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Intellihat: Medicine Compliance Smart Pill Box

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ABSTRACT

These research papers tackle the critical problem of people not taking their medicine correctly by using smart technology. The solutions range from identification to verified consumption. The Med Glasses system is unique: it uses AI built into smart glasses to identify the correct pill in a user's hand, specifically helping visually impaired patients avoid mistakes. The IoT Smart Medicine Dispenser Model provides a basic, reliable system that dispenses pills on time and sends alerts to caregivers. More advanced is the Smart Pill Container, which uses both a camera with AI (YOLOv5) to confirm the pill's identity and weight sensors to verify the correct dosage was removed. Finally, the Smart Pill Dispenser with Smart Cup offers the most complete solution by pairing the dispenser with a special cup that uses motion sensors to definitively check if the patient actually drank the water and swallowed the pill, going far beyond simply dispensing it. Overall, these innovations demonstrate a clear path towards making medication management safer and more reliable.

INDEX TERMS — Medicine Compliance, Smart Pill Box, ESP32, Internet of Things (IoT), Firebase, Flutter, Medication Adherence, Automation, Remote Monitoring.

I. INTRODUCTION

Medication adherence is a critical factor in ensuring the effectiveness of prescribed treatments and overall patient health outcomes. Despite advancements in medical science, a significant number of patients fail to follow their medication schedules properly due to reasons such as forgetfulness, complex dosage regimens, cognitive impairments, and lack of awareness. This issue is particularly prominent among elderly individuals and patients suffering from chronic illnesses who require long-term medication. Poor adherence can lead to serious consequences, including disease progression, increased hospital admissions, and higher healthcare costs. Therefore, there is a growing need for reliable and user-friendly solutions that can assist patients in maintaining proper medication routines.

With the rapid development of embedded systems and smart healthcare technologies, automated solutions have emerged to address the challenges associated with medication management. One such solution is the Medicine Compliance Smart Pill Box, which is designed to provide timely reminders and ensure accurate medication intake. The system typically consists of a microcontroller, real-time clock (RTC), sensors, and alert mechanisms such as buzzers or mobile notifications. These components work together to track time, monitor pill access, and alert users when it is time to take their medication. In more advanced implementations, wireless communication technologies such as Bluetooth or IoT-based systems can be integrated to enable remote monitoring and alert caregivers in case of missed doses.

This paper focuses on the design and development of a smart pill box system aimed at improving medication adherence and enhancing patient safety. The proposed system emphasizes accuracy, ease of use, and reliability, making it suitable for a wide range of users, including elderly patients and individuals with busy lifestyles. By incorporating automation and monitoring features, the system reduces human error and ensures timely medication intake. Furthermore, it contributes to the broader goal of integrating smart technologies into healthcare to improve quality of life and treatment outcomes.

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I. SYSTEM ARCHITECTURE

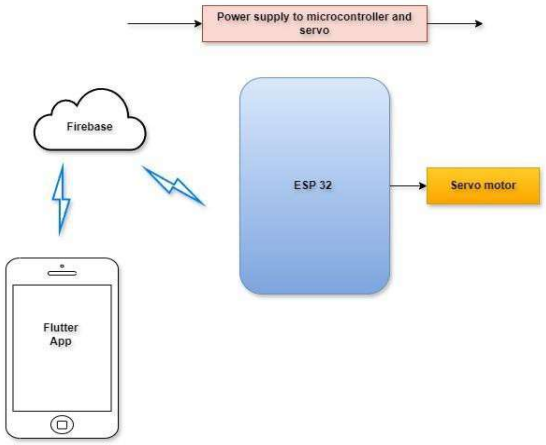

FIGURE 1. SYSTEM ARCHITECTURE

The proposed Medicine Compliance Smart Pill Box system is designed using an integrated architecture that combines hardware and software components for efficient medication management. At the core of the system is the ESP32 microcontroller, which controls the overall operation and communication processes. A regulated power supply provides the necessary energy to both the microcontroller and the servo motor. The servo motor is responsible for the physical dispensing mechanism of the pill box, ensuring that the correct compartment is accessed at the scheduled time. The system is connected to a mobile application developed using Flutter, which allows users to set medication schedules and receive notifications.Datasynchronization and real-time communication are achieved through Firebase, enabling remote monitoring and updates.This integrated approach ensures automation, accuracy,anduserconvenience in maintaining proper medication adherence.

Wearable safety systems require efficient and stable power delivery to ensure uninterrupted operation. The proposed smart helmet employs a DC–DC buck converter to regulate the input voltage and provide a stable supply to the microcontroller and connected sensors. Compared to linear regulators, the buck converter reduces power loss and minimizes heat generation.Stable voltage regulation improves system reliability and extends battery life, making the helmet suitable for long working shifts in hazardous environments. Experimental testing confirms that the power management unit delivers consistent output under operating conditions. In addition to voltage regulation, the power management unit contributes to overall system stability by protecting sensitive electronic components from fluctuations in the input supply. The use of a DC–DC buck converter ensures that variations in battery voltage do not affect sensor performance or microcontroller operation. This regulated supply helps maintain consistent sensor readings and prevents malfunction caused by under-voltage or over-voltage conditions. By providing a reliable power source for continuous operation, the power management unit plays a crucial role in supporting uninterrupted monitoring and timely alert generation in hazardous working environments.

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ii. HARDWARE ARCHITECTURE

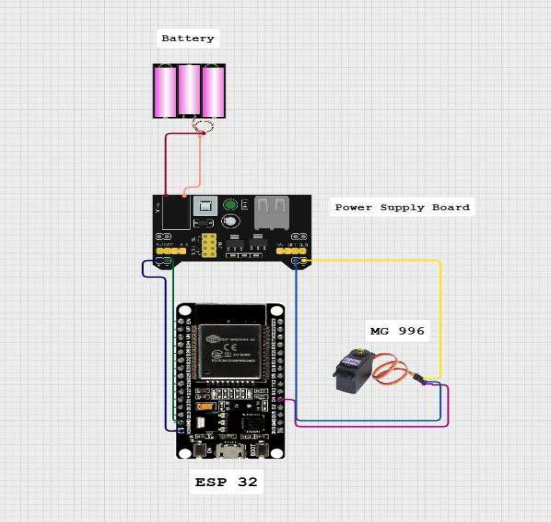


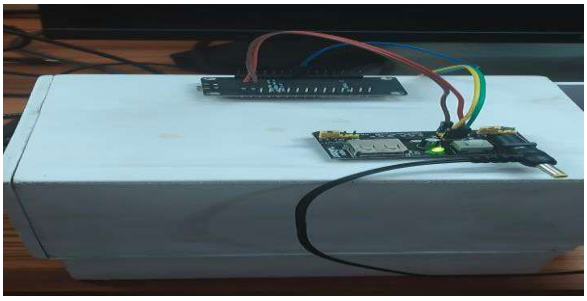
FIGURE 2 HARDWARE ARCHITECTURE

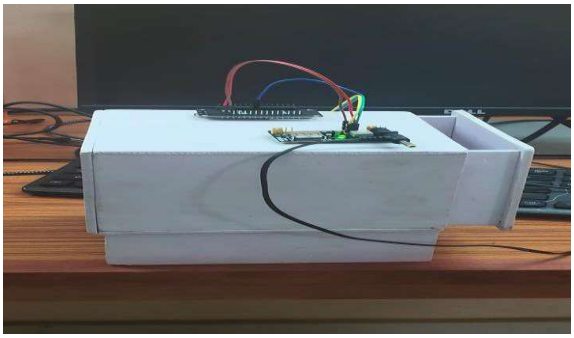
The hardware architecture of the proposed system is designed to ensure reliable and efficient operation of the smart pill box. The system is powered by a battery source, which is connected to a power supply board that regulates and distributes the required voltage to all components. This regulated power is essential for maintaining the stable functioning of the ESP32 and other connected devices. The power supply module ensures protection against voltage fluctuations and provides consistent energy for continuous operation.

At the core of the hardware setup is the ESP32, which acts as the main processing unit of the system. It is responsible for controlling the timing, communication, and execution of commands based on the programmed instructions. The ESP32 interfaces with other hardware components through its GPIO pins, enabling efficient data exchange and control. Its built-in Wi-Fi and Bluetooth capabilities allow seamless integration with external applications and cloud platforms, making it ideal for IoT-based healthcare solutions.

The pill dispensing mechanism is implemented using an MG996 servo motor, which is directly controlled by the ESP32. The servo motor operates based on signals received from the microcontroller to rotate at specific angles, allowing the correct pill compartment to open at scheduled times. Proper wiring between the power supply board, ESP32, and servo motor ensures synchronized operation of the system. This hardware integration enables accurate, automated, and user-friendly medication management.

iii.. HARDWARE REQUIREMENT





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The smart black box module is incorporated to ensure reliable recording of critical system events during operation. This module continuously stores important data related to environmental conditions, physiological alerts, motion events, and corresponding system responses. The availability of such recorded information is particularly useful for analyzing incidents that occur in hazardous work environments.

All logged data is accurately time-stamped using the real-time clock module, allowing precise reconstruction of event sequences during post-incident investigation. Time-based data correlation enables identification of patterns such as gradual environmental deterioration or sudden physiological changes prior to an incident.

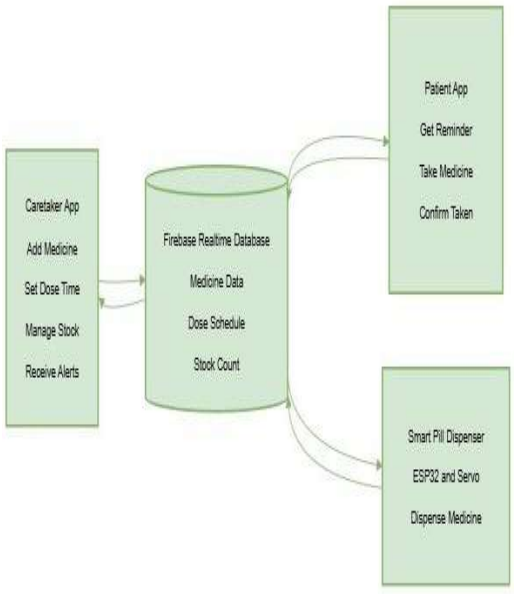
.In addition to accident analysis, the smart black box supports system validation and safety audits by providing historical operational data. This information can be used to evaluate system performance, improve safety procedures, and guide future enhancements. The inclusion a smart black box enhances system accountability and reliability without increasing operational complexity.

iv. SYSTEM OPERATION FLOW

The block diagram of the proposed Medicine Compliance Smart Pill Box represents the overall system architecture and the interaction between its major components. The system is powered by a battery source connected to a regulated power supply module, which ensures stable voltage distribution to all hardware units. This regulated supply is essential for the proper functioning of the ESP32, preventing fluctuations that could affect performance. The ESP32 acts as the central control unit, managing all operations including timing, communication, and control signals. It continuously processes input data, executes programmed instructions, and coordinates with other components to ensure that the medication schedule is followed accurately.

In addition to control operations, the ESP32 communicates with external platforms for enhanced functionality. It connects to a mobile application through cloud integration, enabling users to set schedules, receive notifications, and monitor medication intake in real time. The dispensing mechanism is handled by the servo motor, which operates based on signals from the microcontroller to open the appropriate compartment at the correct time. The block diagram thus highlights the seamless interaction between the power supply unit, control system, communication interface, and actuation mechanism, forming a reliable and automated solution for improving medication adherence.

FIGURE 3. SYSTEM OPERATION FLOW



v. LIMITATIONS

AWhile the Smart Compliance Medicine Pill Box offers a robust solution for medication management, it has certain technical and operational limitations. Primarily, the system is highly dependent on stable Wi-Fi connectivity; any interruption in the internet service prevents real-time synchronization between the Firebase database and the ESP32 microcontroller, potentially delaying critical alerts. Furthermore, the current prototype lacks an automated verification system to confirm that the caretaker has loaded the correct medication into the specific slots. Mechanically, the servo-driven dispensing unit may face challenges with varying pill shapes and sizes, which could occasionally lead to physical jamming. Lastly, while the system tracks when a dose is dispensed, it cannot 100% guarantee actual ingestion by the patient, as it relies on the user or caretaker to confirm the action via the mobile application."

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X CONCLUSION

A medicine compliance smart pill box is an effective solution to improve medication adherence and ensure patient safety, especially for elderly individuals and those with chronic illnesses. By integrating technologies such as microcontrollers, sensors, alarms, and connectivity features, the system provides timely reminders and accurate dosage management. This helps reduce the chances of missed doses or overdosing, which are common problems in traditional medication routines.

Furthermore, the smart pill box enhances healthcare monitoring by allowing caregivers or family members to track medication usage remotely. Features like real-time alerts, data logging, and user-friendly interfaces make it a reliable and efficient tool in modern healthcare systems. It not only supports patients in maintaining their treatment schedules but also reduces the burden on caregivers.

In conclusion, the medicine compliance smart pill box represents a significant advancement in healthcare technology by combining automation, monitoring, and ease of use. Its implementation can lead to better health outcomes, improved patient independence, and overall enhancement in quality of life.

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