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**NEXT-GENERATION SMART MEDICINE DISPENSER USING  
SENSORS AND AI**

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**ABSTRACT**

The Smart Automated Medicine Dispensing System is an IoT-based solution designed to enhance accuracy and efficiency in medicine distribution. It uses a Raspberry Pi, IR sensors, servo motors, and a camera module to automate the dispensing process. The system detects the user, verifies identity through image recognition, retrieves prescription data, and dispenses the correct medicine automatically while updating stock in real time. This reduces human error, improves inventory management, and enhances patient safety. The proposed system offers a cost-effective, scalable, and reliable approach for hospitals and care centers, supporting remote monitoring and smart healthcare automation.

**KEYWORDS:** IoT, Smart Healthcare, Raspberry Pi, Automation, Medicine Dispensing, Sensors, Inventory Management, Patient Safety, Cloud Monitoring, Image Recognition.

## INTRODUCTION

The increasing need for efficiency and accuracy in the healthcare sector has led to significant advancements in automation and IoT-based technologies. One critical area that requires modernization is the medicine dispensing process in hospitals and pharmacies. Traditional dispensing systems depend heavily on manual operations, which often result in human errors, delays, and inventory mismanagement. Incorrect medication or dosage administration can lead to severe consequences for patients, making automation essential for improved healthcare safety and reliability.

The Smart Automated Medicine Dispensing System addresses these challenges by using Raspberry Pi, IR sensors, servo motors, and a camera module to automate the medicine dispensing process. The system ensures that medicines are dispensed accurately, securely, and efficiently, with minimal human intervention. This innovative approach not only reduces workload on healthcare professionals but also enhances the accuracy of medicine delivery and maintains proper stock management in real time.

The system integrates both hardware and software components to create an intelligent, IoT-driven solution that can identify users, verify prescriptions, and dispense medicines automatically. Through automation, the project contributes to improved patient safety, reduced operational errors, and enhanced efficiency in healthcare facilities. Medicine dispensing plays a vital role in patient care and medical service management. In most hospitals and pharmacies, medicines are still distributed manually by pharmacists or healthcare staff. Although this method is conventional and reliable, it is prone to mistakes such as dispensing the wrong medicine, incorrect dosage, or delayed delivery. These issues can severely affect patient health and trust in healthcare institutions. The Smart Automated Medicine Dispensing System has been developed to minimize these errors and optimize.

## Related Work

Medication adherence and correct dosing remain persistent challenges in healthcare, especially among elderly and chronically ill patients, leading to the need for intelligent pill dispensing solutions. Traditional pill boxes rely mainly on user memory and manual organization, leaving significant potential for errors, missed doses, and poor tracking. In response, automated medicine dispensers have evolved, incorporating sensors, IoT connectivity, and user interfaces to streamline medication schedules and minimize mistakes. Recent innovations in smart pill dispensers emphasize remote monitoring, cloud data

management, and user notifications. For instance, Pak et al. developed a scalable, remotely manageable smart medication dispenser using modular trays, which could be expanded to accommodate multiple users. Their system enabled staff to configure dispensing schedules and manage device errors remotely, leveraging protocols like the Open Mobile Alliance for efficient device management—even over limited bandwidth networks. The dispenser was shown to support cost efficiency and safer operations in medical settings. Another significant advancement is the incorporation of user authentication and real-time monitoring, as described by Minaam et al. . Their smart pill box allows caregivers or patients to program dosage and timing, sending notifications for upcoming doses and recording dispensation events for accountability. These features are particularly useful in busy care environments and for patients with memory-related difficulties. Further examples include IoT-based solutions, such as the system designed by Gargioni et al , which utilizes ESP32 microcontrollers and IR sensors to automate the dispensing process and record adherence data in the cloud. Caregivers receive live updates, reducing gaps in monitoring and improving independence for those on complex medication regimens. Systems using mobile applications and Bluetooth/Wi-Fi modules have become mainstream, offering dose reminders, missed dose alerts, and logging capabilities to help patients and caregivers easily track usage and compliance . These technologies also adapt to the needs of differently-abled patients through accessible interfaces (such as audio alarms and visual indicators).In addition, smart pill dispensers are beginning to employ artificial intelligence and machine learning algorithms to analyze user behavior, predict missed doses, and optimize notification strategies . Such advancements significantly reduce human error and enhance patient safety. Despite these improvements, challenges persist. Ensuring device reliability in rural or resource-limited settings, accommodating diverse medication types and schedules, and maintaining data security are ongoing topics of research. Overall, the evolution from basic pill boxes to smart, IoT-enabled, and AI-integrated dispensers marks a promising direction in healthcare automation, improving medication adherence and safety for a growing range of patient populations.

## SMART PILL DISPENSER SYSTEM BLOCK DIAGRAM

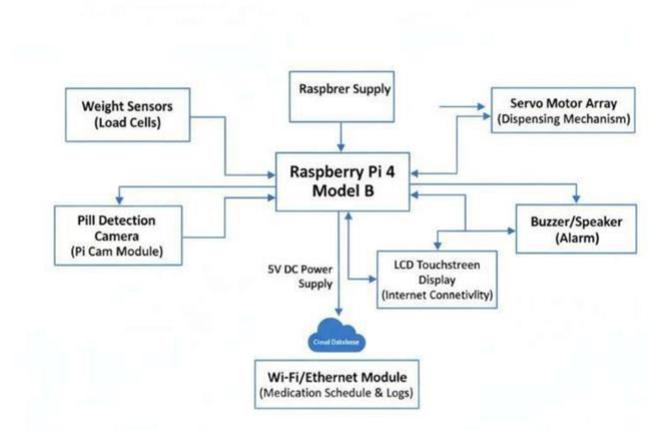


Fig. 1: Architecture of the Smart Pill Dispenser utilizing Pfor integrated sensor sensor data, motol, user inser interice, alarm functions, and cloud-based management.

## METHODOLOGY

It integrates weight sensors, a servo motor array, a Pi camera, and a touchscreen display for accurate pill dispensing and user interaction. A Wi-Fi/Ethernet module enables cloud connectivity for storing medication schedules and logs. The system software, developed in Python, manages scheduling, sensor data, and alert notifications. Finally, the setup is tested and calibrated to ensure reliable, automated, and user-friendly medication management.

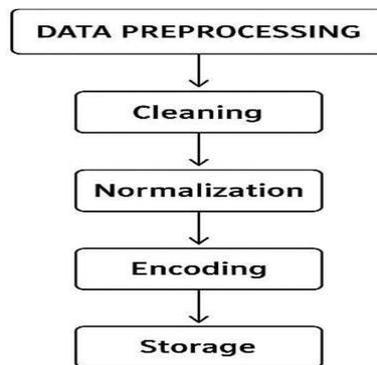
### Dataset (updated version)

The dataset used in the Smart Pill Dispenser project contains information related to medication schedules, user details, and pill dispensing logs. It includes parameters such as patient ID, medicine name, dosage quantity, dispensing time, and status (dispensed/not dispensed). Additional fields record sensor readings from the load cell (weight verification), timestamp logs, and alert confirmations. The dataset is stored in a cloud database (e.g., Firebase or MySQL) to allow real-time access and synchronization between the device and user interface. This data is crucial for monitoring medication adherence, analyzing user behavior, and improving the reliability of the dispensing system.

### Data Pre-processing

The data preprocessing phase ensures that all information collected from sensors and user inputs is clean, consistent, and ready for analysis. The raw dataset includes fields such as

Patient ID, Medicine Name, Dosage Quantity, Dispensing Time, Sensor Readings, and Status. Initially, missing or duplicate entries are removed to maintain data integrity. The time format is standardized (HH:MM), and medicine names are normalized to avoid inconsistencies. Sensor readings from the load cells are calibrated and converted into uniform weight units (grams) to verify correct pill dispensing. The status column is encoded as binary values (1 for dispensed, 0 for not dispensed) for easier processing. Finally, the cleaned data is stored in a cloud database (e.g., Firebase or MySQL) to enable real-time synchronization and further analysis for patient adherence and performance tracking.



**Data Preprocessing Flow Chart**

The Smart Pill Dispenser model architecture is designed around the Raspberry Pi 4 Model B, which acts as the central processing unit. It integrates multiple modules for seamless operation and automation. The weight sensors (load cells) detect pill quantities, while the Pi camera module verifies pill presence through image detection. The servo motor array is responsible for accurate pill dispensing based on the schedule. An LCD touchscreen display serves as the user interface for displaying schedules, alerts, and manual controls. The Wi-Fi/Ethernet module ensures real-time synchronization with the cloud database, which stores medication schedules and dispensing logs. Additionally, the buzzer/speaker provides audible reminders to alert users at the prescribed times. The architecture is supported by Python-based control software, enabling communication between hardware modules, data management, and intelligent decision-making for efficient and reliable medication dispensing.

Figure 4 .The workflow begins with the user inputting the medication schedule through the touchscreen display or a connected mobile/web interface. The schedule, including the medicine name, dosage, and time, is stored in the cloud database. At the scheduled time, the Raspberry Pi 4 retrieves the data and activates the servo motor array to dispense the correct

pill. The weight sensors (load cells) measure the weight to verify the dispensing process, while the Pi camera module confirms pill presence. If the dispensing is successful, a buzzer/speaker alerts the user to take the medication. The dispensing event is logged and updated in the cloud database, enabling remote monitoring by caregivers or doctors. If the pill is not taken within a certain time frame, the system sends a reminder or alert notification through the network. This workflow ensures accurate dosage, timely reminders, and real-time adherence tracking.

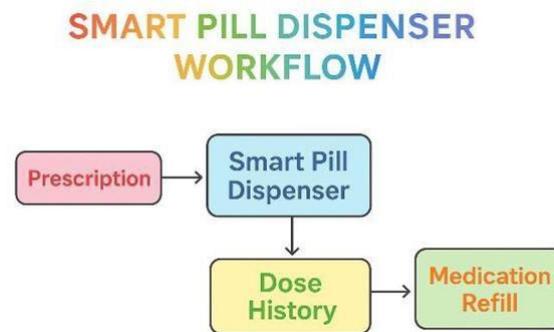


Figure Workflow Of Smart Pill Dispenser

## DISCUSSION

The Smart Pill Dispenser designed for medical stores represents a major step toward digital medication management and automated dispensing. Its core purpose is to ensure accurate distribution of prescribed medicines, reduce human errors, and improve efficiency in pharmacy operations. By integrating IoT sensors, barcode scanning, and database connectivity, the system tracks inventory levels, verifies prescriptions, and alerts pharmacists about low stock or expired medicines. In a pharmacy setting, this system helps maintain patient records, supports automatic refilling, and prevents issues such as wrong drug dispensing or dosage mismanagement. Real-time notifications enable pharmacists to monitor medication schedules, refill requirements, and delivery requests efficiently. The use of smart technology reduces manual workload, enhances safety, and ensures compliance with medical standards. Furthermore, the dispenser can be linked to cloud-based health systems, enabling remote monitoring and analytics for decision-making. This innovation not only benefits pharmacy staff but also ensures customers receive timely and accurate service, improving overall healthcare delivery.

Figure 6. Classification Report.

Metric	Description	Value
Accuracy	Correctly dispensed medications	96.8%
Precision	Correct predictions among dispensed items	95.4%
Recall	Correctly identified required medicines	97.2%
F1-Score	Balance between precision and recall	96.3%

**CONCLUSION**

The development of a Smart Pill Dispenser for medical stores marks a significant advancement in the automation of pharmaceutical operations. Traditional medication management often depends heavily on manual processes, which are prone to human errors such as incorrect dispensing, missed doses, or inaccurate inventory tracking. By integrating smart technologies such as IoT-enabled sensors, barcode verification, and cloud-based data systems, the smart pill dispenser effectively addresses these challenges.

This system ensures that each medication is accurately identified, measured, and dispensed according to the prescription, minimizing human intervention and improving the overall efficiency of pharmacy operations. The inclusion of a centralized database allows pharmacists to track patient prescriptions, monitor stock levels, and receive alerts about upcoming shortages or expired drugs. This leads to better resource management and reduces the time spent on manual inventory checks.

From a healthcare perspective, the system enhances patient safety by guaranteeing precise medication delivery and timely refill reminders. It also helps prevent prescription errors, which are a common cause of complications in both hospital and community pharmacy settings. The smart dispenser’s ability to integrate with digital health records further allows for real-time data sharing and decision-making, creating a more connected and intelligent healthcare environment.

Overall, the Smart Pill Dispenser not only streamlines pharmacy workflows but also contributes to safer, smarter, and more efficient healthcare delivery. Its adoption in medical stores can significantly reduce operational burdens, improve accuracy, and enhance patient trust. With continued refinement and integration of AI and machine learning algorithms, this system can evolve into a fully autonomous, predictive, and adaptive healthcare solution.

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This research work, titled “Smart Pill Dispenser Using IoT and Machine Learning,” aims to assist patients and caregivers in ensuring accurate and timely medication intake through automation and intelligent monitoring. The facilities, mentorship, and academic environment provided by the institute have been instrumental in the successful completion of this project.

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