ISSN 2277-2685
IJESR/April-June. 2025/ Vol-15/Issue-2/834-841
P. Lavanya *et. al.*, / International Journal of Engineering & Science Research

An IoT-Based Medicine Dispenser Machine with Adherence Tracking

N. Nagamani[1], J. Sujatha[2], Ranganath Sarath M[3], P. Lavanya[4], T. Mythili[5], S. Varshitha[6]
[1,2,3]Assistant Professor, Department of Electronics and Communication Engineering
[4,5,6]UG Student, Department of Electronics and Communication Engineering
Avanthi Institute of Engineering & Technology, Tamaram, Makavarapalem, Anakapalli District – 531113, Andhra Pradesh, India

Abstract
This paper presents an IoT-based medicine dispenser that automates medication reminders, dispensing and adherence tracking. A circular container divided into three compartments holds different medicines, and dispensing times are set from a mobile application or web panel. At each scheduled time the system sounds a buzzer to remind the user. The user must place a hand below the dispenser to confirm they are ready, which an infrared sensor detects; only then does a stepper motor rotate the container to the correct compartment and a servo motor release the tablet. Requiring this confirmation is the design decision that separates the system from a reminder device: a tablet released into an empty tray tells nobody whether it was taken, whereas a tablet released only after a hand is detected produces a record of an actual interaction. If no hand appears within the confirmation window, the dose is logged as missed and an alert is sent to the application, so a caregiver can act on it remotely. Schedules and dispensing records are held in Firebase Firestore, giving real-time synchronization between the device and the application, and a seven-day record of consumption supports adherence tracking. The system is built on an ESP32 microcontroller and is intended for elderly patients, people managing chronic conditions, and the caregivers who support them.

Index Terms: *Adherence monitoring, ESP32, Firebase, healthcare automation, Internet of Things, IR sensor, medicine dispenser, servo motor, stepper motor.*

I. Introduction

Taking medication on schedule is a critical part of treating chronic disease and maintaining health, particularly for elderly patients and those with memory-related conditions. Inconsistent intake through forgetfulness or improper administration leads to ineffective treatment or worsening health. The Internet of Things offers a way to address this by bringing automation into everyday healthcare management.

An IoT-based medicine dispenser automates the dispensing process, providing timely reminders and dosage accuracy. It removes the need for manual handling and supports remote monitoring, which gives the user independence while giving a caregiver visibility. The system is built around an ESP32 microcontroller with servo and stepper motors, an infrared sensor, a buzzer, and real-time communication with Firebase for data management.

A. Overview

The dispenser holds medicines in a box divided into three compartments, managed through a combination of servo and stepper motors. The ESP32 controls the components and connects to the internet for Firebase synchronization. It continuously monitors preset schedules fetched from Firestore, Firebase's NoSQL database. At the scheduled time it triggers a buzzer to alert the user. If the user places a hand below the dispenser, detected by the IR sensor, the stepper motor rotates to the correct compartment and the servo releases the pill. If the user does not respond within the confirmation window, the system records a missed dose and writes an alert to the cloud database for remote tracking.

B. Existing System

Medicine management today is largely manual. Users rely on alarms, phone reminders or pill organizer boxes. These approaches share four limitations. They lack automation: the reminder still requires the user to pick and consume the medicine, with no confirmation that it happened. They offer no remote monitoring, so caregivers or doctors cannot know whether a dose was taken unless they are present. They leave room for human error, with doses missed or the wrong medication taken through confusion. And they provide no inventory tracking, so a user is not told when a compartment is empty until they find it so.

Some smart pillboxes exist commercially, but they are expensive, not customizable, and not integrated with real-time database systems for remote updates or analytics, which limits their scalability and affordability.

C. Proposed System

The proposed system combines hardware with cloud integration to automate dispensing, user interaction and data tracking. Stepper motors rotate to the designated slot and servo motors dispense the medicine, giving precision in both position and timing. The ESP32 polls Firestore for schedule updates and activates the buzzer at the scheduled time. The IR sensor verifies the presence of a hand before the tablet is released, ensuring the medicine is not dropped into an unattended tray. Firestore handles real-time reading and updating of schedules, dispensing records and missed-dose alerts, allowing remote monitoring through web or mobile applications. Built from affordable components, the design is suited to individual use or deployment in elder care homes.

II. Literature Survey

Early automated pill dispensers were mechanical or electromechanical devices using internal timers to alert users and open compartments. They functioned as reminder tools rather than complete solutions: they had no internet connectivity, no real-time data tracking and no adaptive behaviour. Some commercial products offered modular compartments for multiple medications but could not track whether the medicine was actually taken.

Researchers have used microcontrollers such as Arduino and Raspberry Pi to build semi-smart medicine boxes, typically with alarms or buzzers activating at set times and LEDs indicating which medicine to take. Most were stand-alone with no remote access. The arrival of ESP8266 and ESP32 microcontrollers, with built-in Wi-Fi, opened up real-time communication with servers and mobile applications, which is what makes remote adherence tracking practical at this price point.

Studies have shown the effectiveness of IoT in healthcare for patient vitals monitoring, fall detection and remote consultation. The advantage of IoT is its ability to collect data, process it locally or remotely, and return meaningful feedback to users or providers. Applied to medication management, IoT devices have collected data on dosage timing and patient interaction which can then be analysed to improve adherence.

Human presence detection through infrared and ultrasonic sensors is common in automation. In dispensers, IR sensors have been used to confirm hand movement, ensuring medicine is taken rather than simply released. Such feedback lets a system distinguish between a successful and a missed dose, which is the distinction that makes adherence data meaningful.

Cloud platforms such as Firebase have made real-time data handling accessible. Firestore allows secure, scalable communication between hardware and software interfaces, and projects integrating Firebase with ESP32 have demonstrated real-time control and data logging in home automation, surveillance and smart agriculture. In healthcare this enables dosage history tracking, alert generation and mobile connectivity that traditional embedded systems could not provide.

Despite this progress, few systems combine real-time cloud connectivity, automated dispensing with physical confirmation, remote logging of adherence data, alerts to both user and caregiver on a missed dose, and affordable hardware suitable for home deployment. Bringing these together in one unit is what the present work addresses.

III. Hardware

A. ESP32 WROOM

The ESP32 WROOM is a low-power system-on-chip with integrated Wi-Fi. It is the controller: it polls Firestore for the schedule, drives the buzzer, reads the IR sensor, commands the motors and writes dispensing records back to the database. Integrated Wi-Fi is what allows a single board to handle both the mechanical control and the cloud connection.

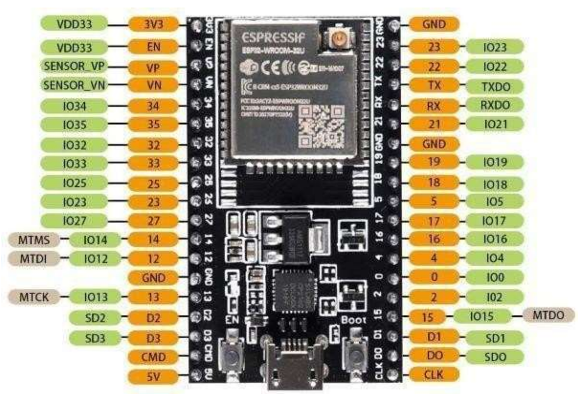

Fig. 1. ESP32 WROOM microcontroller.

B. Stepper Motor and Servo Motor

The two motor types perform different jobs. The stepper motor rotates in discrete steps, which lets the container be positioned at a specific compartment reliably without any position feedback — counting steps is sufficient. The servo motor, a rotary actuator with closed-loop position control, operates the release mechanism that drops a single tablet. Using a stepper for selection and a servo for release matches each motor to the property it is good at: repeatable indexing in one case, precise angular position in the other.

Fig. 2. Stepper motor and servo motor.

C. IR Sensor

The infrared sensor detects an object by reflected infrared light. Positioned below the dispensing outlet, it detects the user's hand and provides the confirmation signal that gates the whole dispensing action.

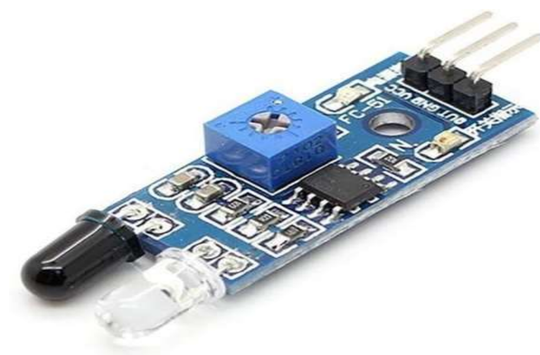

Fig. 3. IR sensor.

D. Buzzer and Power

The buzzer provides the audible reminder at each scheduled time, sounding for the duration of the confirmation window. A 7805 voltage regulator supplies the fixed 5 V rail, with transistors handling switching between the microcontroller outputs and the higher-current loads. The circuit is assembled on a breadboard, which allows the arrangement to be modified during development without rewiring.

Fig. 4. Buzzer and 7805 voltage regulator.

E. Tablet Container

A custom circular box divided into three compartments holds the medicines, with each compartment assigned to a specific medicine. The circular arrangement suits the stepper motor drive: selecting a compartment is a rotation to a known angle, and the container returns to any compartment by the same mechanism rather than needing a separate movement for each.

Fig. 5. Three-compartment tablet container.

IV. System Design

A. Block Diagram

The system structure is shown in Fig. 6.

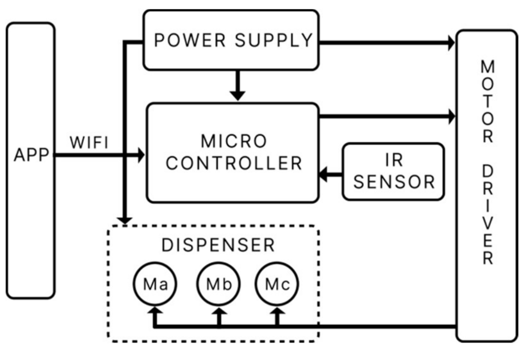

Fig. 6. Block diagram of the system.

B. Input Design

Inputs come from three directions. From the application, the user or caregiver enters medicine details, dispensing schedules and dosage information, with authentication controlling who can change them. From the hardware, the IR sensor supplies the hand-presence signal. From the cloud, the ESP32 reads schedule updates from Firestore, so a change made in the application takes effect on the device without any local reconfiguration.

C. Output Design

Outputs are similarly threefold. Physically, the buzzer sounds at the scheduled time and the motors rotate and release the tablet. To the cloud, the system writes a record of each dispensing event and each missed dose. To the user, the application displays the schedule, the dispensing history and any missed-dose alerts. Because the record is written whether the dose is taken or missed, the seven-day history shows adherence rather than merely showing that the device operated.

V. System Operation

In normal operation the ESP32 holds the current schedule fetched from Firestore and compares it against the current time. When a scheduled time arrives, the buzzer sounds and the system begins watching the IR sensor. If a hand is detected within the confirmation window, the stepper rotates the container to the compartment assigned to that medicine and the servo actuates to release a tablet. The event is written to Firestore with a timestamp.

If no hand is detected before the window closes, no tablet is released, the buzzer stops, and a missed-dose entry is written instead. Withholding the tablet in this case is deliberate: dispensing it anyway would leave a loose tablet in the tray, which is both a waste of medicine and a hazard if a second dose is later dispensed on top of it. The missed-dose entry propagates to the application, so a caregiver monitoring remotely sees the omission without needing to be present.

VI. Results

The assembled dispenser is shown in Figs. 7 to 9.

Fig. 7. Assembled medicine dispenser.

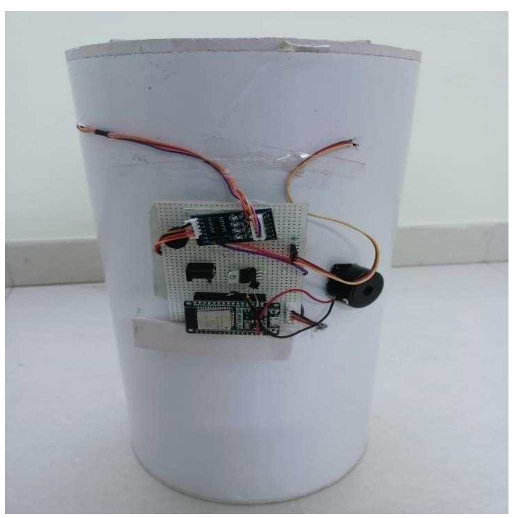

Fig. 8. Front view.

ISSN 2277-2685
IJESR/April-June. 2025/ Vol-15/Issue-2/834-841
P. Lavanya *et. al.,* / International Journal of Engineering & Science Research

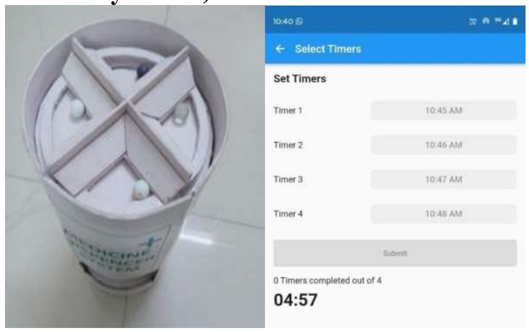

Fig. 9. Internal circuitry and top view.

The system dispensed correctly at the scheduled times set through the application. The buzzer sounded on schedule, the IR sensor detected the hand reliably at the intended distance, the stepper rotated to the assigned compartment, and the servo released a single tablet. Missed doses were logged when the confirmation window expired without a hand being detected, and the entries appeared in the application.

Two limitations bear noting. The IR sensor confirms that a hand was present, not that the tablet was swallowed, so the adherence record is a good proxy rather than proof of consumption. And stock detection is not implemented in the present build: the system will attempt to dispense from an empty compartment and log it as a successful dose. Adding a stock sensor is the change that would close the larger of the two gaps, since an empty compartment currently produces a false adherence record rather than an alert.

VII. Conclusion

The IoT-based medicine dispenser automates medication reminders, dispensing and tracking in a single unit. Combining an ESP32 with stepper and servo motors, an IR sensor for user confirmation and Firebase Firestore for real-time data, it delivers scheduled doses, records what was taken and alerts remotely when a dose is missed. The requirement for physical confirmation before dispensing is what turns the device from a reminder into an adherence monitor, since it distinguishes a dose that was taken from one that was merely announced.

Built from commodity components, the design is affordable enough for home deployment and for use in elder care settings, and its cloud integration lets caregivers monitor adherence without being present.

VIII. Future Scope

Stock detection. Sensors in each compartment would alert the user when a slot is empty, closing the gap that currently allows an empty compartment to be logged as a successful dose.

More compartments. Extending beyond three slots would suit patients on more complex regimens, which is common among the elderly patients the system targets.

Caregiver notifications. Push notifications or SMS on a missed dose, rather than an entry the caregiver must open the application to see, would shorten the time to intervention.

Adherence analytics. Analysing the accumulated record would reveal patterns — a dose consistently missed at one time of day — that a simple log does not surface.

Verification of consumption. A camera or weight sensor could give stronger evidence that the tablet was taken rather than only collected.

Integration with health records. Linking to prescription systems would let schedules be populated from a prescription rather than entered by hand, removing a source of error.

References

[1] W. Antoun, A. Abdo, S. Al-Yaman, A. Kassem, M. Hamad, and C. El-Moucary, "Smart medicine dispenser (SMD)," in Proc. IEEE 4th Middle East Conf. Biomedical Engineering (MECBME), 2018, pp. 20–23.

[2] P. H. Tsai, T. Y. Chen, C. R. Yu, C. S. Shih, and J. W. S. Liu, "Smart medication dispenser: design, architecture and implementation," IEEE Systems Journal, pp. 99–110, 2010.

[3] A. V. Dhukaram and C. Baber, "Elderly cardiac patients' medication management: patient day-to-day needs and review of medication management system," in Proc. IEEE Int. Conf. Healthcare Informatics, 2013, pp. 107–114.

[4] S. L. Gray, J. E. Mahoney, and D. K. Blough, "Medication adherence in elderly patients receiving home health services following hospital discharge," Annals of Pharmacotherapy, vol. 35, no. 5, pp. 539–545, 2001.

[5] C. Fărcaș, I. Ciocan, N. Palaghiță, and R. Fizeșan, "Weekly electronic pills dispenser with circular containers," in Proc. IEEE 21st Int. Symposium for Design and Technology in Electronic Packaging (SIITME), 2015, pp. 125–129.

[6] H. K. Wu, C. M. Wong, P. H. Liu, S. P. Peng, X. C. Wang, C. H. Lin, and K. H. Tu, "A smart pill box with remind and consumption confirmation functions," in Proc. IEEE Int. Conf. Consumer Electronics, 2015, pp. 658–659.

[7] S. C. Huang, H. Y. Chang, Y. C. Jhu, and G. Y. Chen, "The intelligent pill box — design and implementation," in Proc. IEEE Int. Conf. Consumer Electronics, 2014, pp. 235–236.

[8] T. L. Hayes, J. M. Hunt, A. Adami, and J. A. Kaye, "An electronic pillbox for continuous monitoring of medication adherence," in Proc. IEEE Engineering in Medicine and Biology Society Conf., 2006, pp. 6400–6403.

[9] H. C. Yeh, P. C. Hsiu, C. S. Shih, P. H. Tsai, and J. W. S. Liu, "APAMAT: a prescription algebra for medication authoring tool," in Proc. IEEE Int. Conf. Systems, Man and Cybernetics, 2007, pp. 4284–4291.

[10] ESP32-WROOM-32 Datasheet, Espressif Systems.

[11] Cloud Firestore Documentation, Google Firebase.

[12] World Health Organization, Adherence to Long-Term Therapies: Evidence for Action, WHO, Geneva, 2003.