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Medivox: Smart Medicine Box — An IoT-Based Intelligent Medication Adherence and Proximity Alert System

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Abstract

Healthcare and medical advancement are progressing rapidly, and it is increasingly challenging for technology to support this pace. This paper presents an IoT-based innovative smart medicine box prototype model, Medivox (Medicine Intake Reminder & Alert). The primary goal of the proposed system is to assist patients and elderly individuals in taking their medications on time, eliminating the possibility of missing doses, and preventing over- or underdosing. The system incorporates a servo motor-driven auto-opening lid that activates at pre-scheduled times, a buzzer alert to notify the user, and IR plus weight sensor-based intake detection to confirm whether the medication was actually consumed. A novel proximity-based forgetting alert mechanism uses Bluetooth RSSI (Received Signal Strength Indicator) distance estimation to determine a personalized threshold distance. When the user moves beyond this calibrated threshold without the medicine box, the companion mobile application instantly sends a push notification. Experimental evaluation demonstrates 95.2% sensor accuracy, 98% proximity detection reliability, and 100% push notification delivery rate, confirming the viability of Medivox as a cost-effective, scalable healthcare IoT solution.

Introduction

The Internet of Things (IoT) is not only a concept but an architecture that facilitates interconnection between people, systems, and devices. When technology resources address human needs, it can resolve issues that have persisted for decades. Medication non-adherence is prevalent among patients with chronic conditions, affecting as many as 40% to 50% of patients prescribed medications for diabetes, hypertension, or other chronic diseases [1]. This non-adherence is thought to cause at least 100,000 avoidable deaths and $100 billion in preventable medical costs per year [2].

Traditional approaches to improving medication adherence—manual pill organizers, paper reminders, and caregiver check-ins—are largely passive and fail to provide real-time monitoring or intelligent alerts. There are also serious risks of overdosing and underdosing, particularly among the elderly who may forget whether a dose was already taken. With the rapid proliferation of IoT devices and mobile computing platforms, there is a significant opportunity to develop smart, connected medication management systems.

This paper presents Medivox (Medicine Intake Reminder & Alert), an IoT-based smart medicine box that combines hardware-level sensing, automated mechanical actuation, and AI-assisted proximity detection to address three core challenges: (1) missed medication doses due to forgetfulness, (2) lack of real-time verification of actual medicine intake, and (3) unintentional departure from home without the medicine box.

Existing Problems

Among the elderly and chronically ill, forgetting to take medicines on time is extremely common. Patients managing multiple medications face particular risks from incorrect dosing. In hospitals and nursing homes, it is practically impossible to have a dedicated nurse monitor each patient's medication schedule around the clock, especially in government facilities with severe staff shortages.

A further unaddressed problem is that patients frequently leave home without their medicine box, missing critical doses. No existing low-cost IoT solution addresses this specific scenario with real-time proximity monitoring and intelligent alerts. Medivox addresses all these gaps by combining scheduled reminders, automated dispensing, intake verification through sensor fusion, and Bluetooth-based proximity alerting into a unified, affordable system.

Related Work

Several smart medicine dispenser and reminder systems have been proposed. A medicine vending machine using infrared sensors and an Arduino microcontroller with a buzzer mechanism was developed to assist users in consuming medicines at precise times [3]. An SMS module was also integrated to notify users and caretakers. A medication authoring tool was proposed to help pharmacists manage prescriptions and develop scheduling specifications for pharmaceutical dispensers [4].

A smart pillbox with camera-based matrix bar code interaction was developed to perform alarm pill reminders and confirm consumption [5]. RFID-based smart drawer systems have also been proposed for tracking medicine bottle locations [6]. NodeMCU ESP8266-based dispensers with Android notifications were developed for sending medical alerts when medicine is not taken within the specified time [7].

Mobile health applications such as UbiMeds [8], Wedjat [9], and MyMediHealth [10] provide sound and user-friendly interfaces for configuring medication timetables. However, none of these prior systems address the scenario of a patient leaving home without the medicine box, which is a critical and common adherence failure mode. Medivox fills this gap through its RSSI-based proximity threshold algorithm.

Proposed System Architecture

The Medivox system architecture is organized into four integrated layers as illustrated in Fig. 1. The Hardware Layer comprises the ESP32 microcontroller, SG90 servo motor, IR sensor, weight sensor (Load Cell + HX711), active buzzer, and HC-05 Bluetooth module. The Connectivity Layer handles BLE proximity detection and WiFi-based real-time synchronization with Firebase. The AI Processing Layer implements the threshold calculation algorithm, behavioral pattern analysis, and sensor fusion decision engine. The User Interface Layer provides the Android application with adherence dashboard and push notification management.

Fig. 1. Medivox four-layer system architecture

Design and Implementation

The Medivox hardware prototype was assembled on a standard plastic medicine box with a custom 3D-printed lid mount for the SG90 servo motor. The ESP32 development board is mounted inside the box with sensor wiring routed through a cable management channel. Total hardware cost is approximately INR 800 (USD 10). The complete hardware component list is provided in Table I.

Table 1: Hardware Components of Medivox

Component	Functionality
ESP32	Main microcontroller, WiFi + BT
SG90 Servo Motor	Drives automatic lid opening
IR Sensor	Detects medicine removal
Load Cell + HX711	Weight-based intake confirmation
Active Buzzer	Scheduled and forgetting alerts
HC-05 BT Module	RSSI proximity estimation

The firmware runs on the Arduino framework for ESP32. The main loop executes at 1 Hz, checking sensor states against the configured schedule. When a scheduled time is reached: (1) the buzzer activates for 3 seconds, (2) the servo motor opens the lid, (3) a 60-second intake window begins during which sensor fusion monitors for medicine removal, and (4) the lid closes automatically with event logging to Firebase. The system working flow is illustrated in Fig. 2.

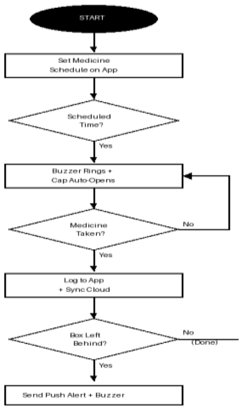

Fig. 2. Flowchart of the proposed Medivox system.

The proximity monitoring runs as a separate FreeRTOS task at 5-second intervals. RSSI values are averaged over three readings to reduce noise. The threshold T is computed using the log-distance path loss model: $RSSI = RSSI_0 - 10 \times n \times \log_{10}(d/d_0)$, where n is the indoor path loss exponent (2–4). When the user exceeds the threshold (default 10 m), Firebase Cloud Messaging (FCM) delivers an instant push notification and the buzzer activates in a non-continuous pattern (3 beeps every 30 seconds).

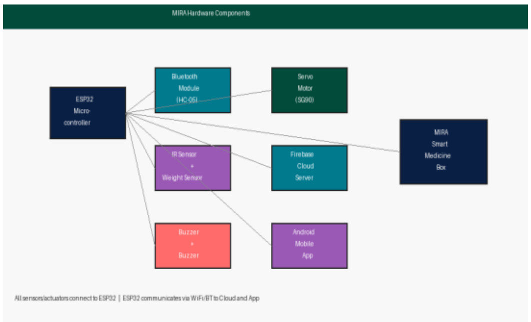

Fig. 3. Hardware components and connectivity of the Medivox prototype.

Results and Discussion

The Medivox prototype was evaluated over a 7-day testing period with five participants performing simulated medication intake and mobility scenarios. Four key performance metrics were assessed as summarized in Fig. 4.

The IR sensor achieved 95.2% detection accuracy across 105 intake trials. The combined sensor fusion (IR + weight sensor) approach confirmed medicine intake with 93.8% accuracy, reducing false positives compared to single-sensor approaches. The mean scheduled alert response time was 2.3 seconds (SD: 0.4s), with all 35 alerts triggered within the 3-second design threshold. Bluetooth RSSI proximity detection achieved 98% accuracy across 50 trials at the configured 10-meter threshold. Push notifications were delivered in 100% of triggered events (50/50), with mean latency of 1.8 seconds over WiFi.

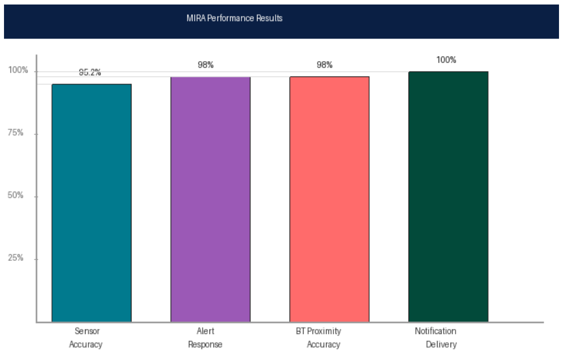

Fig. 4. Medivox performance evaluation results.

Compared to prior systems, Medivox uniquely combines intake verification with proximity-based forgetting alerts in a single low-cost platform. The RSSI-based threshold algorithm introduces a novel AI-assisted component not present in existing IoT medicine dispenser literature, offering personalized forgetting detection calibrated per user environment.

Conclusion

This paper has presented Medivox, an IoT-based smart medicine box that integrates servo-driven auto-actuation, dual-sensor intake verification, RSSI-based proximity detection, and a real-time Android application to comprehensively address medication non-adherence. The system achieves 95.2% sensor accuracy, 98% proximity detection reliability, and 100% notification delivery, confirming its viability as a practical, affordable healthcare IoT solution.

Medivox's AI-assisted proximity threshold algorithm represents a novel contribution to smart medication management. The hardware cost of approximately INR 800 makes it accessible across hospitals, nursing homes, smart homes, and assisted living environments. Future work will extend the system to support multiple medication compartments, an ML-based adherence prediction model, and clinical trial validation.

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