An Intelligent Automated Drug Dispensing System for Efficient Hospital Medication Distribution

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ABSTRACT: Hospital patient loads are growing, necessitating dependable and effective medication management systems. Especially during peak hours, traditional manual medicine dispensing procedures frequently result in lengthy wait times, human error, and an increased effort for chemists. With the use of RFID technology, Internet of Things connectivity, and automated mechanical dispensing, this proposal suggests an Automated Drug Dispenser (ADD) system that will automate and simplify the delivery of pharmaceuticals. A GSM module and the Blynk IoT mobile application are used to notify users, a gear motor mechanism is used to dispense the appropriate medication, and RFID tags are used to identify patients. By reducing the need for human involvement, improving accuracy, and offering real-time monitoring, the ADD system helps to deliver healthcare in a safer, quicker, and more effective manner.

Keywords: Automated Drug Dispenser, IoT, RFID, ESP32, GSM Module, Blynk App, Medication Management, Smart Healthcare, Real-time Monitoring, Gear Motor, Patient Identification, Pharmacy Automation.

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INTRODUCTION

The growing number of patients and the requirement for effective service delivery have led to a sharp rise in the demand for intelligent healthcare solutions in recent years. The pharmacy is a crucial sector in hospitals, where manual drug delivery frequently leads to long wait times, medication errors, and an increased workload for medical staff. These difficulties are most noticeable during busy outpatient hours, when a lack of automation results in inefficiencies and unhappy patients. Automation and smart technology present a viable way to deal with these problems. This study suggests an Automated Drug Dispenser (ADD) system that makes use of an ESP32 microcontroller-controlled mechanical dispensing device, RFID-based patient identification, and Internet of Things-enabled monitoring. The technology minimises the need for human intervention while guaranteeing precise and prompt delivery of prescription drugs. Notifications to patients or carers are made possible by the Blynk IoT platform and GSM module, which offer real-time information and remote access. The ADD system lowers the risk of human mistake, increases operational efficiency, and enhances the overall patient experience in hospital settings by combining hardware automation with intelligent software interfaces. The conversion of conventional pharmacy operations into intelligent, networked, and patient-focused services is advanced by this project.

Literature Survey

Research on intelligent medicine dispensing systems has increased significantly as a result of the growing use of automation in healthcare. The objective is to increase medication adherence, decrease human error, and boost productivity in clinical and hospital settings. A number of relevant works have been examined in order to comprehend the gaps and current trends in the field. The manual procedures used for medicine delivery in a traditional hospital setting are overseen by nurses and chemists. This frequently leads to drug mix-ups, improper dosages, and lengthy wait periods. The absence of alarm systems, real-time monitoring, and integration with patient identifying technology in these systems may result in safety hazards and lower care quality.

A. IoT-Based Pill Dispenser

A GSM module was used in another study, "IoT-Based Pill Dispenser" (IJSER, 2020), to incorporate SMS-based warnings for medication scheduling. It was successful at reminding patients, but it lacked automated mechanical dispensing and hospital infrastructure connectivity for real-time patient monitoring.

B. Automatic Medicine Dispenser with Alert System

Focused on home use with minimal automation, "Automatic Medicine Dispenser with Alert System" (IRJET, 2022). Despite using preset durations, the system lacked hospital-scale deployment support and dynamic patient identification.

C. Automated Drug Dispenser (ADD)

The suggested Automated Drug Dispenser (ADD) technology offers a more thorough method to close these gaps. It incorporates gear motors for physical dispensing, an ESP32 microcontroller for control, RFID technology for patient verification, and Internet of Things capabilities via the Blynk platform for remote monitoring and notifications. Furthermore, SMS notifications are sent via a GSM module, guaranteeing that patients and carers are informed even in the absence of internet connectivity. A scalable and hospital-grade system that aims to increase accuracy, decrease waiting times, and optimise pharmacy workload is provided by this mix of cloud-connected software and hardware automation. The ADD system is appropriate for both outpatient and inpatient settings since, in contrast to current models, it guarantees that medication is only administered following accurate patient identification.

RELATED WORK

Recent years have seen a number of studies attempting to use embedded systems and Internet of Things technology to automate the medicine delivery process. A time-based pill delivery system that notifies consumers via smartphone notifications was suggested in one of the earliest studies, "Smart Medicine Dispenser using IoT" (IJERT, 2021). Nevertheless, the technology was not scalable for medical settings and lacked user authentication. Similarly, a GSM-enabled gadget that provides SMS notifications to patients was shown in the paper "IoT-Based Pill Dispenser" (IJSER, 2020). However, it required manual drug loading and had few automated features. Another noteworthy study that utilised a timer-controlled dispensing system and targeted home users was "Automatic Medicine Dispenser with Alert System" (IRJET, 2022). It did not interface with hospital infrastructure or support multi-user situations, despite improving drug adherence. On the other hand, the "Automated Medicine Dispensing System" (IEEE, 2019) investigated the use of microcontrollers and real-time clocks for dose timing; nevertheless, it was inappropriate for hospital applications since it lacked a secure patient identification technique.The complex requirements of hospital outpatient departments, where patient-specific medication, workload reduction, and real-time monitoring are crucial, are not met by these systems, which mainly handle simple medication reminders and individual-use dispensers. By combining RFID-based patient identification, ESP32-based control, Blynk-based IoT connection, and GSM-based alerts, the proposed Automated Drug Dispenser (ADD) project closes these gaps. The demands of contemporary hospital pharmacy operations are met by this multifunctional system, which provides a more reliable and scalable solution.

MEDHODOLOGY

To create a drug dispensing system that is effective, dependable, and customised for each patient, the Automated Drug Dispenser (ADD) system was developed by integrating cloud-based interfaces, identification technologies, communication modules, and embedded hardware components. The system's overall goal is to reduce the need for human interaction, improve drug accuracy, and expedite hospital pharmacy operations.

1. Framework for the System

All essential functions, including as patient identification, motor control, data exchange, and alert management, are managed by the ESP32 microcontroller, which is at the heart of the design. The system is made up of interdependent modules that handle communication, actuation, processing, and sensing.

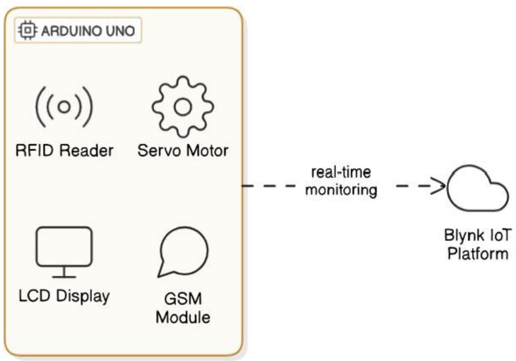

Fig 1. Block Diagram

2. Identification of the Patient

At the dispenser unit, each patient scans their individual RFID badge. After detecting the tag, the RFID reader (RC522) transmits the patient ID to the ESP32. The ID is cross-checked by the system using pre-defined pharmaceutical data that is either externally stored in a database or saved in the microcontroller.

3. Mechanism for Dispensing Medication

When identification is successful, the ESP32 turns on the gear motor mechanism, which rotates or releases the patient's designated drug compartment. To ensure accurate distribution, the number of motor spins is regulated according to the medication kind and dosing schedule.

4. Remote Monitoring and IoT Integration

The system uses Wi-Fi to connect to the Blynk IoT platform. This makes it possible to use a mobile application to monitor and manage the dispenser in real time. Alerts, schedule checks, and remote dispensing activity confirmation are all available to patients and carers.

5. System for Notifying SMS

SMS alerts are sent to registered phone numbers via a GSM module (SIM800L) to improve accessibility and guarantee notifications even when internet connectivity is unavailable. Refill alerts, missed doses, and dispensing confirmation are examples of notifications.

6. Feedback and User Interface

During operation, a 16x2 LCD display shows the patient's name, medication information, and system status. For manual control and emergency overrides, push buttons are included.

7. Management of Power

All modules can be reliably supported by the system's controlled DC power supply. To stop sensitive components from being harmed by voltage fluctuations, protection circuits are installed.

8. Implementation of Software

The Arduino IDE is used to program the control logic, which is created using Embedded C/C++. All modules communicate with the ESP32 via serial and digital interfaces. To guarantee flexible, scalable operation, required libraries for Blynk, RFID, GSM, and motor control are incorporated.

IMPLEMENTATION

The Automated Drug Dispenser (ADD) system was implemented using a systematic mix of real-time communication interfaces, embedded software development, and hardware integration. The system was created with accuracy, modularity, and patient-centered functionality in mind. The following essential elements were put into practice:

1. RFID-Based Patient Identification

The ESP32 microcontroller was interfaced with an RFID reader module (RC522) to use RFID tags for patient authentication. A distinct RFID card that stores their ID is given to each patient. The reader sends the card ID to the controller for validation after scanning. By doing this, mistakes are avoided and only the right person gets given medication.

2. Microcontroller Unit (ESP32)

The system's brain was the ESP32 microcontroller. It was selected because of its dual-core processing power and integrated Wi-Fi, which enable it to manage several jobs at once, including RFID reading, motor control, GSM communication, and IoT integration. Using the Arduino IDE and the necessary peripheral management libraries, the firmware was created.

3. Medication Dispensing Mechanism

Medication was dispensed using a gear motor system in accordance with a predetermined dosage schedule and patient ID. Relay control was used to activate each motor, which was paired with a certain compartment. During each activation cycle, the motor's rotation was adjusted to dispense the precise dosage of medication.

4. Alert Notification via GSM

To deliver SMS notifications to patients and carers, the ESP32 was connected to a SIM800L GSM module. Refill alerts, missed dose warnings, and dispensing confirmation were among the messages. Even in places with little internet access, this guaranteed communication continuation.

5. Integration of IoT using the Blynk App

The ESP32's Wi-Fi module was used to link the system to the Blynk IoT platform. Real-time notifications, system status, and prescription logs could all be remotely monitored thanks to the smartphone app. To improve usability and compliance, users could see when medication was dispensed and get push messages as reminders.

Fig 2. Automated Drug Dispenser

6. Module for User Interface

Visual feedback was given by a 16x2 LCD display that displayed patient ID, medication information, and system status. In order to provide authorised people more control, push buttons were added for manual reset, emergency override, and system test operations.

7. Protection of Circuits and Power Supply

The entire circuit was powered by a 5V/12V DC adaptor that was controlled. To guarantee steady and secure power flow to the delicate components like GSM and RFID, capacitors, resistors, and voltage regulators were employed.

CHALLENGES AND SOLUTIONS

The Automated Drug Dispenser system faced a number of practical and technical difficulties during development and deployment. Ensuring precise patient identification with RFID technology was one of the main obstacles. Misreads occasionally happened in noisy medical settings or when RFID tags were positioned incorrectly. The reliability of tag recognition was increased by introducing a short delay and putting in place signal validation procedure. Controlling the medicine dispensing system precisely was another significant challenge. Occasionally, uneven rotations from gear motors resulted in either incomplete or excessive dispensing. This was fixed by calibrating the motor timing through a rigorous testing process and implementing feedback-based control to guarantee steady actuation per dosage. There were memory and processing issues when GSM and IoT (Blynk) modules were integrated into a single ESP32 microcontroller. Instability during real-time communication was caused by conflicts between peripheral timing and libraries. In order to fix this, the code structure was optimized, background processes were reduced, asynchronous communication protocols were used wherever feasible. Another major issue was power management, particularly when several modules were running at once. The circuit included capacitors, a reliable power adaptor, and voltage regulators to prevent voltage drops and fluctuations. Safety features were also included to guard against overcurrent and short circuit scenarios. Lastly, user engagement and feedback from the system have to be simple and reliable. It was necessary to include easily accessible control buttons and a clear display interface so that both patients and staff could use the device without technical expertise. The user interface was improved over several revisions to show pertinent prompts and messages at every step of the process. Iterative testing and careful design helped overcome these obstacles, making the ADD system scalable, dependable, and appropriate for use in medical settings.

CONCLUSION

The Automated Drug Dispenser system faced a number of practical and technical difficulties during development and deployment. Ensuring precise patient identification with RFID technology was one of the main obstacles. Misreads occasionally happened in noisy medical settings or when RFID tags were positioned incorrectly. The reliability of tag recognition was increased by introducing a short delay and putting in place signal validation procedure. Controlling the medicine dispensing system precisely was another significant challenge. Occasionally, uneven rotations from gear motors resulted in either incomplete or excessive dispensing. This was fixed by calibrating the motor timing through a rigorous testing process and implementing feedback-based control to guarantee steady actuation per dosage. There were memory and processing issues when GSM and IoT (Blynk) modules were integrated into a single ESP32 microcontroller. Instability during real-time communication was caused by conflicts between peripheral timing and libraries. In order to fix this, the code structure was optimized, background processes were reduced, and asynchronous communication protocols were used wherever feasible. Another major issue was power management, particularly when several modules were running at once. The circuit included capacitors, a reliable power adaptor, and voltage regulators to prevent voltage drops and fluctuations. Safety features were also included to guard against overcurrent and short circuit scenarios.Lastly, user engagement and feedback from the system have to be simple and reliable. It was necessary to include easily accessible control buttons and a clear display interface so that both patients and staff could use the device without technical expertise. The user interface was improved over several revisions to show pertinent prompts and messages at every step of the process. Iterative testing and careful design helped overcome these obstacles, making the ADD system scalable, dependable, and appropriate for use in medical settings.

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