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IoT Medicine Management System for Automated Dosage Delivery and Monitoring Applications

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Abstract

The growing prevalence of chronic diseases and aging populations has increased the demand for reliable medication management systems, with over 60% of elderly patients requiring daily medication and nearly 50% of them missing doses due to forgetfulness, while smart healthcare devices are projected to grow at over 20% annually. Additionally, improper medication adherence leads to severe health complications, increased hospitalizations, and reduced treatment effectiveness, highlighting the need for intelligent and automated solutions. Traditional medicine management relies on manual reminders or caregiver supervision, which are often unreliable due to human error, memory lapses, or lack of continuous monitoring. Furthermore, conventional systems do not provide automated alerts, precise dosage guidance, or remote configuration, reducing their effectiveness in long-term healthcare management. To address these challenges, the proposed IoT smart medicine dispenser utilizes the ESP32 microcontroller to develop an intelligent and automated medication management system. The system allows users or caregivers to set medication schedules through an IoT-based mobile interface, ensuring accurate timing and dosage. At the scheduled time, the system activates buzzer alerts, visual indicators, and automatically opens the specific pill compartment, guiding the patient to the correct medication. Voice alerts further enhance usability, especially for elderly users. A 16x2 LCD display provides real-time status updates, while IoT connectivity enables remote monitoring and configuration. This smart system improves medication adherence, reduces health risks, enhances patient independence, and provides a reliable and scalable solution for modern healthcare management.

Keywords: Health Monitoring, Internet of Things, Medication Adherence, Medicine Dispenser, Patient Care System, Remote Monitoring, Smart Healthcare, Voice Alert System

1. Introduction

The growing prevalence of chronic diseases and the rising aging population have significantly increased the demand for reliable medication management systems. Studies show that over 60% of elderly patients require daily medication [1], while nearly 50% miss doses due to forgetfulness, leading to serious health risks. Improper medication adherence contributes to increased hospitalizations, reduced treatment effectiveness, and higher healthcare costs [2]. At the same time, smart healthcare devices are projected to grow at over 20% annually, reflecting the shift toward automated and connected healthcare solutions. In environments such as home healthcare, elderly care centers [3], hospitals, and remote patient monitoring systems, there is a critical need for solutions that ensure timely medication intake, accurate dosage management, and real-time monitoring to improve patient outcomes.

Traditional medication management methods rely on manual reminders, caregiver supervision, or simple alarm systems. These approaches are often unreliable due to human error [4], memory lapses, or inconsistent monitoring, especially for elderly patients or those with complex medication schedules. Caregivers may not always be available to

provide continuous supervision, leading to missed or incorrect doses [5]. Additionally, conventional systems lack automation, precise guidance, and integration with modern communication technologies [6]. They do not provide features such as remote configuration, real-time alerts, or intelligent scheduling, limiting their effectiveness in long-term healthcare management.

In real-time scenarios, these limitations lead to several critical challenges that directly impact patient health and safety. Missed or incorrect medication doses can result in worsening health conditions, delayed recovery, or severe complications, particularly for chronic diseases [7]. The absence of automated reminders and guidance increases dependency on caregivers and reduces patient independence. Furthermore, lack of real-time monitoring and remote access prevents timely intervention by healthcare providers or family members. Complex medication schedules can be difficult to manage without intelligent systems, increasing the risk of errors [8]. These challenges highlight the need for an IoT-based smart medication management system capable of automated scheduling, real-time alerts, and guided dispensing, ensuring improved adherence, enhanced patient safety, and efficient healthcare delivery.

2. Literature Survey

Nasr et al. [9] proposed a comprehensive study on smart healthcare systems in the era of Artificial Intelligence (AI), analyzing recent advancements, challenges, and prospects. Fernández-Ballesteros [10] proposed a conceptual framework for successful aging, defining key dimensions such as physical health, cognitive function, and social engagement. Annele et al. [11] proposed a review of multidimensional definitions of successful aging, analyzing various perspectives and criteria used in healthcare studies.

Qian et al. [12] proposed an Artificial Intelligence of Things (AIoT)-based framework for elderly care, integrating IoT and AI for assisted living and healthcare monitoring. Landaluce et al. [13] proposed a review of IoT sensing applications using Radio Frequency Identification (RFID) and wireless sensor networks, focusing on system architectures and challenges. Abdulmalek et al. [14] proposed a review of IoT-based healthcare monitoring systems aimed at improving quality of life through continuous patient monitoring.

Grant et al. [15] proposed a typology of review methodologies, categorizing different review types and their associated research approaches. Ngankam et al. [16] proposed an IoT-based microservices architecture for ambient assisted living environments that supported elderly care in smart cities. Qian et al. [17] proposed a study on IoT applications in sustainability and emerging technologies such as AI and the metaverse, highlighting future directions and integration challenges.

Kosmatos et al. [18] proposed a unified IoT architecture integrating RFID and smart objects for seamless communication and data exchange. Priyadarshi et al. [19] proposed a review on security and privacy in machine learning for Internet of Healthcare Things (IoHT) and Internet of Medical Things (IoMT) systems. Lakhotia et al. [20] proposed an intrusion detection system for Internet of Everything (IoE)-based medical networks that enhanced security through anomaly detection techniques.

3. Proposed System

Figure 1 illustrates the architecture of an IoT-based smart medicine reminder and dispensing system built around the ESP32. The system integrates an RTC timer for scheduling medicine intake, an IoT module connected with an Android application for remote configuration, and output modules such as an LCD display, APR voice module, and automated medicine boxes. A regulated power supply (RPS) ensures stable operation by converting AC input into regulated DC

voltage. The ESP32 processes timing data and user inputs to provide timely reminders and automatically dispense medicines, ensuring improved medication adherence and patient care.

Step 1: Power Supply Initialization: The regulated power supply converts 230V AC into 5V DC and provides stable power to the ESP32 and all connected components, ensuring reliable operation.

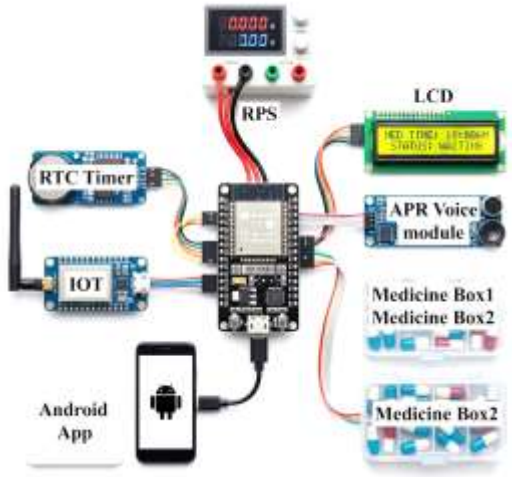


Figure 1. IoT-Based Smart Medicine Reminder and Dispenser System Using ESP32.

Step 2: Time Scheduling using RTC Timer: The RTC (Real-Time Clock) module is connected to the ESP32 and maintains accurate time. It is programmed with medicine schedules to trigger reminders at predefined intervals.

Step 3: IoT and Android App Integration: The system is connected to an IoT platform through Wi-Fi, allowing users to configure medicine schedules using an Android application. This enables remote monitoring and control.

Step 4: Data Processing by ESP32: The ESP32 processes time data from the RTC and user inputs from the IoT platform. It determines when to trigger reminders and dispense medicines based on programmed schedules.

Step 5: LCD Display Output: The LCD (16×2) displays real-time information such as current time, medicine schedule, and reminder notifications, helping users easily understand system status.

Step 6: Voice Alert using APR Module: The APR voice module generates audio alerts to remind users to take their medication at the correct time, enhancing usability especially for elderly or visually impaired individuals.

Step 7: Automatic Medicine Dispensing Mechanism: The ESP32 controls medicine boxes (Medicine Box1 and Medicine Box2) through motor/actuator mechanisms. At scheduled times, the system automatically releases the required medicine dose.

3.1 Working Procedure

The system operates by continuously tracking time using the RTC module and comparing it with predefined medicine schedules as shown in Figure 2. When the scheduled time is reached, the ESP32 triggers alerts through the LCD and voice module and automatically dispenses medicine through the pill box mechanism. Simultaneously, IoT connectivity allows remote monitoring and control via an Android app. This ensures accurate medication timing, reduces human error, and improves patient health management.

Figure 3 illustrates the circuit diagram of an IoT-based smart medicine reminder and automatic dispensing system designed to ensure timely medication intake. The system is powered by a regulated power supply unit comprising a step-down transformer, bridge rectifier, filter capacitors, and a 7805-voltage regulator to provide a stable +5V output.

The ESP32 microcontroller acts as the central control unit, interfacing with an APR voice module to provide audible reminders and alerts to the user. An RTC (Real-Time Clock) module is used to maintain accurate timing for scheduled medicine dispensing. Two dispenser units are controlled through an L293D motor driver, enabling automated release of

medicines at predefined intervals. The system also includes an IoT module for remote monitoring and notifications, and a 16×2 LCD to display dosage timings and system status. A buzzer provides additional alert notifications to ensure user attention. This integrated system improves medication adherence, reduces human error, and supports healthcare automation for elderly and patients.

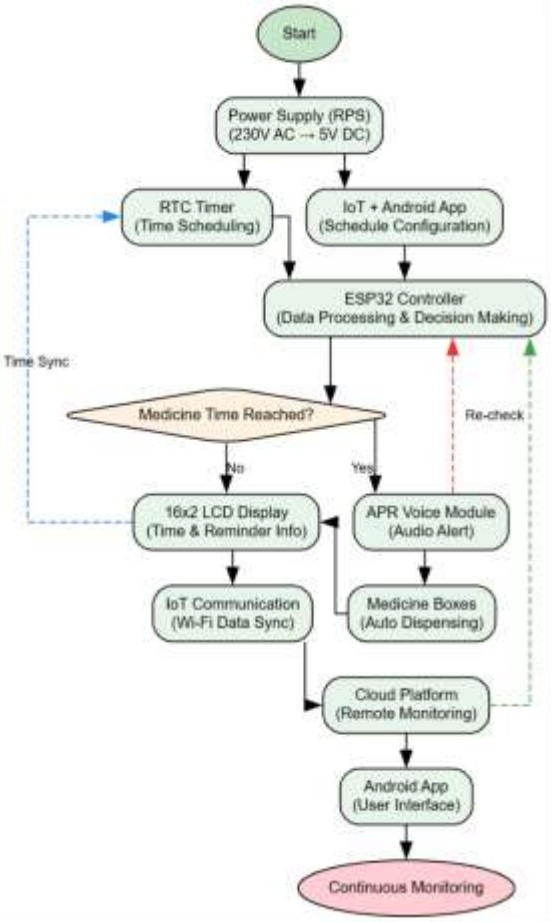


Figure 2. Proposed Flowchart.

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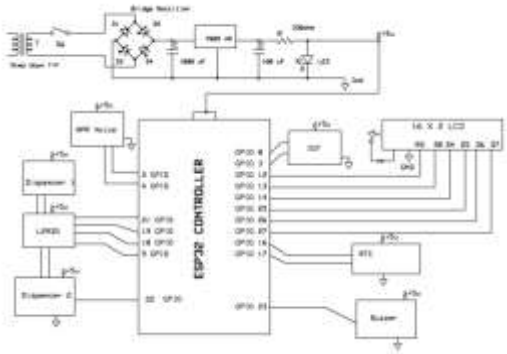


Figure 3. Circuit Diagram of IoT-Based Smart Medicine Reminder and Dispensing System.

4. Results and Discussion

The IoT Based Medicine Dispenser is an intelligent healthcare assistance system designed as shown in Figure 4 to ensure that patients take their medicines at the correct time without missing doses. The system uses a Real Time Clock (RTC) module to maintain accurate timing, a microcontroller (ESP32/Arduino) to control the system, an LCD display to show medication schedules, and an APR voice module to provide voice reminders. This system is especially useful for elderly patients, individuals with memory problems, and those who require strict medication schedules.



Figure 4. Hardware Architecture.

The RTC module continuously keeps track of the current date and time even when the main power is turned off, using its internal backup battery as shown in Figure 5. The microcontroller reads the time from the RTC and compares it with the programmed medicine schedule. When the scheduled time matches the current time, the system triggers the medicine dispensing mechanism and alerts the user.



Figure 5. System Intialization.

The LCD display provides clear information to the user, such as the system title, current time, medicine schedule, and reminder messages as shown in Figure 6. It helps the user understand when the next dose should be taken and confirms when medicine is being dispensed.



Figure 6. Medicince Reminder Outcome.

5. Conclusion

The proposed IoT smart medicine dispenser provides an effective and intelligent solution for improving medication adherence, particularly among elderly and chronically ill patients, by integrating automation, real-time alerts, and IoT connectivity. By utilizing the Arduino Uno microcontroller, the system ensures accurate scheduling and dispensing of medications, reducing the chances of missed or incorrect doses. The combination of buzzer alerts, visual indicators, voice guidance, and automatic compartment opening enhances usability and accessibility, especially for users with limited mobility or memory challenges. The LCD display offers real-time status updates, while IoT integration enables caregivers to remotely monitor and configure medication schedules, ensuring continuous supervision. This system overcomes the limitations of traditional manual methods by providing a reliable, user-friendly, and automated approach to medication management. Finally, it enhances patient safety, promotes independence, reduces healthcare risks, and contributes to the development of smart and connected healthcare solutions.

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