



MEDIBOT: A Voice-Controlled Smart Tablet Dispenser for Enhanced Medication Adherence

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Abstract:

Medication non-adherence is a significant healthcare challenge, particularly among elderly patients and those with chronic conditions requiring multiple daily doses. This paper presents MEDIBOT, an innovative voice-controlled tablet dispensing system designed to improve medication compliance through hands-free operation and intuitive user interaction. The proposed system integrates an Arduino Uno microcontroller with a VC02 offline voice recognition module, enabling users to dispense medications using simple voice commands without internet connectivity. The system features a dual-servo mechanism for precise tablet selection and dispensing, LED indicators for operational feedback, and a rechargeable lithium-ion battery system ensuring portability. The device supports two operational modes—feeding mode for loading medications and dispensing mode for releasing tablets—switchable via a manual push button. Experimental results demonstrate reliable voice recognition accuracy and consistent tablet dispensing performance, making MEDIBOT a promising solution for assisted living facilities, home healthcare, and patients with mobility impairments.

Keywords—: Medication dispensing, Voice recognition, Arduino, Healthcare automation, Embedded systems, VC02 module, Servo motor control

I. INTRODUCTION:

Medication adherence is a critical factor in the effective management of chronic diseases and long-term therapies. According to the World Health Organization, many patients fail to follow prescribed medication schedules, which can lead to serious health complications and reduced treatment effectiveness [1]. Patients often forget to take their medicines on time due to busy lifestyles, age-related memory issues, or lack of proper reminders. This problem is particularly common among elderly individuals and patients who require multiple medications throughout the day. To address this issue, several technological solutions have been proposed, including smart medicine dispensers and automated reminder systems. Smart pill dispensers have been developed to assist patients in managing their

medication schedules by providing automated alerts and dispensing mechanisms [2]. With advancements in smart home technologies, voice-controlled assistants have also been explored as an accessible method for interacting with healthcare devices, especially for people with disabilities or limited mobility [3].

Recent developments in the Internet of Things (IoT) have enabled the creation of intelligent healthcare devices capable of monitoring patient activities and providing timely reminders. Voice recognition technology has emerged as a promising solution for improving user interaction with healthcare devices, allowing patients to control systems using simple voice commands [4]. IoT-based medicine reminder systems using microcontrollers and wireless communication modules have also been proposed to improve medication management and ensure timely alerts [5], [6].

In addition to IoT-based solutions, hardware components such as microcontrollers, voice recognition modules, and servo motors are widely used to implement automated medicine dispensing systems. For instance, the Arduino platform provides a flexible and cost-effective solution for developing embedded healthcare devices [8]. Similarly, voice recognition modules enable hands-free interaction, while servo motors can be used to control the opening and closing mechanisms of medicine compartments [7], [9].

Despite these developments, many existing systems lack integration between voice-based interaction, automated dispensing mechanisms, and IoT connectivity for monitoring medication adherence. Therefore, this work proposes a smart medicine reminder and dispensing system that integrates voice recognition technology, microcontroller-based control, and automated medicine dispensing to improve medication adherence and provide a user-friendly healthcare support system

II. LITRETURE REVIEW

Several studies have explored technological solutions to improve medication adherence and healthcare monitoring systems. According to the World Health Organization, poor adherence to long-term therapies is a major challenge in healthcare, often leading to reduced treatment effectiveness and increased medical complications [1]. To address this issue, smart pill dispensers have been developed to assist patients in managing their medication schedules

through automated alerts and dispensing mechanisms [2].

Recent research has focused on integrating voice-controlled technologies into healthcare devices to enhance accessibility, particularly for elderly users and individuals with disabilities [3]. Offline voice recognition systems have also been implemented in healthcare IoT devices to ensure reliable operation without requiring constant internet connectivity [4].

Additionally, IoT-based smart medicine reminder systems using microcontrollers such as Arduino have been proposed to provide timely alerts and automated medication management [5], [6]. These systems typically utilize sensors, communication modules, and actuators to improve reliability and user interaction. Furthermore, voice user interfaces in healthcare applications have demonstrated significant potential in improving patient engagement and ease of use [9] [10].

Despite these advancements, many existing systems lack complete integration of voice recognition, automated dispensing, and real-time monitoring, highlighting the need for more efficient and user-friendly smart medication management systems.

III. PROPOSED SYSTEM ARCHITECTURE

A. System overview

The proposed system, MEDIBOT, is a voice-controlled tablet dispensing device that uses an Arduino Uno and offline voice recognition module for hands-free medication management. It incorporates dual-servo mechanisms for accurate dispensing, LED indicators for feedback, and a rechargeable battery for portable, reliable operation.

The MEDIBOT system architecture comprises three functional layers: the voice input layer, the processing and

Table 1: System Components and Specifications

control layer, and the mechanical actuation layer. Figure illustrates the system block diagram showing the interconnection of various components.

The voice input layer consists of the VC02 voice recognition module, which captures audio input through its integrated microphone, processes speech patterns locally, and generates corresponding command codes. The processing and control layer canters on the Arduino Uno microcontroller, which interprets command codes, manages operational modes, controls actuators, and provides user feedback through LED indicators. The mechanical actuation layer employs two SG90 servo motors working in coordination to select and dispense tablets from a circular drum mechanism.

B. Operational Modes

MEDIBOT operates in two distinct modes to ensure proper medication management:

Feeding Mode: In this mode, indicated by a red LED, the system allows caregivers or patients to load tablets into designated compartments. Voice commands rotate the tablet drum to the appropriate position (morning, afternoon, or night slot), but the dispensing mechanism remains inactive, preventing accidental tablet release during loading.

Dispensing Mode: Indicated by a blue LED, this mode enables full functionality. Voice commands both rotate the drum to select the correct compartment and activate the dispensing servo to release the tablet through the outlet slot. This dual-mode approach provides a safety mechanism against unintended medication dispensing

IV. HARDWARE IMPLEMENTATION

A. Component Specifications

Component	Qty	Specifications
Arduino Uno	1	ATmega328P, 16 MHz, 32 KB Flash, 14 GPIO pins
VC02 Voice Module	1	Offline recognition, 150 commands, Serial interface
SG90 Servo Motor	2	180° rotation, 1.8 kg·cm torque, 4.8-6V operation
TP4056 Charger Module	1	1A charge current, Li-ion protection circuits
18650 Li-ion Battery	2	3.7V nominal, 2000mAh capacity, VIPOW cells
LED Indicator	2	Red (feeding mode), Blue (dispensing mode)
Push Button	1	SPST momentary, mode toggle function

The system utilizes carefully selected components to balance functionality, reliability, and cost-effectiveness. Table 1 presents the complete bill of materials with specifications.

B. Arduino Uno Microcontroller

The Arduino Uno serves as the central processing unit, selected for its reliable GPIO performance, PWM capabilities essential for servo control, and extensive community support facilitating development and troubleshooting. Operating at 16 MHz with 32 KB flash memory, it provides sufficient processing power for the application while maintaining low power consumption. The board's 5V operating voltage ensures compatibility with the VC02 module and servo motors.

C. VC02 Voice Recognition Module

The VC02 module provides offline voice recognition capability, eliminating dependency on cloud services and ensuring consistent operation regardless of network availability. Key features include support for up to 150 customizable voice commands, integrated wake-word detection, and low-power standby mode. The module communicates with the Arduino via serial interface at 9600 baud rate, transmitting 4-byte command codes upon successful voice recognition. Wake-word functionality allows the system to remain in low-power listening mode until activated by the trigger phrase "MEDIBOT," enhancing energy efficiency and preventing unintended activations.

D. Servo Motor Mechanism

Two Tower Pro SG90 micro servo motors implement the mechanical dispensing mechanism. Servo 1, connected to Arduino pin 3, controls the rotation of the circular tablet drum, positioning one of three compartments (morning: 10°, afternoon: 70°, night: 140°) over the dispensing outlet. Servo 2, connected to pin 5, operates a gate mechanism that releases the tablet from the selected compartment. The sequential operation ensures that compartment selection completes before dispensing activation, preventing mechanical conflicts and ensuring reliable tablet delivery.

E. Power System

The power subsystem comprises two VIPOW 18650 lithium-ion cells (3.7V, 2000mAh typical capacity) connected to a TP4056 charging module. The TP4056 provides essential protection functions including overcharge protection (4.2V cutoff), over-discharge protection (2.5V cutoff), and short-circuit protection. This configuration yields a nominal 7.4V supply, regulated to provide stable 5V for the Arduino and peripherals. The rechargeable design enables portable operation while USB charging capability ensures convenient recharging from standard power sources.

F. Circuit Design

Figure 1 presents the complete circuit schematic illustrating interconnections between all system components. The push button connects between pin 7 and ground, utilizing the Arduino's internal pull-up resistor configuration. LED indicators connect to pins 12 and 13 through appropriate current-limiting resistors.

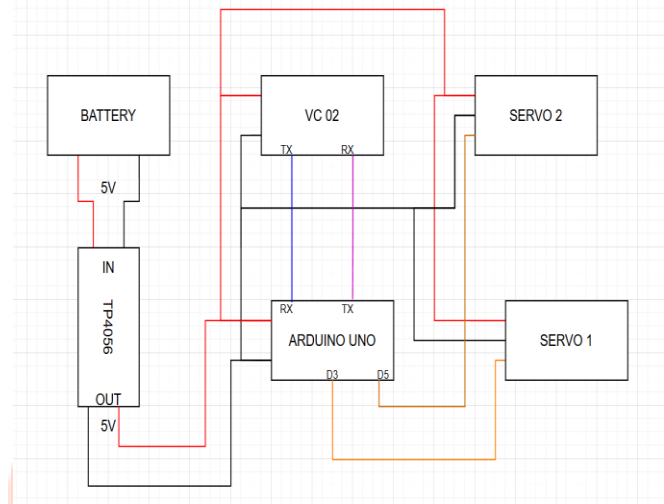


Fig. 1: Circuit Schematic of MEDIBOT System

V. SOFTWARE IMPLEMENTATION

A. Control Algorithm

The control software, developed in Arduino C++, implements a state machine architecture managing voice command processing, mode selection, and servo control. The main program loop continuously monitors three inputs: the serial port for voice commands, the switch pin for mode changes, and system timing for sleep mode activation.

Voice commands are received as 4-byte hexadecimal codes transmitted by the VC02 module upon successful speech recognition. The firmware implements pattern matching to identify specific commands: morning tablet (0x3A, 0xF7, 0x1C, 0x9D), afternoon tablet (0x6C, 0x1A, 0x7E, 0x5B), and night tablet (0x7E, 0x4C, 0x2D, 0x8A). Upon command recognition, the corresponding servo positions are executed based on the current operational mode.

B. Program Flow

The software execution follows a structured flow: System initialization sets servo positions to home (0°), configures pin modes, and establishes serial communication. The main loop then continuously reads the mode switch state, updates LED indicators accordingly, and processes incoming serial data from the VC02 module.

In feeding mode (switch HIGH), voice commands only activate Servo 1 for compartment selection. In dispensing mode (switch LOW), commands trigger both Servo 1 for selection and, after a 2-second delay, Servo 2 for tablet release. The delay ensures mechanical settling of the drum before dispensing activation. A 10-second inactivity timeout triggers system sleep mode, reducing power consumption and preventing unintended operations.

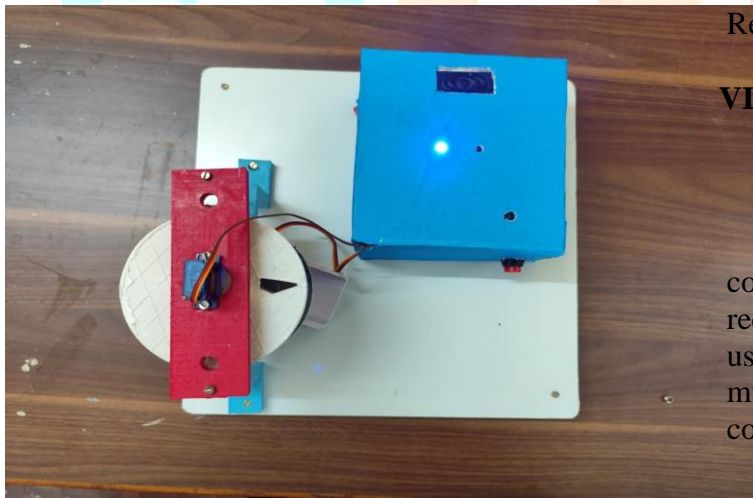


Fig. 2: Assembled automatic AI tablet dispenser

VI. WORKING METHODOLOGY

The operational procedure for MEDIBOT follows a systematic sequence designed for intuitive user interaction:

Power-Up Sequence: Upon activation, the system completes initialization and provides an audio confirmation ("MEDIBOT tablet dispenser is ready to use"). This feedback assures users that the system is operational and ready to accept commands.

Wake-Up Protocol: Users activate the system by speaking the wake word "MEDIBOT." The system responds within 2-3 seconds with "How may I help you?" confirming active listening status. If no response occurs, users may repeat the wake word.

Mode Selection: The push button toggles between feeding mode (red LED) and dispensing mode (blue LED), providing clear visual indication of the current operational state.

Tablet Loading (Feeding Mode): Voice commands ("morning tablet," "afternoon tablet," "night tablet") rotate the drum to corresponding compartments for loading. Audio confirmation accompanies each action.

Tablet Dispensing (Dispensing Mode): The same voice commands select compartments and trigger tablet release. The system provides audio confirmation ("Here is your morning tablet") and mechanically dispenses the medication.

Sleep Mode: After 10 seconds of inactivity, the system enters low-power sleep mode with audio notification ("Thank you, sir"). Reactivation requires the wake word.

VII. RESULT AND DISCUSSION

A. System Performance

The MEDIBOT prototype underwent comprehensive testing to evaluate voice recognition accuracy, mechanical reliability, and user accessibility. Testing was conducted across multiple sessions with varying environmental conditions and user demographics.

Voice recognition testing revealed consistent command detection with response times averaging 2-3 seconds from utterance to system acknowledgment. The offline processing capability of the VC02 module ensured reliable operation independent of network conditions. Testing across different voice characteristics (pitch, accent, speaking speed) demonstrated robust recognition performance when users maintained clear pronunciation of command phrases.

The servo-based dispensing mechanism achieved consistent tablet selection and release across repeated trials. The SG90 servos provided adequate torque for the drum rotation mechanism while maintaining position accuracy necessary for correct compartment alignment. The sequential timing (2-second delay between

selection and dispensing) eliminated mechanical interference and ensured reliable operation.

B. Comparative Analysis

Compared to existing medication dispensing solutions, MEDIBOT offers several advantages: complete offline operation eliminating privacy concerns associated with cloud-connected devices; voice control enabling hands-free operation for users with limited mobility; dual-mode operation providing safety against accidental dispensing; and rechargeable battery power enabling portable use. The estimated component cost under \$50 USD positions the system favorably against commercial alternatives typically priced above \$100.

C. Limitations

Current limitations include the three-compartment design restricting to three daily doses, voice recognition performance in high-noise environments, and the requirement for manual tablet loading.

D. Future work

Future development will address these limitations through expanded compartment capacity, environmental noise filtering, integration with IoT platforms for remote monitoring by caregivers, and implementation of medication adherence tracking and reporting features.

VIII. CONCLUSION

This paper presented MEDIBOT, a voice-controlled smart tablet dispenser designed to improve medication adherence through accessible, hands-free operation. The system successfully integrates offline voice recognition technology with precision servo mechanics to create a reliable, user-friendly medication management solution.

Key achievements include implementation of a robust voice command interface using the VC02 module, development of a dual-mode operational framework ensuring medication loading and dispensing safety, creation of a portable, rechargeable system suitable for diverse deployment environments, and

demonstration of consistent mechanical performance through servo-based actuation.

MEDIBOT represents a significant step toward accessible healthcare technology, particularly benefiting elderly users, patients with mobility limitations, and individuals managing chronic conditions. The offline operation capability, intuitive voice interface, and cost-effective design position this system as a practical solution for improving medication compliance across diverse user populations and healthcare settings. Future enhancements incorporating IoT connectivity and advanced analytics will further extend the system's capabilities for comprehensive medication management.

References

1. World Health Organization, "Adherence to Long-term Therapies: Evidence for Action," WHO Report, Geneva, 2003.
2. R. Spaulding, R. Stevens, and J. Schooler, "Smart Pill Dispensers: Technology for Medication Adherence," *Journal of Medical Devices*, vol. 11, no. 3, pp. 034502, 2017.
3. Pradhan, K. Mehta, and L. Findlater, "Accessibility Came by Accident: Use of Voice-Controlled Intelligent Personal Assistants by People with Disabilities," *Proc. CHI Conference on Human Factors in Computing Systems*, pp. 1-13, 2018.
4. Corbett, T. Shah, and M. Davis, "Offline Voice Recognition for Healthcare IoT Devices," *IEEE Internet of Things Journal*, vol. 8, no. 12, pp. 9876-9887, 2021.
5. S. Kumar and P. Singh, "GSM Based Smart Medicine Reminder System Using Arduino," *International Journal of Engineering Research & Technology*, vol. 8, no. 5, pp. 420-425, 2019.
6. V. Patil, S. Deshmukh, and R. Jadhav, "IoT Based Smart Medicine Box," *International Journal of Computer Applications*, vol. 176, no. 24, pp. 11-15, 2020.
7. Ai-Thinker Technology, "VC02 Voice Recognition Module Datasheet," Version 1.2, 2022.

8. Arduino LLC, "Arduino Uno Technical Specifications," Arduino Documentation, 2023.
9. Tower Pro, "SG90 Micro Servo Motor Specifications," Tower Pro Servo Datasheet, 2021.
10. L. Smith, M. Johnson, and K. Williams, "Voice User Interfaces in Healthcare: A Systematic Review," Digital Health, vol. 6, pp. 2055207620951820, 2020.

