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Pill-Pal: The Smart Medication Companion

An IoT and AI-Based Smart Medication Management System

Sowmya C G
Department of Biomedical Engineering
ACS College of Engineering
Bengaluru, India
sowmyacg.bmi@gmail.com

Chaitra Gubbi
Department of Biomedical Engineering ACS College of Engineering Bengaluru, India
chaitragubbi@gmail.com

Nandika BU
Department of Biomedical Engineering
ACS College of Engineering
Bengaluru, India
nandikabu44@gmail.com

Vidya Hegde
Department of Biomedical Engineering
ACS College of Engineering
Bengaluru, India
vidyahegde2305@gmail.com

Abstract

Medication non-adherence is a major problem among elderly patients, Alzheimer's patients, and people living in rural and hilly regions. Forgetting to take medicines on time can lead to serious health complications. This paper presents the design and development of a Smart Pill Box with Voice Alert System that reminds patients to take medicines at scheduled times using audio alerts and visual indications. The system is built using a microcontroller, real-time clock (RTC), speaker module, and IoT connectivity for remote monitoring. The device is designed to be low-cost, portable, and user friendly. It can be particularly useful for rural healthcare applications where continuous supervision is not possible. The proposed system improves medication adherence, reduces human dependency, and enhances patient safety.

KEYWORDS

Smart healthcare, Medication adherence, IoT, Voice alert, Elderly care, Rural healthcare.

INTRODUCTION

Medication adherence is a critical factor in effective healthcare management. Patients are often required to follow strict medication schedules to ensure proper treatment outcomes. However, maintaining consistent adherence to prescribed medication regimens remains a major challenge worldwide. Studies indicate that a significant percentage of patients fail to take their medications on time, skip doses, or take incorrect dosages. This problem is particularly common among elderly individuals who may suffer from memory loss, cognitive decline, or complex medication schedules involving multiple drugs.

In addition to age-related challenges, lifestyle factors such as busy daily routines, lack of awareness, and insufficient caregiver support also contribute to poor medication adherence. The issue becomes even more severe in rural areas where access to healthcare professionals and regular medical supervision is limited. Patients in such regions often rely on manual pill organizers or written reminders, which are not always reliable. As a result, missed doses, accidental overdoses, and irregular medication intake can occur, potentially leading to serious health complications, prolonged illness, or hospitalization.

Technological advancements in embedded systems and Internet of Things (IoT)

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technologies provide new opportunities to address these challenges. Smart healthcare devices can assist patients in managing their medication schedules more effectively while also allowing caregivers and healthcare providers to monitor adherence remotely. In this context, the development of intelligent medication reminder systems has gained increasing attention.

To address the problem of medication non-adherence, this paper proposes a Smart Pill Box with Voice Alert. Unlike traditional pill organizers, the proposed system integrates electronic components, voice alerts, and IoT connectivity to provide automated and interactive reminders. The system is designed to notify patients through voice messages and alarms at scheduled medication times, ensuring that medicines are taken at the correct time and in the correct dosage. The use of voice alerts makes the device particularly suitable for elderly users who may have difficulty reading small text or remembering alarm meanings.

Furthermore, the integration of IoT technology enables remote monitoring of medication intake. Caregivers or family members can track whether the patient has taken the prescribed medicine on time, thereby improving patient safety and reducing the risk of medication errors. The system is designed to be cost-effective and user-friendly, making it suitable for deployment in rural and resource-limited environments.

The main objectives of this project are as follows:

1.To design and develop a low-cost smart medication reminder system that can assist patients in maintaining their medication schedules.
2.To provide voice-based alerts and alarm notifications that are easy for elderly users to understand and follow.
3.To enable remote monitoring using IoT technology, allowing caregivers or healthcare providers to track medication adherence.
4.To improve healthcare support in rural areas by providing an affordable and accessible smart healthcare solution.

The proposed Smart Pill Box aims to enhance medication adherence, reduce health risks associated with missed or incorrect doses, and provide better support for elderly patients and individuals living in remote areas

METHODOLOGY

The proposed system integrates a Smart Medicine Box with an AI-based voice chatbot to ensure timely medication intake and provide interactive assistance to users. The overall methodology follows three major stages: input sensing, centralized processing, and output response, which together enable automated medication reminders, pill dispensing, monitoring, and caregiver notification.

The Smart Medicine Box begins with the input sensing stage, which includes IR sensors, a Real-Time Clock (RTC) module, and servo motors. The IR sensors are positioned near each pill compartment to detect whether a pill has been removed by the user. When the pill is taken, a change in infrared reflection is detected and transmitted to the Arduino microcontroller. The RTC module maintains accurate timekeeping and continuously provides scheduling information for medication reminders throughout the day. Based on the scheduled time provided by the RTC, the servo motors automatically open the corresponding pill compartment, allowing the user to access the required medication easily.

The processing stage is managed by the Arduino UNO, which acts as the central controller of the Smart Medicine Box. It continuously reads time data from the RTC module and monitors the status of the IR sensors to verify whether the medication has been taken. When the scheduled time matches the predefined medication schedule, the Arduino activates the appropriate servo motor and triggers reminder notifications.

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In addition, it coordinates communication with other output modules such as the LCD display, DF Player Mini, speaker module, and GSM module, ensuring synchronized operation of the entire system.

In the output stage, the system provides both visual and audio reminders to assist the user. A 16×2 LCD display shows important information such as the current time and reminder messages like "Take Morning Medicine." Simultaneously, the DF Player Mini and speaker module generate voice alerts that clearly instruct the user to take the medication. If the system detects that the pill has not been taken within the specified time window, the GSM module sends an SMS notification to a caregiver or family member, indicating that the scheduled medication has been missed. This feature enables remote monitoring and enhances patient safety.

The system also includes an AI-based voice chatbot module that allows users to interact with the device through voice commands. The interaction begins when the user presses a tactile button to start recording. The INMP441 I2S MEMS microphone captures the user's speech and sends the digital audio signal to the ESP32-S3 microcontroller through the I2S communication protocol. The ESP32-S3 then connects to a Wi-Fi network and transmits the recorded audio to an external AI server for processing.

The AI server performs tasks such as speech recognition, natural language processing, and response generation. After processing, the server returns a synthesized audio response to the ESP32-S3. The microcontroller then displays system status messages such as "Recording," "Processing," or "Speaking" on the LCD display. The audio response is transmitted through the I2S interface to the MAX98357A audio amplifier, which amplifies the signal and outputs it through the speaker, allowing the user to hear the AI-generated response clearly.

Overall, the proposed methodology combines sensor-based monitoring, embedded system control, wireless communication, and cloud-based artificial intelligence to create a reliable and user-friendly healthcare support system. This integrated approach improves medication adherence, reduces the risk of missed doses, and provides interactive assistance for users who require continuous medication management.

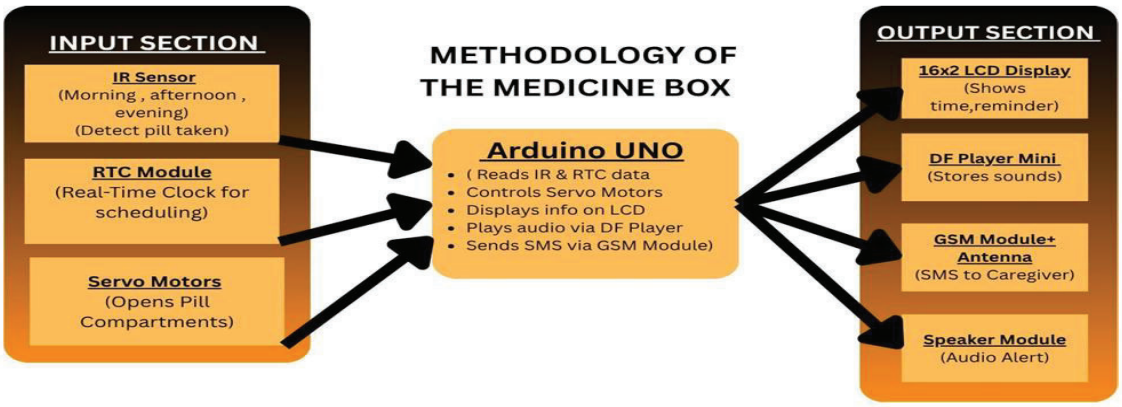

Figure 1: Block Diagram of Methodology of medicine box

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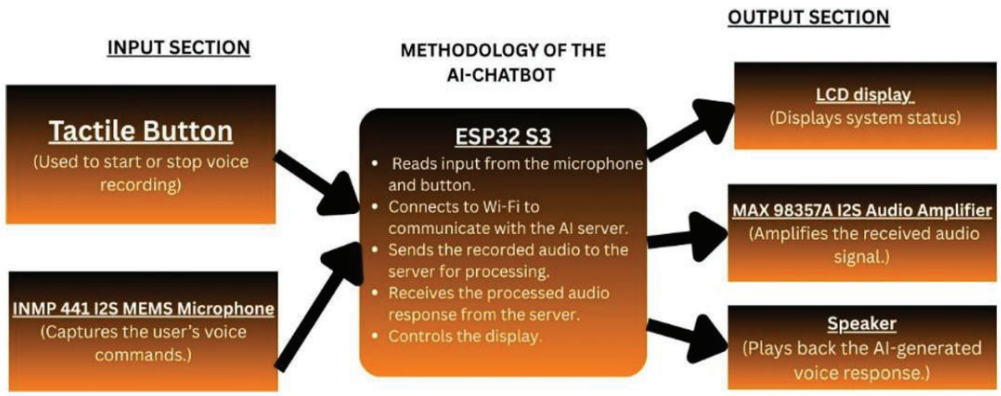

Figure 2: Block Diagram of Methodology of AI-CHATBOT

RESULT AND DISCUSSION

The implementation of the PillPal mini-project resulted in the successful design and simulated operation of an integrated smart medication management system. The system demonstrates the feasibility of combining embedded hardware with an AI-based voice interface to improve medication adherence and user interaction. The obtained results validate the functionality of the three primary components of the PillPal.

ecosystem: the Smart Pill Box hardware module, the AI voice bot system, and the mobile application interface. The coordinated functioning of these components shows the potential of the proposed system to provide automated reminders, adherence monitoring, and intelligent voice-based assistance for users.

A. A.Smart Pill Box Functionality

The Smart Pill Box hardware module was designed as an automated multi-compartment medication dispenser. One of the key results achieved was the successful implementation of automated dispensing using a Real-Time Clock (RTC) module, which triggers the opening of the correct pill compartment at scheduled medication times. When the dispensing event occurs, the system simultaneously activates a visual alert using an LED and an audible alert through a buzzer, ensuring that the user receives clear reminders to take the medication. This dual-alert mechanism improves the effectiveness of the reminder system and makes it suitable for elderly users or individuals with sensory limitations.Another important outcome was the implementation of non-adherence detection. A sensor mechanism, such as an optical or weight-based sensor placed near the dispensing area, monitors whether the pill has been removed from the compartment. When the user takes the medication, the sensor records a “pill retrieved” event, which is logged in the system. However, if the scheduled time passes and the sensor does not detect pill retrieval within a predefined time window, the system records a “missed dose” event. This capability enables the system to track medication adherence accurately.

The system also demonstrated inventory monitoring functionality. By simulating sensor-based tracking of remaining medication levels, the system calculates the number of doses left in the pill compartment. When the available quantity falls below a predefined threshold, such as five days of medication supply, the system generates a low-stock alert. This feature helps prevent unexpected medication shortages and ensures continuity in the patient’s treatment schedule.

A. AI Voice Bot System

The project also integrated an AI-based voice bot

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module, which allows users to interact with the system using voice commands. The voice bot is designed to assist users by providing medication-related information, answering queries, and offering guidance through an interactive audio interface. When the user speaks into the microphone, the system captures the voice input and processes it through the AI module for speech recognition and response generation.

The AI system converts the spoken query into text, processes it using natural language understanding techniques, and generates an appropriate response. The response is then converted into speech using a Text-to-Speech (TTS) engine and delivered through a speaker, enabling the user to hear the answer clearly. This voice interaction capability makes the system highly accessible, particularly for elderly users or individuals who may find traditional mobile interfaces difficult to use. The AI voice bot therefore enhances user engagement and
provides an additional layer of assistance within the medication management system.

B. Mobile Application Interface

The PillPal mobile application interface, simulated through a web-based dashboard, demonstrated effective functionality for managing medication schedules and monitoring adherence. The application provides a centralized platform where users and caregivers can view medication schedules, track adherence rates, and review historical medication events.

The dashboard displays important information such as the user's weekly medication compliance rate and a chronological log of events, including dispensing times, pill retrieval confirmations, and missed doses. This organized presentation of data allows users and caregivers to monitor medication patterns and identify potential adherence issues. Overall, the integration of the mobile interface with the Smart Pill Box and AI voice bot creates a comprehensive medication management system that improves accessibility, user engagement, and healthcare support

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CONCLUSION

The development of the Smart Pill Box integrated with intelligent monitoring and automated reminders represents an effective step toward improving medication management in modern healthcare systems. The proposed system addresses common challenges faced by elderly individuals, chronically ill patients, and users with memory or cognitive limitations, such as forgetting medication schedules, taking incorrect doses, or missing refill times. By incorporating embedded hardware components, sensor-based monitoring, IoT communication, and AI-enabled features, the system provides a reliable and user-friendly solution that supports consistent medication adherence while reducing the burden on caregivers and healthcare providers.

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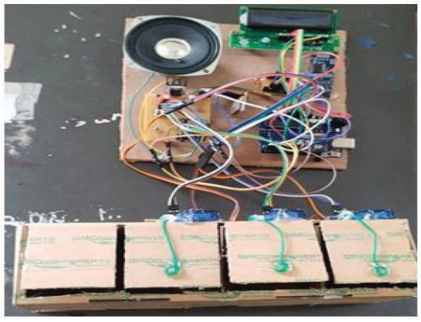

Figure3: Final Circuit

The Smart Pill Box functions not only as a simple reminder device but also as an intelligent monitoring system capable of detecting medication intake and generating alerts when scheduled doses are missed. Through the integration of communication modules, the system can automatically send notifications to caregivers or family members, ensuring that timely intervention can occur when necessary. This remote monitoring capability enhances patient safety and offers reassurance to caregivers who may not always be physically present. Additionally, the inclusion of refill alerts improves the practicality of the system by preventing unexpected medication shortages and ensuring continuity in treatment.

From a technological perspective, the project demonstrates the successful implementation of embedded systems, real-time sensing, wireless Figure4: App interface
communication, and cloud-assisted processing within a compact healthcare device. The modular architecture of the system allows for easy scalability and future enhancements, while

how smart technology can be effectively integrated into everyday healthcare routines to improve medication adherence and patient safety. By combining automation, real-time monitoring, and caregiver communication, the system provides a practical and scalable approach to medication management. This project demonstrates the potential of engineering innovations in addressing real-world healthcare challenges and contributes toward the broader goal of enhancing patient care through intelligent and accessible digital health solutions.

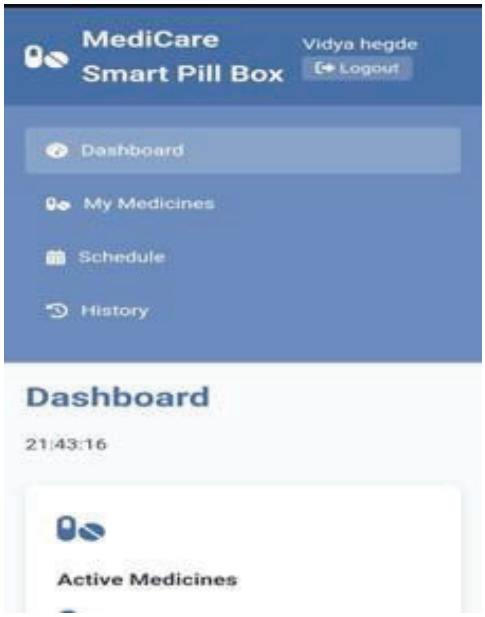

Figure4: App dashboard

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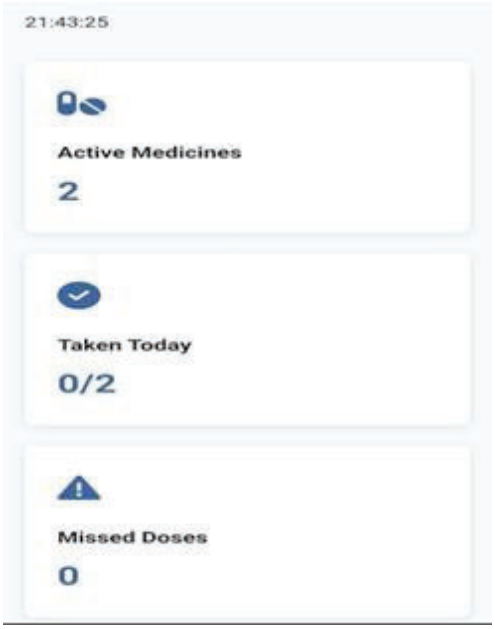

Figure5: App funcations

Figure6: App login

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REFERENCES

[1] Laily, B., Shareefin, M., Bhaumik, M., Gorai, D. P., authored the article "A Smart Medication box with Regular Medications and in-time Refilling" in Proceedings of the Second International Conference on Edge Computing and Applications (ICECAA) (2023).

[2] Poornaguru, J., Satish, S., Kavitha, K., published "SMB: An Smart Featured Medicine Box for Patient Monitoring" in Proceedings of the Third International Conference on Electronics and Communication Technology (ICECT) (2023).

[3] Zaidan, I., Ayuk, A., Karam, K., Dao, R. Z., wrote the article "Smart Medicine Box System" in 2023 IEEE International Conference on Engineering Technology (ICET) (2023).

[4] Ma, S. K., Almutairi, A., Martinez, R., Eghbali, K., Arredondo, A., authored "Smart Cup for a Smart Pill Dispenser for Verification of Pill Consumption" in 2023 IEEE 12th Global Conference on Consumer Electronics (GCCE) (2023).

[5] Chung, T., Lin, Y., Liu, W. J., published "A smart pillbox for increasing user's medication adherence" in 2022 IEEE International Conference on Consumer Electronics (ICCE) (2022).

[6] Pondeep, R., Rajan, T., Ayuk, A., Raghunath,

V., Poongodi, S., and Karthik, C., wrote "Smart Pill Box with Reminder to Consume and Auto-filling Process Using IOT" in Proceedings of the Fifth International Conference on USMAC (IOT in Social, Mobile, Analytics and Cloud) (USMAC) (2023).

[7] Vachhrajani, A., Vachhrajani, M., authored "Automated pill dispenser to improve medication compliance, efficiency, and accuracy" in 2022 IEEE World Forum on Public Safety Technology (WF PST) (2022).

[8] Poddi, J. S., Awart, A., published "AI-IoT based Smart Pill Expert System" in Proceedings of the Fifth International Conference on Trends in Electronics and Informatics (ICEI) (2023).

[9] Oncescu, C.-M., Moca, A., Craciunescu, O. T., wrote the article "A Smart Pillbox Integrated with an eHealth Platform" in 2022 IEEE International Conference on E-Health and Bioengineering (EHB) (2022).

[10] Philip, N. J., Kunjumon, A., Elza, S., Rema, K. A., published "Pill Care- The Smart Pill Box with Remind, Authenticate and Confirmation Function" in Proceeding of 2018 International Conference On Emerging Trends in Engineering and Technological Research (ICETR) (2018).

[11] Balaraman, K., Ammad, J., B., and R., V., published the article "Design of an Intelligent and Smart Pill Box Using Arduino and Sensors" in Proceedings of the Fourth International Conference on Smart Electronics and Communication (ICOSEC) (2023).

[12] Lakkad, N., Padiya, P., and Rathod, M., authored "Smart Medicine Reminder Box" in 2023 2nd International Conference on Emerging Trends in Engineering and Medical Sciences (ICETEMS) (2023).

[13] K., K., Saravanan, M., M., R., V., R., and Saravanan, S., wrote the article "Design and Implementation of Internet of Things - based Smart Medicine Box for Patients" in 2023 Third International Conference on Ubiquitous Computing and Intelligent Information Systems (ICUCIS) (2023).

[14] Priya, P., L., and Nagarajan, N., published "Raspberry pi based Automated Reminder Pill Box for Elderly People" in Proceedings of the Ninth International Conference on Communication and Electronics Systems (ICCES) (2024).

[15] Daoud, H., Daoud, M., Jardak, N., & Albouzidi, C. (2023). Design and Implementation of Smart Pill Box for Healthcare Applications. 2023 20th International Multi-Conference on Systems, Signals & Devices (SSD), 1046–1050