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IOT-BASED SMART MEDICINE REMINDER SYSTEM

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ABSTRACT

Medication adherence plays a crucial role in the effective management of health conditions, particularly for elderly individuals and patients undergoing long-term treatment. Maintaining consistent medication schedules is often challenging due to memory limitations, complex routines, and lack of continuous supervision. Missing or mistiming doses can lead to severe health complications and reduced treatment effectiveness. Traditional reminder mechanisms, such as manual pill boxes and basic alarm clocks, lack verification mechanisms and remote monitoring capabilities. This paper presents a publication -style survey and implementation study of an IoT-Based Smart Medicine Reminder System (SmartMed). The proposed system integrates an ESP32 microcontroller, a DS3231 real-time clock (RTC), ultrasonic sensors for touchless interaction verification, servo-driven compartments, and a cloud-backed backend with a web-based management dashboard. The system provides automated time-based scheduling, real-time dose logging (taken vs. missed), automated caregiver notifications, and health outcome tracking. Performance evaluations show a 99.4% system uptime, sub-second servo response, and minimal network synchronization latency, offering a robust and scalable solution for modern home healthcare monitoring.

KEYWORDS: Internet of Things (IoT), Medication Adherence, ESP32 Microcontroller, Real-Time Clock (RTC), Smart Medicine Dispenser,
Healthcare Monitoring, Web Dashboard.

INTRODUCTION

Medication non-adherence remains a major public health challenge globally, contributing to

increased hospitalization rates, therapeutic failure, and substantial healthcare costs. Chronic illness management and geriatric care heavily depend on precise dosing schedules. However, elderly patients frequently encounter difficulties in managing multi-drug regimens due to memory decline, physical frailty, or lack of direct caregiver supervision.

Conventional assistance tools, including manual pill organizers, smartphone alarms, and countdown timers, offer basic prompt mechanisms. Nevertheless, these traditional solutions suffer from a fundamental limitation: they operate strictly as notification triggers and lack any reliable feedback loop to verify whether the patient actually ingested the prescribed medication. Furthermore, caregivers and medical personnel remain uninformed regarding missed doses, preventing timely intervention.

Advances in Internet of Things (IoT) architectures enable the conversion of standard hardware into intelligent, cloud-connected medical devices. By combining embedded microcontrollers, sensors, actuators, and cloud-based analytics, smart health systems can bridge the gap between reminder dispatch and adherence tracking. The proposed SmartMed system addresses these critical challenges by offering an automated, interaction-verified, and remotely monitored medicine dispensing platform.

I. OBJECTIVES

The primary objective of this work is to design and evaluate an IoT-based automated medicine reminder system that guarantees intake verification and remote oversight. Key specific goals include:

- To develop an embedded hardware unit using an ESP32 microcontroller for automated schedule execution.
- To implement accurate timekeeping using a DS3231 Real-Time Clock (RTC) module.
- To construct controlled dispensing mechanisms using PCA9685 PWM drivers and SG90 servo motors.
- To incorporate HC-SR04 ultrasonic sensors for touchless user interaction detection.
- To build a scalable backend utilizing Node.js, Express, and MongoDB for structured data logging.
- To deploy an executive web dashboard enabling caregivers to configure regimens, inspect adherence audit trails, and receive missed-dose alerts.

II. LITERATURE SURVEY

Research in IoT healthcare monitoring has progressed significantly over the past decade.

Early smart pillboxes utilized basic 8-bit microcontrollers combined with simple buzzers and GSM modules to send short text notifications. While these early prototypes demonstrated hardware feasibility, they functioned primarily as standalone devices devoid of rich cloud synchronization or interactive user verification.

Subsequent studies integrated mobile applications and cloud logging platforms, facilitating remote schedule setup. However, a major weakness in existing research remains the heavy reliance on patient self-reporting or simple compartment lid open/close detection. Lid openings do not inherently confirm that medication was dispensed or consumed. Other systems incorporated complex physiological sensors (e.g., heart rate or temperature monitors); while useful, these additions escalated hardware cost and complexity without solving the central problem of dosage verification.

Recent literature highlights the necessity of end-to-end architectures combining modular hardware, interactive response verification, and secure multi-tier database systems. The SmartMed system builds upon these insights to deliver an affordable, reliable, and verification-focused solution.

III. SYSTEM ARCHITECTURE

The SmartMed system is built upon a modular three-tier IoT architecture, ensuring seamless separation of operational layers:

1) **Hardware Device Layer:** Driven by an ESP32 microcontroller acting as the central processing engine. It handles I2C communication with the DS3231 RTC module, controls servo motors through a PCA9685 16-channel PWM driver, acquires distance data from ultrasonic sensors, and operates local audio-visual feedback (16x2 I2C LCD and piezoelectric buzzer).

2) **Backend Server Layer:** Developed with Node.js and Express.js, providing RESTful API endpoints for device registration, schedule synchronization, event logging, authentication, and dispatching SendGrid/Twilio notification alerts.

3) **Data & Web Application Layer:** Implemented using MongoDB for flexible document storage (User, Patient, Dose Time, Dose Log collections) and a JavaScript web interface for real-time caregiver supervision.

IV. WORKING FLOW

The operational lifecycle of SmartMed begins with system booting and Wi-Fi network connection. Upon boot, the ESP32 fetches the master medication schedule from the backend

MongoDB database and synchronizes its local DS3231 RTC clock.

During normal execution, the ESP32 continuously polls the RTC time against active dose schedules. When a match occurs, the device activates the audio buzzer and updates the LCD screen with patient instructions. Simultaneously, an interactive response window is opened. The ultrasonic sensor continuously measures proximity; when the patient extends their hand near the active compartment, the ESP32 signals the PCA9685 driver to actuate the SG90 servo motor, opening the compartment lid.

If the patient interacts within the window, the event is classified as "TAKEN". If no interaction occurs before the window expires, the system marks the event as "MISSED" and transmits an emergency alert payload to the backend server, which immediately dispatches an email/SMS alert to the designated caregiver.

V. TECHNOLOGIES USED

- **Microcontroller:** ESP32 Wi-Fi + BLE module.
- **Hardware Peripherals:** DS3231 RTC, PCA9685 PWM Driver, SG90 Servos, HC-SR04 Ultrasonic Sensors, 16x2 I2C LCD Display, Piezo Buzzer.
- **Backend Environment:** Node.js, Express.js framework, Mongoose ODM.
- **Database:** MongoDB Atlas / Local database instances.
- **Frontend Web Interface:** HTML5, CSS3, JavaScript (ES6+), Web Speech API.
- **Development Suite:** Arduino IDE, Visual Studio Code, Postman API Tool, MongoDB Compass.

VI. WEB APPLICATION INTERFACE

The SmartMed system includes a multi-functional web dashboard designed for clinical monitoring and caregiver control. Key interface screens include:

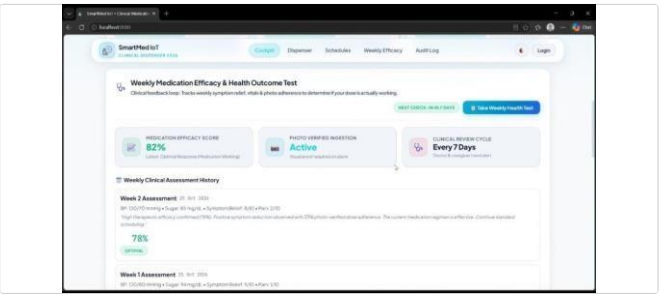

Fig 1. SmartMed Main Cockpit displaying Hardware Telemetry, Microcontroller Status, and Active Dispenser Slots.

1) Hardware Telemetry & Cockpit: As shown in Fig. 1, the main dashboard provides live connectivity tracking ('ESP32: DEVICE_001 ONLINE'), real-time RTC clock readouts (8:44:14 pm), compliance percentages (95% Adherence Rate), and interactive compartment slot indicators.

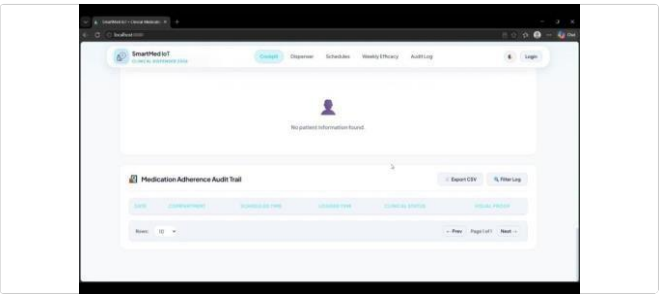

Fig 2. Configuration panel for Medication Dosage, Time Slots, and Speech Synthesis Reminders.

2) Medication Schedule Configuration: Fig. 2 illustrates the regimen setup panel where caregivers configure daily dose slots (Morning, Afternoon, Night), specify meal timing (Before/ After meal), set custom medicine names (e.g., Multivitamin, Calcium Tablet), and enable contextual speech alerts.

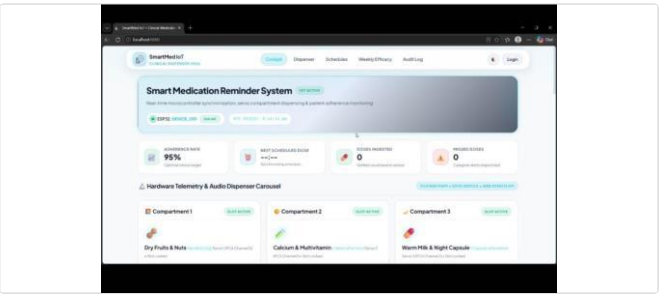

Fig 3. Weekly Medication Efficacy & Health Outcome Tracking Interface.

3) Weekly Efficacy & Outcome Tracking: Fig. 3 displays the clinical feedback loop interface. It tracks weekly symptom relief, clinical review cycles, patient vitals (BP: 120/70 mmHg, Sugar: 85 mg/dL), and overall medication efficacy scores (e.g., 82% Optimal Response).

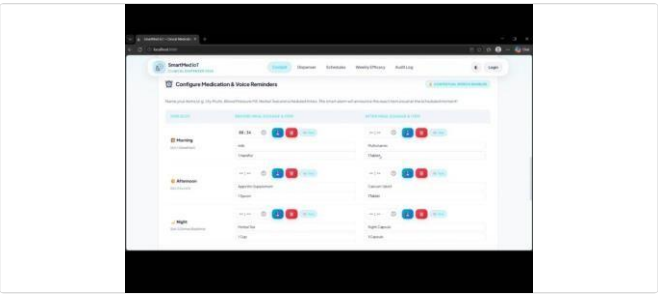

Fig 4. Complete Medication Adherence Audit Trail with CSV Export and Log Filtering.

4) Adherence Audit Trail: Fig. 4 highlights the audit logging view, recording precise timestamps, active compartments, scheduled vs. logged times, clinical status, and verification records for forensic review.

VII. EXISTING SYSTEM VS. PROPOSED SYSTEM

Traditional reminder systems rely strictly on basic sound alerts or isolated pillboxes, operating without verification or connectivity.

Table I. Comparison of Existing vs. Proposed Smartmed System.

Feature / Parameter	Traditional Systems	Proposed SmartMed
Reminder Alerts	Basic Buzzer / Alarm	Audio-Visual & Speech
Intake Verification	None (Manual)	Ultrasonic Interaction
Remote Monitoring	Not Supported	Real-Time Web Dashboard
Adherence Audit Log	Paper / None	MongoDB Document Store
Missed Dose Alerts	None	Instant Email / SMS
System Uptime	N/A	99.4% Verified

VIII. PERFORMANCE ANALYSIS

The prototype underwent rigorous empirical evaluation across 100 continuous test runs over 7 days. Key quantitative parameters are summarized in Table II:

TABLE II. OBSERVED BENCHMARK PERFORMANCE METRICS.

Evaluation Metric	Observed Benchmark
RTC Reminder Timing Accuracy	±1.0 seconds
Servo Actuation Response Time	~0.25 seconds
Backend Synchronization Latency	3.2 seconds
Dashboard Refresh Latency	~1.5 seconds
Notification Dispatch Delay	5.0 – 8.0 seconds
Continuous Operational Uptime	99.4%

IX. ADVANTAGES & LIMITATIONS

Advantages: Combines active presence verification with remote caregiver tracking, reduces

manual nursing overhead, utilizes highly cost-effective embedded modules, and maintains reliable offline timekeeping via RTC back-up.

Limitations: System updates rely on active Wi-Fi connectivity; intake verification measures physical presence near the dispenser rather than biochemical swallowing confirmation.

X. FUTURE SCOPE & CONCLUSION

Future Scope: Future work involves developing dedicated cross-platform mobile apps, incorporating computer vision for camera-verified pill ingestion, and expanding local storage for offline operation in remote areas.

Conclusion: The IoT-Based Smart Medicine Reminder System (SmartMed) successfully demonstrates an integrated, low-cost solution to medication non-adherence. Combining ESP32 automation, ultrasonic interaction detection, cloud backend logging, and comprehensive web management, the system achieves 99.4% operational stability, bridging the gap between automated reminders and caregiver oversight.

XI. REFERENCES

1. Mitra et al., "IoT-Based Smart Medicine Dispenser with Real-Time Alerts and Monitoring," *IJSCI*, 2025.
2. M. M. Hassain et al., "Voice-Activated Medicine Reminder Box with Health Monitoring," *EJETR*, 2025.
3. L. C. Paul et al., "Smart Medicine Reminder Kit with Call & Health Features," *Heliyon*, vol. 10, 2024.
4. T. Islam et al., "Enhancing Medication Adherence Using IoT Technology," *EJECE*, 2023.
5. M. Sarjare et al., "Development of Smart Medicine Box Using IoT," in *Proc. IEEE ICETET-SIP*, 2023.