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Automated Healthcare Dispenser for Timely Medication and Hydration

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ABSTRACT: This project presents an intelligent IoT-based automatic pill dispensing and medication adherence monitoring system that ensures patients take medicines at the correct time. The system uses a microcontroller-based mechanism along with sensors to automatically dispense pills and detect whether the medication has been taken. It continuously monitors patient adherence and stores data using cloud connectivity. When a dose is missed, instant alerts are sent to caregivers for timely intervention. The proposed system enhances patient safety, reduces dependency on memory, and improves overall medication adherence through automation and real-time monitoring.

I. INTRODUCTION

Medication adherence is a fundamental aspect of effective healthcare, especially for elderly individuals and patients with chronic illnesses. Missing doses or taking medicines at incorrect times can lead to serious health complications, reduced treatment effectiveness, and increased healthcare costs. Despite the importance of following prescribed medication schedules, a large number of patients struggle to maintain consistency due to factors such as forgetfulness, busy lifestyles, or lack of proper supervision.

In many cases, patients rely on traditional methods like manual pill organizers, alarm clocks, or mobile reminders to manage their medications. While these methods provide basic assistance, they are not fully reliable as they depend entirely on the patient's response. There is no mechanism to confirm whether the medicine has actually been taken, which limits their effectiveness, particularly for elderly patients or those with memory-related issues.

Another major limitation of existing systems is the absence of real-time monitoring and communication with caregivers. In critical situations, such as when a patient repeatedly misses doses, there is no immediate alert system to notify family members or healthcare providers. This delay in response can lead to worsening health conditions and may even result in emergencies that could have been prevented with timely intervention.

With the rapid advancement of Internet of Things (IoT) technology, there is an opportunity to develop smarter healthcare solutions that address these challenges. IoT enables seamless connectivity between devices, allowing real-time data collection, monitoring, and communication. By integrating sensors, microcontrollers, and cloud platforms, it is possible to create automated systems that not only assist patients but also actively ensure adherence to medication schedules.

This project proposes an intelligent IoT-based automatic pill dispensing and medication adherence monitoring system. The system is designed to automatically dispense medicines at scheduled times, detect whether the medication has been taken using sensors, and send alerts to caregivers if a dose is missed. By combining automation with real-time monitoring, the proposed system aims to improve patient safety, reduce dependency on manual effort, and provide a reliable solution for effective medication management.



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II. A REVIEW OF THE EXISTING SYSTEMS

The existing systems for medication management are largely based on manual methods and simple reminder mechanisms. One of the most common approaches is the use of pill organizers, where patients sort their medicines according to days and time slots. While this helps in organizing medication, it does not guarantee that the patient will take the medicine at the correct time, making it unreliable in ensuring proper adherence.

Alarm-based reminder systems are another widely used solution. These include mobile applications, smartwatches, and electronic reminder devices that alert patients when it is time to take their medication. Although these systems improve awareness, they still depend entirely on the patient's response to the alert. There is no mechanism to verify whether the medicine has actually been consumed, which limits their effectiveness.

In recent years, some electronic pillboxes and smart reminder devices have been introduced with additional features such as scheduling and basic tracking. However, these systems are still limited as they do not provide automatic dispensing of medicines. Patients are still required to manually take the pills, which can lead to missed or incorrect dosages, especially among elderly individuals or those with memory-related conditions.

Another significant limitation of existing systems is the lack of real-time monitoring and caregiver communication. Most systems do not provide remote access or cloud-based tracking, making it difficult for caregivers or healthcare providers to monitor patient adherence. In cases where a patient misses multiple doses, there is no immediate alert system to notify responsible individuals, which can result in delayed medical intervention.

Overall, the current systems are reactive and heavily dependent on human involvement, making them prone to errors and inefficiencies. They fail to provide a complete solution that integrates automation, monitoring, and communication. These shortcomings highlight the need for an advanced IoT-based system that can automatically dispense medication, track intake, and provide real-time alerts to ensure better adherence and improved patient safety.

III. PROPOSED METHODOLOGY

The proposed IoT-based automatic pill dispensing and medication adherence monitoring system is designed as an intelligent and automated framework that ensures timely medication intake and real-time monitoring. The system operates using a microcontroller (ESP32) integrated with a Real-Time Clock (RTC) to maintain accurate scheduling of medication timings. At predefined intervals, the dispensing mechanism, driven by servo and stepper motors, releases the appropriate pill for the patient. Sensors such as IR modules are used to detect whether the dispensed medicine has been taken, enabling adherence tracking. The system is connected to a cloud platform where medication data is stored and monitored continuously. In case a dose is missed, instant alerts are sent to caregivers through IoT communication. This integrated approach combines automation, sensing, and cloud connectivity to minimize human intervention, reduce errors, and ensure efficient and reliable medication management in real-time.

A. System Architecture & Modules:

The proposed system follows a modular architecture that enables efficient execution of multiple tasks such as scheduling, dispensing, monitoring, and communication. The Scheduling Module, integrated with a Real-Time Clock (RTC), ensures accurate tracking of medication timings and triggers the dispensing process at predefined intervals. The Dispensing Module, controlled by the ESP32 microcontroller, uses servo and stepper motors to release the correct pill at the right time. Additionally, the User Interface Module allows patients or caregivers to set schedules and view system status through a display or web application.

The Monitoring and Communication Modules work simultaneously to ensure medication adherence and real-time updates. The Monitoring Module uses IR sensors to detect whether the patient has taken the dispensed medicine, recording the intake data for further analysis. The Cloud Communication Module uploads this data to an IoT platform, enabling remote access and tracking. In case of missed doses, the Alert Module sends instant notifications to caregivers, ensuring timely intervention. This integrated modular approach enhances system reliability, reduces human error, and provides a comprehensive solution for effective medication management.



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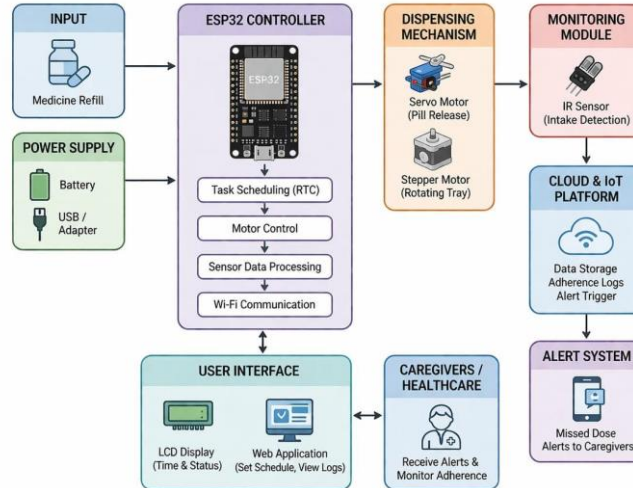


Fig: System Architecture

B. Algorithm Implementation:

The core computational logic of the proposed system is built around a microcontroller-based control algorithm that integrates scheduling, dispensing, monitoring, and communication functionalities. Unlike traditional reminder systems, the algorithm ensures not only timely alerts but also automated execution of pill dispensing and verification of medication intake. The system is designed to operate continuously with minimal human intervention, providing a reliable and efficient solution for medication management.

The algorithm begins with system initialization, where the ESP32 microcontroller configures all connected components such as the Real-Time Clock (RTC), sensors, motors, display, and communication modules. During this phase, predefined medication schedules are loaded into memory. The RTC module continuously provides accurate time data, which serves as the reference for triggering all subsequent operations in the system.

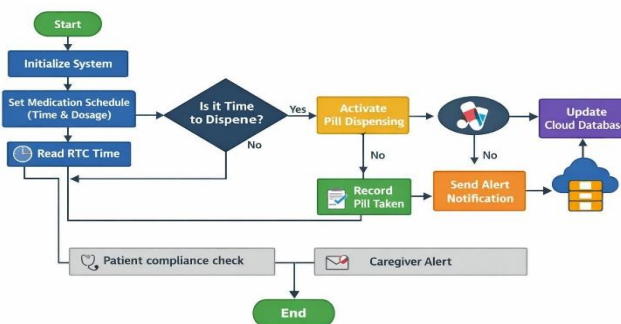
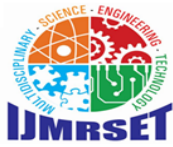


Fig: Algorithm Implementation

IV. IMPLEMENTATION

The implementation of the proposed system involves the integration of both hardware and software components to achieve automated pill dispensing and medication adherence monitoring. The system is designed to ensure timely medication intake while reducing dependency on patient memory. It combines embedded systems with IoT technology to provide a reliable and efficient healthcare solution.



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The hardware setup consists of an ESP32 microcontroller, Real-Time Clock (RTC) module, servo motor, and sensor units. The ESP32 acts as the central controller, managing all system operations and enabling wireless communication. The RTC module is interfaced with the controller to maintain accurate timing, ensuring that medicines are dispensed at the correct scheduled intervals.

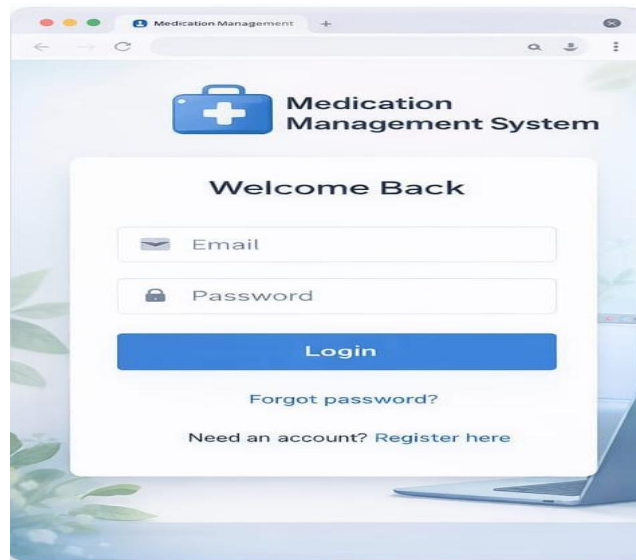


Fig: Login page

The dispensing mechanism is implemented using a servo motor, which rotates the pill container to release the required medication at predefined times. Sensors are incorporated to detect whether the dispensed pill has been taken by the patient. This enables the system to monitor medication adherence and record patient activity accurately.

On the software side, the system is programmed using Embedded C through the Arduino IDE to control all hardware components. A cloud platform such as Firebase is used to store and manage medication data. The ESP32 transmits real-time data to the cloud, allowing remote access and monitoring of patient medication records.

Additionally, a notification mechanism is integrated into the system to alert caregivers in case of missed doses. This ensures timely intervention and improves patient safety. The overall implementation focuses on reliability, low cost, and ease of use, making it suitable for real-world healthcare applications, especially for elderly and chronic disease patients.



Fig: Admin Page



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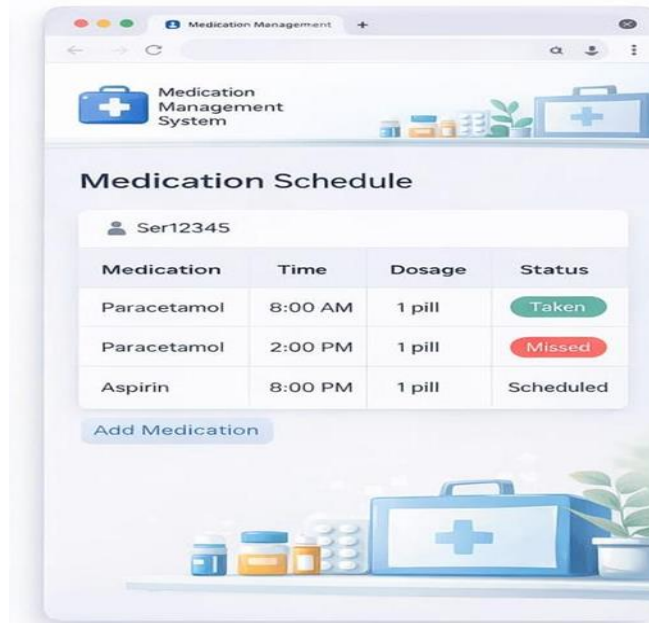
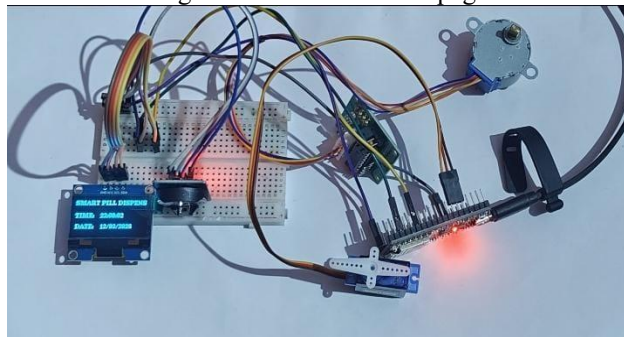


Fig: Medication Schedule page



V. RESULT

The results of the proposed IoT-based automatic pill dispensing and medication adherence monitoring system demonstrate effective performance in ensuring timely medication delivery and improving patient adherence. The system was tested under multiple scheduling scenarios, and it consistently dispensed pills at the predefined times without delay. The integration of the Real-Time Clock (RTC) provided accurate time management, ensuring that medications were released exactly as scheduled.

The dispensing mechanism, which includes servo and stepper motors, operated with high precision and reliability. It successfully released the correct pill at each scheduled interval, minimizing the chances of dosage errors. The system showed stable performance over repeated cycles, indicating its suitability for continuous real-time operation in practical healthcare environments.

The monitoring module, which uses IR sensors, effectively detected whether the patient had taken the dispensed medication. The sensor readings were accurate and consistently reflected the presence or absence of pill intake. This feature plays a crucial role in verifying adherence, as it eliminates the uncertainty associated with traditional reminder-based systems.



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The cloud communication module also performed efficiently by transmitting real-time data to the IoT platform. Medication intake records were stored successfully, enabling remote monitoring through web or mobile applications. This allowed caregivers to track patient adherence from any location, improving accessibility and ensuring better supervision of patient health.

In addition, the alert system proved to be highly effective in handling missed doses. Whenever a patient failed to take the medication within the specified time, instant notifications were sent to caregivers. This immediate response capability ensures timely intervention and reduces potential health risks. Overall, the system demonstrated high reliability, accuracy, and efficiency, making it a valuable solution for enhancing medication adherence and patient safety.

VI. CONCLUSION AND FUTURE WORK

In Conclusion, This work presents an intelligent and cost-effective solution for automated medication management using IoT technology. The system ensures timely dispensing of medicines based on a predefined schedule and monitors whether the patient has taken the medication. By integrating components such as a microcontroller, Real-Time Clock, sensors, and cloud connectivity, the system improves medication adherence and reduces dependence on patient memory. The ability to send alerts to caregivers in case of missed doses further enhances patient safety and supports effective healthcare monitoring, especially for elderly and chronic disease patients.

In the future, the system can be enhanced by incorporating advanced features such as artificial intelligence for predicting medication adherence and providing personalized reminders. Additional improvements may include voice assistance for better usability, biometric authentication for security, and integration with hospital databases for comprehensive healthcare management. Further development can also focus on making the system more compact, energy-efficient, and user-friendly, enabling wider adoption in real-world healthcare applications.

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