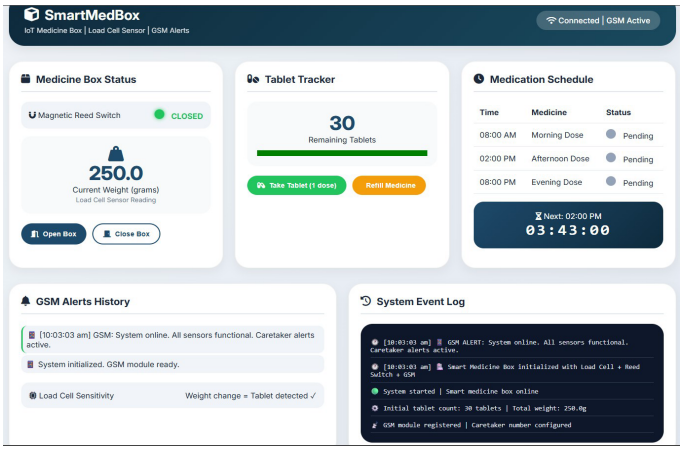

Fig. 5. Dashboard of Smart medicine box

VIII. Future Enhancements

Although the proposed Smart Medicine Box with Biometric Authentication and Emergency Alert System is an effective solution for medicine management, several enhancements can be made to increase the capabilities, reliability, and usability of the system in the real world. Some of the possible enhancements that can be made in the future include the incorporation of other biometric sensors, such as face detection or iris scanning, along with fingerprint sensors. This ensures the security of the system, allowing only the authorized users to access the medicine compartments. The system could also be improved by integrating cloud-based storage services and healthcare systems, which would allow doctors, caregivers, and family members to monitor the patient's medication in real time. For instance, the system could send notifications to the caregivers if the patient is missing a scheduled dose of medication, thus improving the management of the patient's health. Another possible way the system could be improved is by using artificial intelligence and data analysis tools to analyze the patient's medication habits and forecast possible risks to the patient's health. For example, the system could provide the patient with reminders and recommendations on the appropriate amount of medication, as well as warnings about possible medical conditions. In addition, the system could also be improved by incorporating wearable technology, such as smart watches, that would enable the system to monitor the patient's health status and send emergency messages in case of abnormal health conditions. Additionally, future versions of the Smart Medicine Box could include GPS technology that would enable emergency messages to be sent in critical health conditions. This would be useful in emergency situations involving the elderly, especially if they live alone. From a technological point of view, the battery life of the device could be improved, in addition to incorporating solar power that would make the device more user-friendly. Additionally, the device would be user-friendly if it were compact and portable. Moreover, incorporating robust security mechanisms would ensure that sensitive medical information is not compromised. Lastly, pilot implementations in various healthcare environments would help in evaluating the performance of the system. This would enable further improvements that would help in transforming the Smart Medicine Box into a trusted smart healthcare system.

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