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IoT Based Smart Pillbox Device with Robot Arm

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Abstract: There are several challenges that elderly people face, one of the most common being taking their medication on time. Often, they forget to take their medication or struggle to recall whether they have already taken it. This can sometimes lead to overdosing and severe medical complications. While there are several expensive medicine dispensers available on the market, many elderly individuals around the world are unaware of such products and continue to store their medications in simple boxes. Although various types of medicine dispensers are commercially available, they often have several drawbacks that need to be addressed. The IoT-based smart pillbox device with a robotic arm is designed to help solve this problem. It includes a medicine dispenser, a robotic arm, an alert system with voice reminders, a user interface displaying prescription details, keys for setting alert timings, and an IoT platform that allows access to medication information from anywhere in the world.

Keywords*:* Servo Motor, IoT Platform, Robotic Arm, Medicine Dispenser, Liquid Crystal Display

1. Introduction

Poor medication adherence, defined as the extent to which patients take their medications as prescribed, remains a significant healthcare challenge, often leading to treatment failures [1]. Bedell et al. [2] identified a 76% discrepancy between prescribed and consumed medications. Errors in dosage and timing further contribute to increased morbidity and mortality rates [3]. To address this issue, researchers have developed various devices to ensure accurate medication delivery, particularly benefiting individuals with physical or cognitive impairments, such as seniors. Automatic pill dispensers can significantly improve users' quality of life by ensuring timely medication administration.

The widespread adoption of Internet of Things (IoT) technology has transformed numerous industries, with its impact becoming increasingly evident in the medical field over the past decade. However, a crucial limitation of existing medication dispensing solutions remains unaddressed: verifying whether the user actually consumes the medication after it is dispensed and determining who should be notified if the medication is not taken. Most pill dispensers focus solely on dispensing medication at scheduled intervals without confirming consumption.

Rajan et al. developed a "Smart Pill Box" that integrates IoT technology with GSM interfaces and Arduino [4]. Utilizing the Blynk app, the system ensures timely notifications, enhances medication adherence through reminders, and automates refilling, simplifying medication management.

Al-Mahmud et al. introduced an IoT-based Medical Box designed to send medication reminders via email notifications [5]. The system incorporated health sensors for continuous monitoring and leveraged wireless connectivity to improve healthcare management and facilitate remote communication between patients and healthcare providers. Hayes et al. created the Med Tracker system, which focused on mobility and provided detailed insights into medication non-adherence and errors. However, its dependency on a Bluetooth-enabled computer for data transfer posed accessibility limitations [6].

This paper proposes a comprehensive solution to medication adherence through the development of an IoT-enabled Smart Pill Dispenser and Smart Cup, seamlessly integrated with an Android application. This system enables real-time monitoring of pill consumption, scheduled reminders, and alerts for medication refills. Additionally, the solution mitigates the risk of overdoses by ensuring that medications are dispensed only once within designated timeframes, thereby promoting safer and more effective medication management [7] – [8].

2. Proposed Method

The proposed methodology for the IoT-based smart pillbox with a robotic arm aims to address medication adherence challenges faced by elderly individuals. First, a thorough needs assessment will be conducted through surveys and interviews with elderly users, caregivers, and healthcare professionals to understand the specific difficulties in medication management. Based on these insights, a system will be designed, integrating a smart pillbox with compartments, a robotic arm for dispensing medications, a voice reminder system, a user-friendly interface for managing prescriptions, and an IoT platform for remote monitoring and control. The dispensing mechanism will be automated, with the robotic arm retrieving the correct medication based on pre-set schedules, while the alert system will provide both voice reminders and visual cues to ensure timely medication intake.

2.1 Operational and Element Description

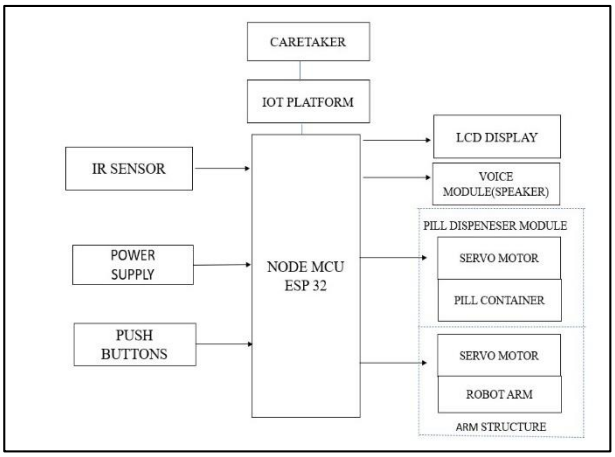

Fig.1 *Block diagram of the prototype system*

The IoT-based smart pill dispenser system, as shown in Fig.1, is designed to help patients take their medication on time. Its central component, the NodeMCU ESP32, controls various modules, including an IR sensor for detecting hand presence, push buttons for manual control, and a power supply for system operation. The pill dispenser module, consisting of a servo motor and pill container, releases medication at scheduled times, while a robotic arm picks and places the pills for easy access. For user interaction, an LCD display provides real-time updates, and a voice module delivers audible reminders. The system is IoT-enabled, allowing caregivers to monitor medication intake remotely through notifications. By automating the process and providing visual and audio reminders, the system enhances medication adherence, particularly for the elderly or forgetful patients, ensuring efficient and reliable healthcare management.

2.2 Circuit Diagram

Fig.2 represents the circuit diagram of the system. The IoT-based Smart Pill Dispenser circuit integrates multiple components to automate pill dispensing, ensure medication adherence, and provide real-time notifications. The core of the system is the ESP32-WROOM microcontroller, which manages pill dispensing, user interactions, and IoT connectivity. Various sensors, servos, an LCD display, an audio module [11], and push buttons work together to create an efficient medication management system.

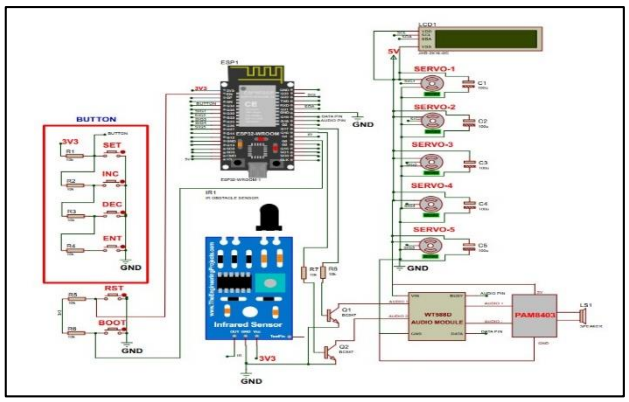

Fig.2 Circuit diagram of the prototype system

3. Performance and Analysis

3.1 Results of BLYNK Platform

The Blynk-based IoT med box system, integrated with an ESP32 microcontroller, enables efficient remote monitoring and control of the pill dispensing mechanism. The system consists of various components, including an IR sensor for object detection, push buttons for user input, an LCD display for real-time status updates, servo motors for pill dispensing, and a WT588D audio module with a PAM8403 amplifier for voice alerts. Through the Blynk platform, users can monitor the system remotely and receive real-time notifications about its status.

In conclusion, Fig.3 represents the Blynk-integrated med box system performs efficiently, providing a reliable solution for remote medication dispensing. With proper power management and Wi-Fi optimization, its overall effectiveness can be significantly enhanced.

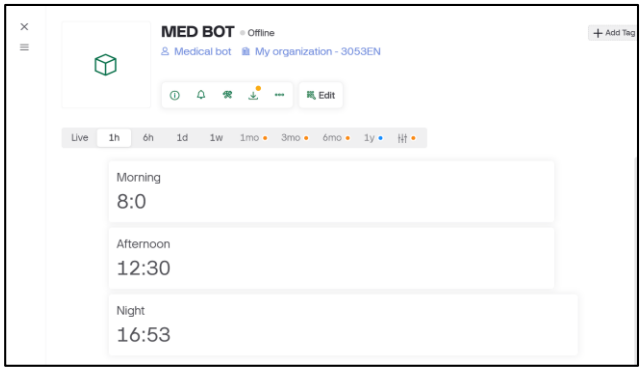

Fig.3 Dashboard of the BLYNK software

3.2 Initial time settings for pill dispensing

Initially the time is set for the tablet dispensing schedule for morning, lunch and night by using the buttons in the circuit board. It can also be displayed in the BLYNK platform and in LCD Display Fig.4, then the system is set for the operation. The wi-fi time will be set in the display by default until the schedule time arrives, then the message “it’s time to take the meal” will be displayed and “time to consume medicine” is also displayed on LCD Display for every schedule set.

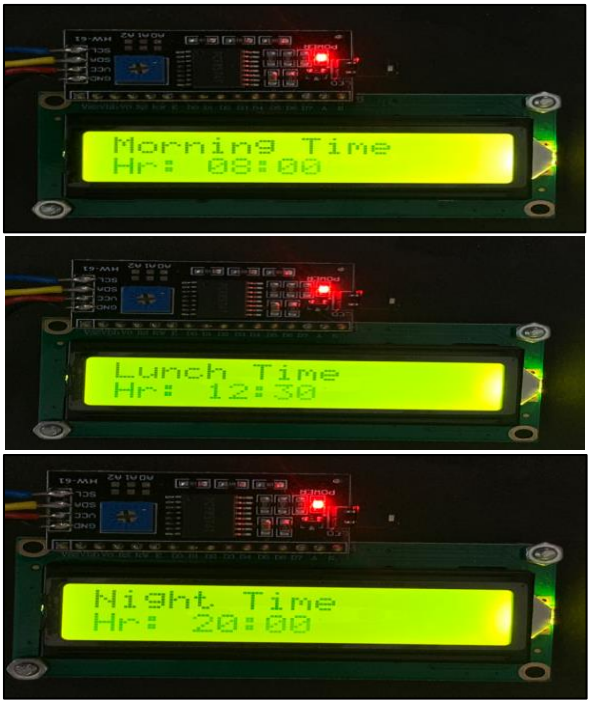

Fig.4 Time settings in LCD Display

3.3 Pill dispensing and Robotic Arm Movements

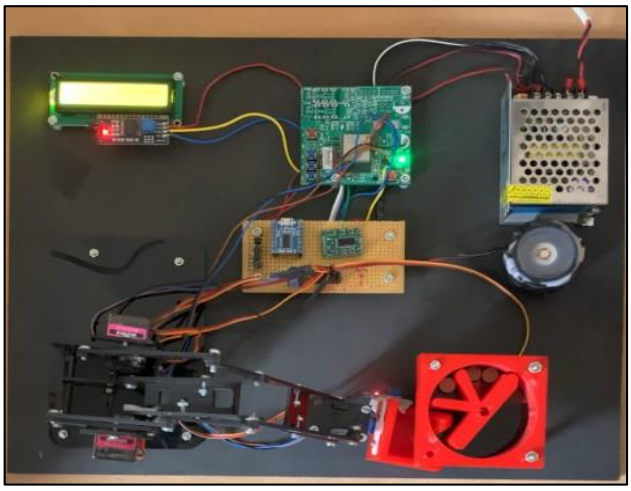

Fig.5 Initial position of Arm

After the time schedule is set the system will start its operation, the robotic arm and pill dispenser positions will be in normal position [Fig.5] until the schedule time arrives.

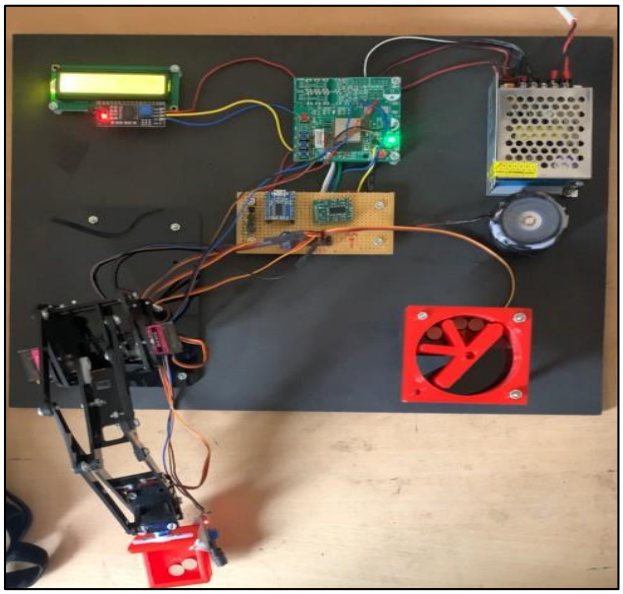

Fig.6 Movement of Arm to 90 degrees

If the set time arrives the internet time the pill dispenser module dispenses the tablet in pill container attached to the robotic arm, then the robotic arm rotates about 90 degrees [Fig.6].

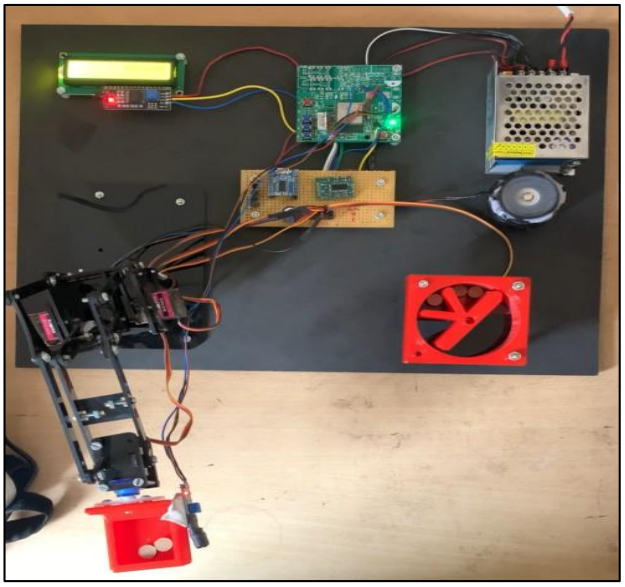

Fig.7 Arm lifts upward to desired position

Then the arm position will move upwards to a desired position of the patients [Fig.7].

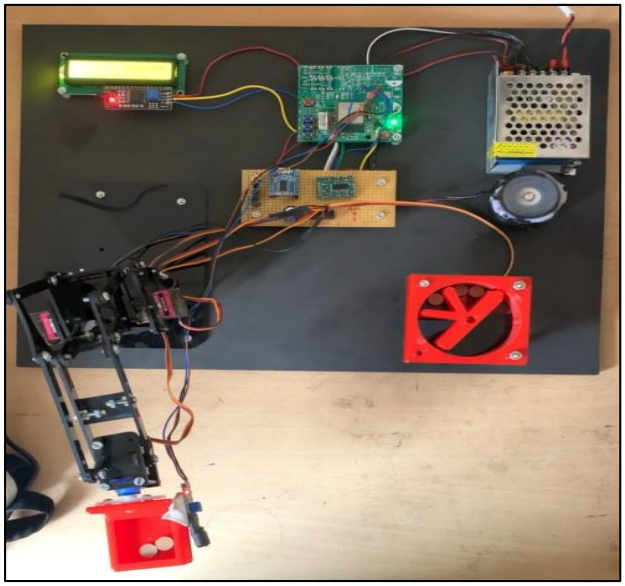

Fig.8 IR Sensor senses patients hand position

After the set position the IR sensor will detecting the movement [Fig.8] around it for patients' hand for dispensing the pills.

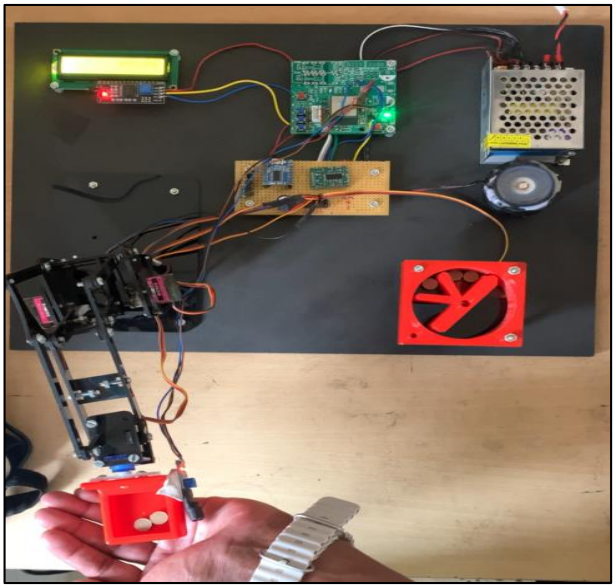

Fig.9 IR sensor detects the patient's hand

If patients keep the hand under the IR Sensor [Fig.9] then the sensor sends the signal to the controller to dispense the tablet. If the patient fails to collect the tablet, the robotic arm will dipose the tablet in order to avoid excess dosage and then go for the next dosage routine.

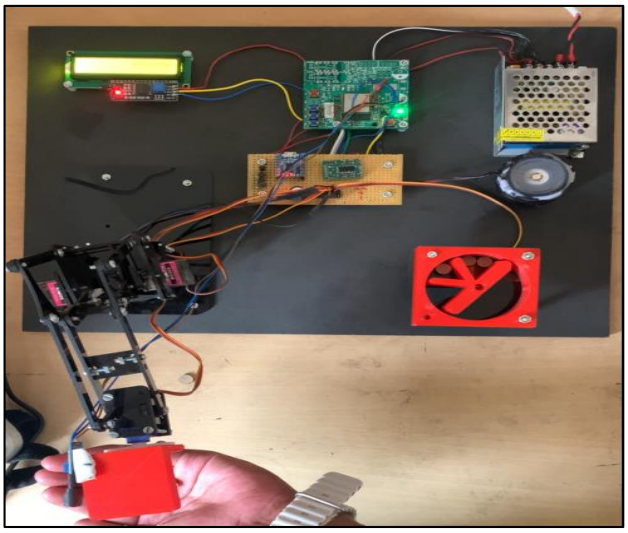

Fig.10 Pill cointainer dispenses tablets

Then the pill container will rotate about 180 degrees to dispense the tablet from the pill container to patients' hand [Fig.10] and returns back to the original position.

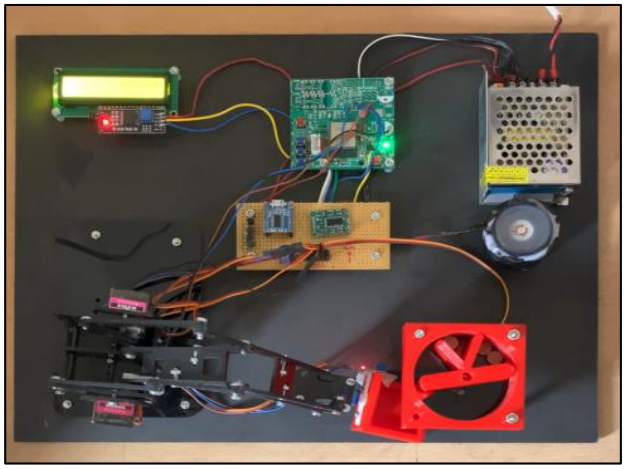

Fig.11 Robotic Arm and pill dispenser returns to original position

After the pill is dispensed, the robotic arm and pill dispenser [Fig.11] will again move to its original position as initial position.

4. Results and Discussion

The IoT-based smart pillbox device with a robotic arm was developed and tested to address the challenges elderly individuals face in managing their medication. The system successfully dispensed the correct dosage of medication at the pre-set times, significantly reducing the risk of missed or overdosed doses. The robotic arm effectively assisted in retrieving and organizing pills, ensuring ease of access. The alert system with voice reminders proved beneficial in notifying users about their scheduled medication, improving adherence rates. The user interface displayed clear prescription details, allowing elderly individuals to verify their medication schedules effortlessly. The incorporated IoT platform enabled caregivers and family members to monitor medication adherence remotely, enhancing patient safety. During testing, the device demonstrated high accuracy in dispensing pills and reliability in triggering alerts. Users found the system user-friendly and helpful, particularly those with memory impairments. However, some challenges, such as the initial setup complexity and cost considerations, were identified. Future improvements include refining the user interface, optimizing the robotic arm's efficiency, and exploring cost-effective manufacturing solutions to make the device more affordable for a larger audience.

Overall, the IoT-based smart pillbox device with a robotic arm successfully addressed the problem of medication adherence among the elderly, providing a promising solution for safer and more efficient medication management.

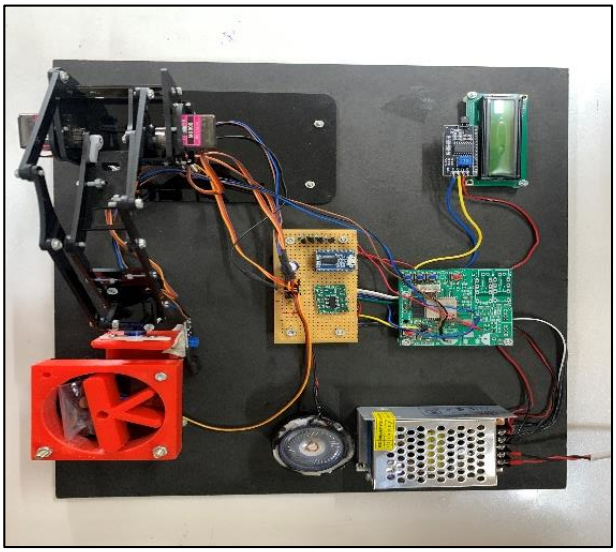

Fig.12 Hardware picture of IoT Based Smart Pillbox Device with Robot Arm

5. Conclusion

The IoT-based smart pillbox device with a robotic arm effectively addresses the challenges elderly individuals face in managing their medication. By integrating automated dispensing, voice alerts, and remote monitoring through IoT, the system enhances medication adherence and reduces the risks associated with missed or overdosed doses. The user-friendly interface and prescription display further improve accessibility, making it easier for elderly users to follow their medication schedules.

While the device demonstrated high accuracy and reliability during testing, challenges such as initial setup complexity and cost considerations remain. This smart pillbox offers a promising solution for elderly individuals and caregivers, ensuring safer and more efficient medication management while using modern technology to improve healthcare outcomes.

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