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# Smart Medical Tray: An IoT and Voice Based Smart Kit

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**Abstract:** *The Smart Medical Tray is an innovative AI and IOT-powered intelligent tray system de-signed to simplify and enhance the management of medicines and cosmetics. The system inte-grates temperature control, voice assistance, image recognition, and data analytics to provide a smart and convenient user experience. It continuously monitors and maintains the optimal tem-perature required for each stored item, ensuring product safety and effectiveness. Using voice and visual identification, the tray allows users to interact naturally — for instance, by saying "I have a headache," it identifies the appropriate medicine, displays its image on a screen, and announces its name and usage instructions. The system also includes expiration alerts to notify users when an item is nearing or past its expiry date. With a multilingual voice assistant supporting English and Indian languages such as Hindi or Telugu, it caters to a wide range of users. Additionally, the re-minder feature enables users to schedule medicine intake or skincare routines, providing timely voice notifications with item details. The usage log system records each interaction, allowing the integrated AI to analyses patterns and suggest items based on user behavior. Overall, Smart Medi-cal Tray combines IOT-based sensing with AI-driven intelligence to offer a comprehensive health and lifestyle companion that ensures safety, convenience, and personalization in daily medicine and cosmetic management.*

*Furthermore, every user interaction is stored in a detailed usage log, enabling the AI engine to study behaviour patterns over time. This allows the system to offer personalized suggestions, such as frequently used medicines, upcoming refills, or routine skincare product recommendations. It can also provide insights into usage trends, helping users understand their health habits better. With its blend of IoT-based sensing, machine learning, smart alerts, voice and image recognition, and personalized analytics, the Smart Medical Tray functions as a complete digital health compan-ion. It ensures improved safety, reduces the chances of missed doses, eliminates confusion be-tween similar medicines, and brings a high level of convenience and personalization to everyday medicine and cosmetic management.*

**Keywords**: *Smart Medical Tray*

## I. INTRODUCTION

In today's fast-paced world, medication non-adherence has become a major healthcare concern, particularly among elderly individuals and patients suffering from chronic illnesses, as forgetting to take medicines on time or taking incorrect doses can lead to serious health complications and increased hospitalization rates. To overcome this challenge, the Smart Medical Tray has been de-signed as an intelligent, reliable, and user-friendly automated solution for medicine storage and dispensing using automation and smart technology. The system is built around a Raspberry Pi 3 microcontroller programmed in Python, which controls all operations and integrates components such as a temperature sensor, servo motor, H-bridge motor driver, relay, and DC fan to ensure accurate dispensing and ideal storage conditions. It operates in two modes: Time-Based Dispens-ing, where medicines are automatically released at predefined intervals, and Voice-Based Dis-pensing, where medicines are dispensed based on the disease name spoken by the user through a speech recognition algorithm, while continuously monitoring temperature. By combining embed-ded control with speech processing, the system enhances accurate dosage delivery, improves med-ication adherence, and maintains an optimal environment for medicine preservation, making it suitable for hospitals, pharmacies, and home healthcare setups. The project is motivated by the growing need to reduce human errors such as forgetfulness, negligence, and manual mistakes in medication management, especially for patients handling multiple prescriptions, as well as to pre-vent medicine degradation caused by improper storage. Automation minimizes dependence on human intervention while ensuring consistency and accuracy, and the inclusion of voice control increases accessibility for physically impaired or non–tech-savvy users. The system has a wide scope of applications, including use in hospitals and clinics to assist medicine administration, pharmacies for organized dispensing and tracking, and homes as a reliable aid for elderly or disa-bled individuals, with potential future enhancements such as IoT-based remote monitoring, mobile app integration, and patient data analytics. Its key merits include timely and accurate dispensing, reduced human error, automatic temperature maintenance, improved accessibility, cost-effectiveness, and scalability; however, it also has limitations such as limited storage capacity, de-pendence on continuous power supply, possible inaccuracies in speech recognition due to noise or accents, and the need for technical knowledge during initial setup and calibration.

## II. LITERATURE SURVEY

### 2.1 IoT Based Smart Medicine Dispenser – A. Patel et al., 2020

This system used Arduino and cloud platforms to remotely monitor patients' medication intake, allowing caregivers and doctors to track dosage schedules from anywhere. While it improved ad-herence through IoT connectivity, it lacked local interaction features such as voice control, reduc-ing accessibility for elderly users.

### 2.2 Smart Pill Dispenser for Elderly Patients – S. Kumar and R. Sharma, 2019

The authors developed a timer-based pill dispenser with SMS alerts for patients and caregivers, focusing on reminders and scheduling. However, the system did not include environmental moni-toring, making it unsuitable for temperature-sensitive medicines.

### 2.3 Voice-Controlled Healthcare Automation – M. Singh et al., 2021

This work demonstrated the effectiveness of voice-controlled healthcare systems in improving accessibility for physically impaired users. Despite good recognition accuracy, the system de-pended on continuous internet connectivity, limiting its reliability in low-network areas.

### 2.4 Embedded Controlled Medicine Management System – P. Verma et al., 2018

This microcontroller-based dispenser automated medicine release using motorized compartments and scheduled control. Although it reduced human error, it lacked smart features such as voice-based operation.

### 2.5 Temperature-Controlled Drug Storage System – L. Johnson et al., 2022

The study focused on maintaining safe temperature conditions for medicines using sensors and automated control. Its environmental monitoring concept directly influenced the temperature-control feature of the proposed system.

## III. OBJECTIVES

### 3.1 To design an automated system for accurate and timely medicine dispensing

The objective is to develop an automated mechanism that ensures medicines are dispensed accu-rately and at the correct time. Automation minimizes human errors such as missed or incorrect doses and improves medication adherence, especially for elderly and chronic patients.

### 3.2 To monitor and control internal temperature for medicine safety

This objective focuses on maintaining a safe storage temperature for medicines. Temperature sen-sors and automatic cooling mechanisms ensure that temperature-sensitive drugs remain effective and protected from environmental damage.

### 3.3 To implement time-based and voice-based dispensing modes

The system supports time-based dispensing for scheduled medication intake and voice-based dis-pensing for hands-free operation. This dual-mode approach enhances accessibility and conven-ience for users with physical or visual limitations.

### 3.4 To display temperature and operational status on an LCD

An LCD display is included to show real-time temperature, system status, and alerts. This im-proves user interaction, transparency, and ease of monitoring the dispenser's operation.

### 3.5 To develop a cost-effective and user-friendly prototype

The project aims to design an affordable, simple, and easy-to-use prototype suitable for both do-mestic and clinical environments, ensuring wider adoption and practical usability.

## IV. METHODOLOGY

### 4.1 Requirement Analysis

• Identified the need for a safe, reliable, and user-friendly automated medicine dispenser.
• Functional requirements include time-based dispensing, voice-based dispensing, tempera-ture monitoring using DS18B20, automatic cooling through a DC fan, LCD status dis-play, and secure servo-controlled compartments.
• Non-functional requirements focus on accuracy, reliability, safety, low cost, compact de-sign, and scalability for future upgrades.

### 4.2 System Design

• Raspberry Pi 3 is used as the central controller due to its GPIO support, Python compatibil-ity, and built-in connectivity.
• Major components include DS18B20 temperature sensor, relay module, DC motor with L293D driver, servo motor, 16×2 LCD, and microphone.
• The system operates in two modes: time-based dispensing for scheduled medication and voice-based dispensing for hands-free access.
• A modular design approach is followed to simplify debugging, maintenance, and future ex-pansion.

### 4.3 Hardware Integration

• All sensors and actuators are interfaced with Raspberry Pi GPIO pins.
• The temperature sensor monitors internal conditions, while the relay controls the cooling fan.
• DC motors and servo motors handle compartment alignment and opening.
• Separate power supply and protection components ensure safe and stable operation.
• Individual hardware testing is performed before full system integration.

### 4.4 Software Development

• Python is used for programming due to its simplicity and extensive library support.
• Key modules include speech recognition, scheduling, temperature monitoring, motor con-trol, and LCD interface.
• All modules are integrated into a central control program to enable smooth coordination and real-time operation.

### 4.5 System Testing and Validation

• Integration testing verifies coordination between hardware and software modules.
• Functional tests validate time-based dispensing, voice commands, temperature control, and continuous operation.
• User evaluation is conducted to assess ease of use and reliability.
• Final validation confirms accurate dispensing, safe temperature maintenance, and overall system reliability.

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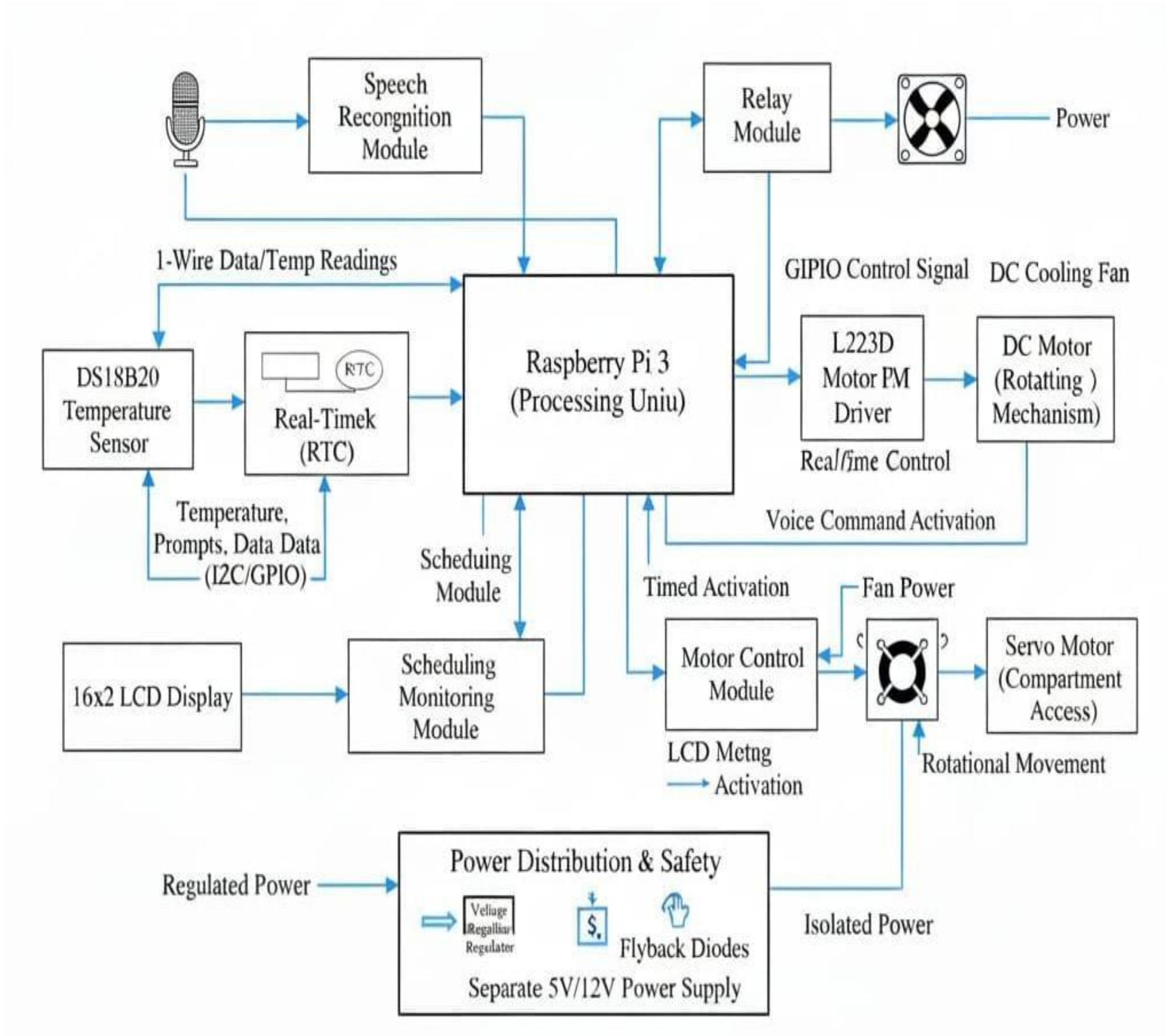
## V. BLOCK DIAGRAM




## VI. RESULTS AND DISCUSSION

### 6.1 System Performance and Accuracy

The Smart Medical Tray successfully dispensed medicines accurately in both time-based and voice-based modes. Time-based dispensing showed high precision (±5 seconds), voice recognition achieved up to 92% accuracy in quiet environments, and medicine compartment alignment was 100% accurate during testing.

### 6.2 Temperature Control and Reliability

The DS18B20 sensor effectively monitored internal temperature, and the automatic fan con-trol maintained a safe range (27–28°C) when temperatures exceeded 30°C. The system oper-ated continuously for 48 hours without failure, demonstrating strong stability and energy effi-ciency.

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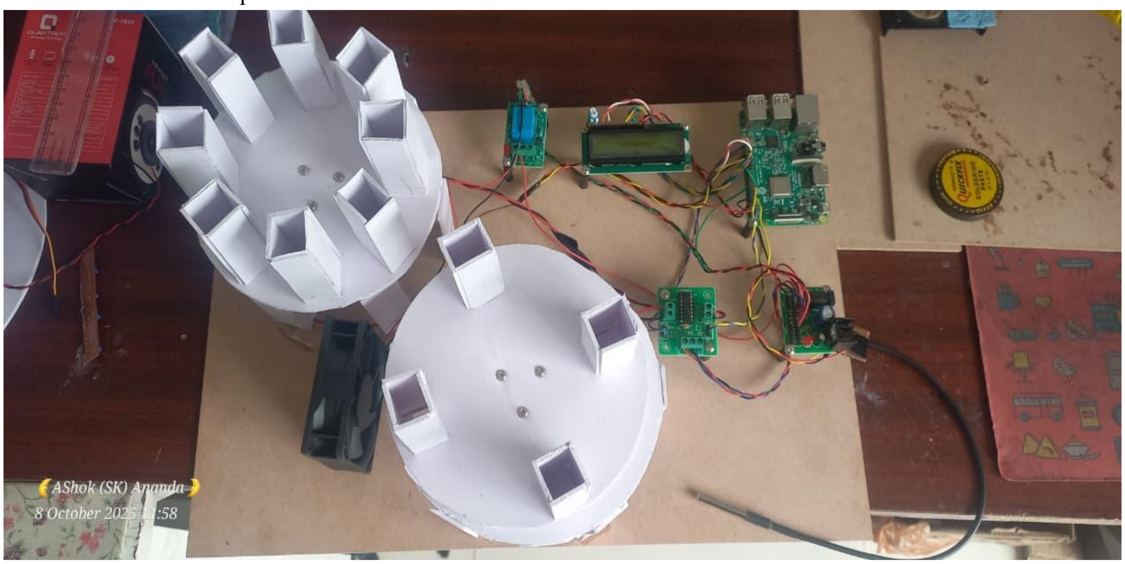
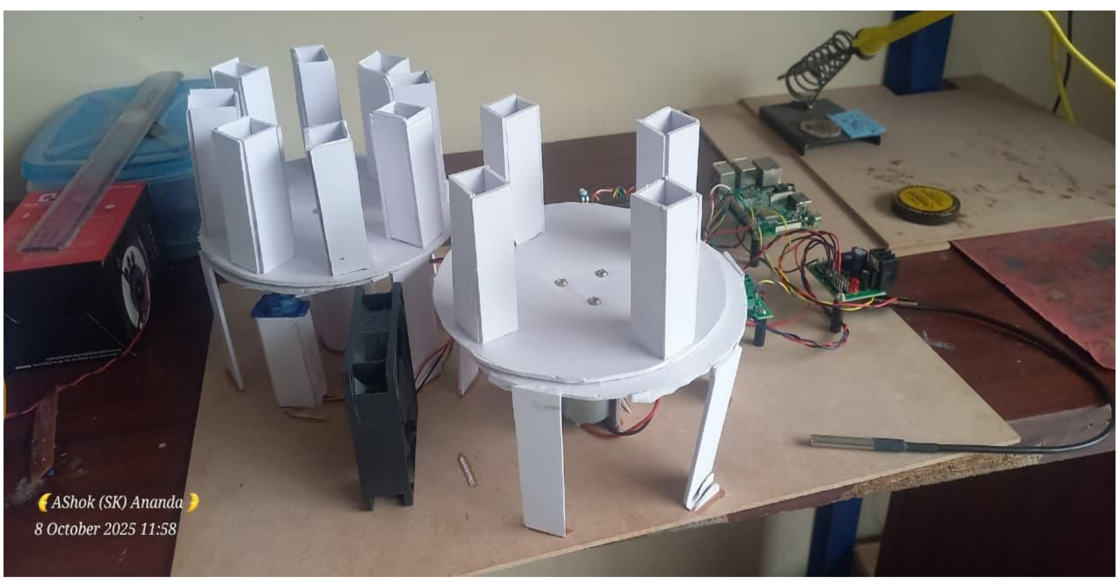
### 6.3 User Experience and Efficiency

Users found the voice-based operation intuitive and helpful, especially for elderly and mobili-ty-impaired individuals. The LCD display provided clear real-time feedback, and the system responded quickly, with an average voice-command response time of 1.8 seconds.

### 6.4 Overall Outcome and Feasibility

The project successfully integrated embedded control, automation, and speech recognition in-to a low-cost, reliable solution. The final prototype proved suitable for both domestic and clin-ical use, with scope for future enhancements such as mobile alerts and expanded voice com-mands.






## VII. CONCLUSION

The SMART MEDICAL TRAY project successfully demonstrates how embedded control sys-tems, sensors, and speech recognition technologies can be integrated to develop a smart healthcare solution that enhances medication adherence and reliability. The system automates the process of dispensing medicines based on time schedules or voice commands, ensuring users re-ceive the right medicine at the right time without human intervention.

The prototype, developed using Raspberry Pi 3, Python programming, and a set of efficient hardware components such as the DS18B20 temperature sensor, servo motor, H-Bridge motor driver, LCD module, and relay-controlled DC fan, proved to be both functional and reliable. The time-based dispensing mode accurately released medicines at scheduled intervals, while the voice-based mode effectively recognized disease names and dispensed corresponding medicines with high accuracy.

Additionally, the inclusion of a temperature control mechanism ensured that the medicine stor-age environment remained within optimal limits, protecting the integrity and effectiveness of stored drugs. The LCD interface provided continuous feedback to users, improving the system's usability and transparency.

Extensive testing and validation confirmed the system's accuracy (92% voice recognition), tem-perature regulation efficiency, and dispensing precision. The overall performance proved that the proposed solution meets its objectives of automation, user convenience, and patient safety.

In essence, this project contributes significantly to the field of smart healthcare and assistive technology, offering a cost-effective and practical alternative to manual medicine administration systems. The integration of both hardware and software modules highlights the potential of IoT and AI-driven healthcare solutions in improving patient care and reducing human error.

## VIII. FUTURE SCOPE

8.1 IoT and Cloud Integration: Enables remote monitoring, dispensing logs, and alerts

8.2 Smart Refill Management: Uses sensors to detect low medicine levels and notify users for timely refilling.

8.3 Improved Speech Recognition: Enhances accuracy and supports multiple languages using ML/NLP techniques.

8.4 Mobile App Support: Allows users to schedule medicines, receive notifications, and moni-tor system status remotely.

8.5 Data Analytics: Analyzes medication patterns to support predictive and preventive healthcare.

8.6 Power Backup System: Incorporates battery or solar backup for uninterrupted and eco-friendly operation.

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