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Smart Dose Assistant

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ABSTRACT: Medication non-adherence poses a significant challenge in healthcare, leading to worsened patient outcomes and increased treatment costs. This paper introduces the "Smart Dose Assistant," an IoT-based automated medicine dispenser designed to improve medication compliance. The system utilizes an Arduino Uno as its central controller, operating a multi-compartment dispenser where servo motors release scheduled doses (e.g., morning, afternoon, evening) at predefined times. To ensure secure access, an RFID module authenticates users, while an IR sensor confirms physical removal of medication. For remote monitoring, a NodeMCU (ESP8266) transmits event data—including access time, user identification, and dose retrieval status—to the ThingSpeak cloud platform. This enables real-time adherence monitoring by caregivers. An ESP32-CAM module offers additional visual verification. The implemented prototype demonstrates reliable operation, presenting a cost-effective and scalable solution to enhance medication adherence, patient safety, and caregiver oversight.

KEYWORD: Smart Dose Assistant, Medication Adherence, Automated Dispenser, Internet of Things (IoT), Arduino, RFID Authentication, Remote Patient Monitoring, ThingSpeak, Healthcare Technology

I. INTRODUCTION

The consistent and timely intake of medication is a critical determinant of successful treatment outcomes, particularly for individuals managing chronic diseases and the elderly. However, medication non-adherence remains a pervasive global challenge, leading to complications, increased hospitalizations, and substantial healthcare costs. Existing solutions, such as simple pill organizers and manual reminders, often fall short as they rely heavily on user memory and intervention, failing to provide verification of actual consumption.

Advancements in embedded systems and the Internet of Things (IoT) present a transformative opportunity to address this issue through automation and intelligent monitoring. This paper presents the design and implementation of the "Smart Dose Assistant," an automated dispensing system that integrates hardware and software to ensure medication adherence. The system leverages an Arduino microcontroller to automate timed dispensing, an RFID module for secure user authentication, and IR sensors to physically confirm pill removal.

Furthermore, by incorporating a Node MCU module for IoT connectivity, the system relays adherence data to a cloud platform, enabling remote real-time monitoring by caregivers. This integration of automation, security, and remote oversight represents a significant step beyond conventional methods. The Smart Dose Assistant aims to provide a reliable, scalable, and cost-effective solution that not only reminds patients but also verifies and records medication intake, thereby enhancing patient safety and treatment efficiency.

II. LITERATURE REVIEW

The challenge of medication non-adherence has spurred significant research into technological interventions. Early studies focused on passive reminder systems, such as SMS alerts and mobile applications, which demonstrated improved timing but could not verify actual consumption [1]. This limitation led to the development of automated dispensers. Research by [2] showed that mechanized devices significantly improve adherence rates for elderly patients, though early models lacked connectivity and security features.

The integration of the Internet of Things (IoT) marked a critical evolution, enabling real-time monitoring and data logging. Systems utilizing cloud platforms like ThingSpeak have been explored for remote patient monitoring, allowing caregivers to track adherence patterns [3]. Furthermore, incorporating authentication mechanisms like RFID has been identified as a vital step to prevent unauthorized access and ensure medication safety, as highlighted in studies on secure medical dispensers [4]. The proposed Smart Dose Assistant synthesizes these elements, building upon existing work by combining timed dispensing with multi-layered verification (RFID and sensors) and IoT-based remote surveillance, creating a more comprehensive solution to a well-documented problem.

III. PROPOSED SYSTEM

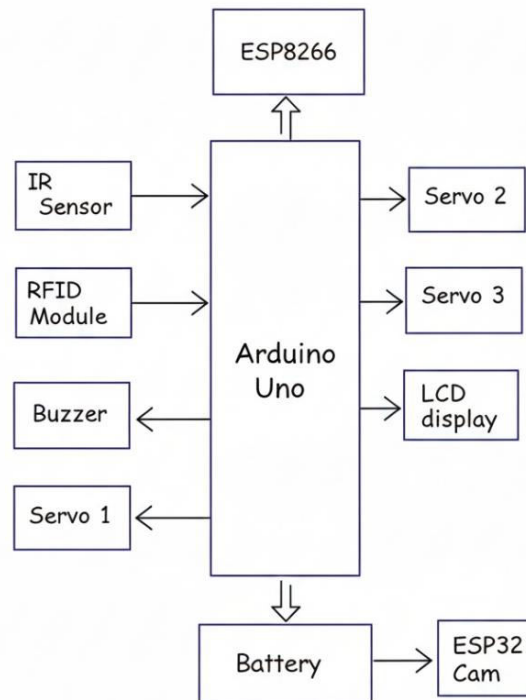
The proposed "Smart Dose Assistant" is a comprehensive, IoT-based solution designed to automate and monitor medication adherence. The system's core is an Arduino Uno microcontroller, which manages the entire operation. It controls a multi-compartment dispensing unit where each compartment, designated for a specific dosage time (e.g., morning, afternoon, evening), is locked by a dedicated servo motor. At pre-programmed times, the Arduino activates the corresponding servo to release the scheduled dose.

A critical security layer is added via an RFID module, requiring authorized user authentication before any compartment can be accessed. Furthermore, an IR sensor within each compartment provides a secondary verification, detecting whether the patient has physically removed the medication. For remote supervision, a NodeMCU (ESP8266) module transmits event data—including timestamp, user ID, and pill removal status—to the ThingSpeak cloud platform. This allows caregivers to monitor adherence in real-time through a customized dashboard. An integrated ESP32-CAM module offers an additional layer of oversight by capturing visual evidence during access events, ensuring a robust and reliable system for improving patient compliance.

IV. METHODOLOGY AND WORKING

The operational framework of the "Smart Dose Assistant" is a seamless integration of hardware control and software logic, designed to automate and verify medication adherence. The process begins with the Arduino Uno microcontroller, which acts as the central nervous system of the device. It is programmed with the patient's specific medication schedule, utilizing a Real-Time Clock (RTC) module to maintain accurate time. The system remains in a standby state, continuously monitoring the time until it matches a pre-set dosage period for one of the three compartments, designated for Morning, Afternoon, and Evening doses.

Upon reaching a scheduled time, the system activates an alert to notify the user. However, the dispensing mechanism remains locked until a secure authentication process is completed. The user is required to present their unique RFID tag to the module. The Arduino reads the tag's Unique Identification Number (UID) and verifies it against a pre-authorized list stored in its memory. Only upon a successful match does the system proceed; if the tag is unrecognized, access is denied and the event is logged as an unauthorized attempt. Following positive authentication, the Arduino sends a command to the specific servo motor attached to the corresponding compartment, which rotates to an "open" position, physically presenting the dose to the user.



The next critical stage involves confirming that the medication has been physically handled. This is accomplished using an IR sensor placed within each compartment. When the user removes the medicine blister pack or box, it interrupts the sensor's infrared beam. The Arduino detects this state change and logs it as a successful "Dose Removed" event. If the beam remains uninterrupted after a configured timeout period following the compartment opening, the system logs a "Dose Not Removed" status, indicating a potential missed dose.

For an additional layer of oversight, the ESP32-CAM module can be triggered to capture an image during the access event, providing visual confirmation.

Finally, all data generated from the event—including the timestamp, user ID, compartment ID, and dose removal status—is processed for remote monitoring. The NodeMCU (ESP8266) module formats this information into a data packet and transmits it securely via Wi-Fi to a designated channel on the ThingSpeak cloud platform. This transmission allows the system to update a private dashboard in real-time, which can be accessed by caregivers or guardians from any location. This dashboard provides an immediate and historical overview of the patient's adherence, enabling timely intervention in case of missed medications and offering peace of mind through continuous, remote supervision.

V. RESULT

The prototype of the "Smart Dose Assistant" was rigorously tested to evaluate its operational reliability and effectiveness. The system demonstrated a high degree of success in its core functionalities. The timed dispensing mechanism, driven by the Arduino Uno and servo motors, proved exceptionally reliable, with compartments opening precisely at their scheduled times without failure. The RFID authentication system successfully granted access only to authorized users, effectively preventing unauthorized medication retrieval. The IR sensor-based verification consistently and accurately detected the physical removal of medicine, confirming adherence for each dispensed dose.

Data transmission to the ThingSpeak cloud via the NodeMCU module was stable and real-time, with all critical events—including timestamps, user IDs, and dose status—being logged correctly and displayed on the remote dashboard. The ESP32-CAM also functioned as intended, providing visual evidence of access events. Overall, the system achieved its primary objective of ensuring medication adherence through automation, security, and reliable remote monitoring, validating the proposed design as a robust and practical solution for addressing medication non-adherence.

VI. FUTURE SCOPE

The "Smart Dose Assistant" prototype establishes a strong foundation for several advanced enhancements. Future work could integrate machine learning algorithms to analyze adherence patterns and predict potential missed doses, proactively alerting caregivers. The system's connectivity can be expanded by developing a dedicated mobile application with push notifications and two-way communication. Incorporating biometric authentication, such as fingerprint or facial recognition, would further enhance security beyond RFID. The physical design can be refined to include a larger, modular cartridge system for easier loading and support for liquid medications. Adding environmental sensors to monitor storage conditions like temperature and humidity would ensure drug efficacy. Integration with larger healthcare ecosystems through standardized APIs could enable direct data sharing with electronic health records and telemedicine platforms. Finally, implementing a solar-powered battery system would make the device more energy-efficient and suitable for areas with unreliable power supply, significantly broadening its accessibility and impact.

VII. CONCLUSION

The "Smart Dose Assistant" successfully demonstrates an effective and innovative solution to the critical issue of medication non-adherence. By integrating automated dispensing with robust user authentication and real-time remote monitoring, the project addresses key challenges in medication management. The system's core components—Arduino-based control, RFID security, IR sensor verification, and IoT connectivity—work in synergy to ensure timely, secure, and verified medication intake.

The implemented prototype has proven highly reliable in executing scheduled dispensing, authenticating users, and transmitting adherence data to the cloud for caregiver oversight. This practical approach not only enhances patient safety but also provides peace of mind to families and healthcare providers. The project validates the potential of affordable, scalable IoT technologies to transform personal healthcare management.

By bridging the gap between simple reminders and verified adherence, the Smart Dose Assistant establishes a foundational model for future developments in intelligent healthcare systems, contributing meaningfully to the pursuit of improved patient outcomes and reduced treatment costs.

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