

Automatic Drug Dispenser using Fingerprint Sensor

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Abstract— The proposed system implements an automated drug dispenser secured by fingerprint recognition using an AS608 fingerprint sensor and stepper motor. Users enroll fingerprints and link them to specific medication dispensers. Fingerprint verification authorizes medication dispensing via chosen stepper motors. The system improves medication adherence and security compared to traditional pillboxes, offering personalized medication management. It addresses critical issues such as preventing accidental misuse, enhancing security for high-risk medications, and providing peace of mind for caregivers by ensuring timely and accurate dispensing.

Index Terms— drug dispenser, fingerprint sensor, stepper motor, medication adherence, biometric security, healthcare innovation.

I. INTRODUCTION

Improper medication adherence is a significant global health concern, leading to avoidable health complications and increased healthcare costs. Traditional pillboxes often lack security features, leading to potential misuse or missed doses. This project addresses these issues by developing a secure and automated drug dispenser that utilizes fingerprint recognition technology.

The project aims to create a prototype for a secure and automated drug dispenser that utilizes fingerprint recognition for user authentication. This system can significantly enhance medication adherence by ensuring only authorized users can access medication.

Biometric authentication through fingerprints eliminates the risk of accidental misuse or unauthorized access, promoting adherence to prescribed regimens. Additionally, for individuals with memory impairments or requiring assistance with medication management, this dispenser offers a secure and automated solution, providing caregivers peace of mind knowing medications are taken correctly and on time. Furthermore, for medications with a high risk of misuse or diversion, this dispenser can provide an additional layer of security by restricting access only to authorized users through fingerprint recognition.

The core functionalities of this prototype will include fingerprint enrollment, fingerprint verification, medication selection, and controlled dispensing. The system will allow authorized users to enroll their fingerprints for future medication access.

Upon dispensing medication, the system will prompt users for fingerprint verification. Successful verification will authorize the dispensing mechanism. The dispenser will be equipped with multiple compartments or mechanisms to hold different medications, and the system will allow users to link their fingerprints to specific medication dispensers during enrollment. Once fingerprint verification is successful, the system will activate the designated stepper motor(s) to dispense the chosen medication.

II. LITERATURE REVIEW

Medication adherence is a critical aspect of successful healthcare management. Non-adherence can lead to adverse drug events (ADEs), reduced treatment efficacy, and increased healthcare costs [1]. Traditional pillboxes lack features to ensure proper medication use, contributing to adherence challenges. Automated dispensing systems (ADS) have emerged as a potential solution to improve medication adherence and patient safety.

Several studies have explored the design and implementation of smart medication dispensers for independent users [2]. These dispensers often utilize features like automated scheduling, medication reminders, and real-time monitoring to enhance medication adherence and reduce errors. Notably, Sharma et al. [3] proposed a smart medication dispenser with scheduling, medication count verification, and mobile app interaction, specifically targeting elderly individuals with complex medication regimens.

The effectiveness of pharmacist-led medication reviews in conjunction with ADS has also been investigated. The study by Van den Bemt et al. [4] showed a positive impact of medication reviews on identifying and addressing potential drug-related problems in older adults using ADS. However, the study also highlighted challenges in implementing medication adjustments, suggesting the need for improved collaboration between pharmacists and general practitioners.

The impact of ADS on pharmacy workflow has been assessed in various studies. While a study by Bates et al. [5] did not find significant changes in pharmacist workload or satisfaction after implementing ADS, another study by Chang et al. [6] reported positive perceptions of safety and efficiency among nurses using automated medication dispensing cabinets. These findings suggest that ADS can potentially improve workflow and safety within healthcare settings.

Beyond individual user-focused dispensers, research has also explored automated medication dispensing systems for hospital pharmacies [7]. These systems aim to improve efficiency, space utilization, and medication management within hospital environments. For instance, a study by Li et al. [8] described the design and implementation of an automated medicine depositing and dispensing system for a hospital pharmacy, demonstrating successful application in a real-world setting.

In conclusion, the existing literature highlights the potential of automated medication dispensing systems to improve medication adherence, patient safety, and healthcare workflow efficiency. Studies have explored various functionalities and applications of these systems, demonstrating their promise in addressing medication management challenges.

III. PROPOSED METHODOLOGY

Before designing the system, let us recap what the system should be capable of:

- Biometric fingerprint sensor securing access to medication details.
- Automated dispensing with electro-mechanical mechanism ensuring accurate dosages.
- Streamlining medication management in old age homes.
- Improve efficiency, reduce workload, and enhance medication adherence.

This section explores the methodologies used and how the components interact with each other. The system employs an Arduino Uno R3 board, an AS608 fingerprint sensor, and stepper motors. Fig. 1 represents a block diagram of the system design:

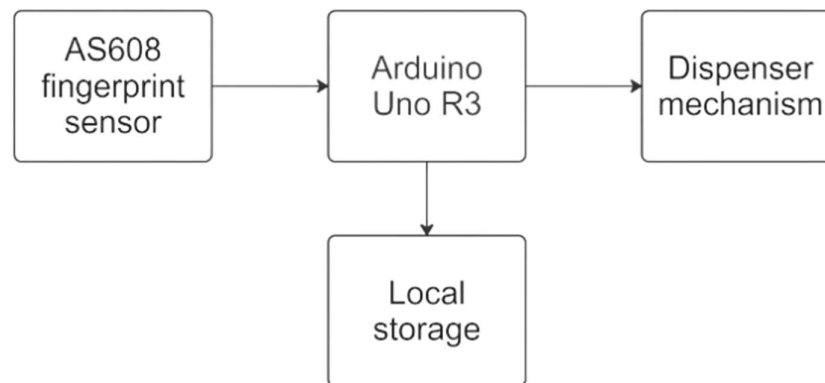


Fig. 1: System Design Architecture

A. System Initialization

The system startup process involves establishing essential functionalities before user interaction

- **Serial Communication Initialization:** The system begins by initializing serial communication. This establishes a connection between the Arduino and a computer through the Serial Monitor software. Serial communication serves as the primary interface for user interaction and system debugging. The code includes a delay loop to ensure the serial interface is ready before proceeding, preventing potential errors during data transmission.
- **Fingerprint Sensor Initialization:** Next, the system initializes the Adafruit Fingerprint sensor. This involves establishing communication with the sensor and verifying its functionality. The provided code utilizes the Adafruit Fingerprint library to send commands and receive responses from the sensor. If the sensor fails to respond correctly, signifying its absence or malfunction, the system enters an infinite loop, halting further operations. This fail-safe mechanism prevents the system from attempting to function without a crucial component.
- **Set Initial Time:** The provided code snippet includes an optional step utilizing the Time library. This library allows the system to manage and track time-based operations. In this instance, the code sets the initial time to the epoch (00:00:00 on January 1, 1970, Coordinated Universal Time) for testing purposes. This simulated time reference can be used to implement features like daily reset of dispense limits or tracking medication usage patterns over time.
- **Operation Overview:** Once the system is initialized, it enters a user interaction loop, presenting options and responding to user input.
- **Display Menu Options:** The system presents a user-friendly menu on the Serial Monitor displaying three primary options:
 - **Enroll Fingerprint:** This option allows users to register their fingerprints for medication access.
 - **Dispense Medicine:** This option allows authorized users to dispense medication using their enrolled fingerprints.
 - **Exit Program:** This option terminates the program and halts system operations.
- **User Input Handling:** The system employs the `readnumber()` function to wait for user input and convert the received data into an integer value. This allows the system to interpret user selections from the displayed menu. Based on the chosen option (1, 2, or 3), the system executes the corresponding operation.

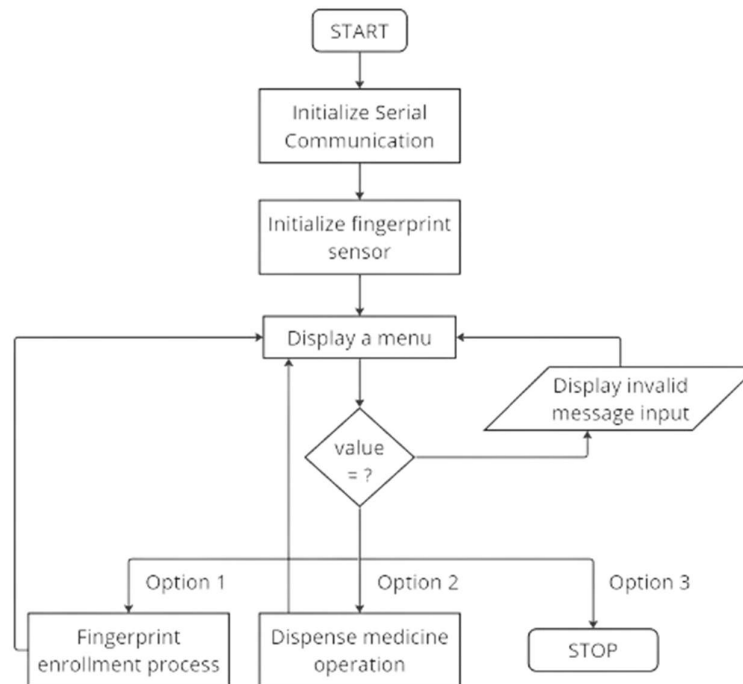


Fig. 2: Initial user interaction loop

In Fig. 2, the flowchart visually represents the overall system operation. It depicts the system initialization process, followed by the user interaction loop. Within the loop, the flowchart illustrates how the system presents the menu options, receives user input, and directs the system to perform the corresponding task (enroll a fingerprint, dispense medicine, or exit).

B. Enroll Fingerprint Operation

The Enroll Fingerprint operation allows users to register their fingerprints with the system for future medication access.

- **Prompt for Fingerprint ID:** The system prompts the user to enter a unique ID number (ranging from 1 to 127) to associate with the enrolled fingerprint. This ID serves as an identifier for the user within the system. The code includes a check to ensure ID number 0 is not used, as it might be reserved for special purposes or create unintended behavior.
- **Fingerprint Existence Check:** Before enrolling a new fingerprint, the system performs a security check. It utilizes the check If Finger print Exists () function to search the fingerprint sensor's database and verify if the user's fingerprint is already registered. This prevents duplicate enrollments and ensures a single fingerprint is associated with a unique ID.
- **Pill Selection:** The system allows users to specify which medication compartment (controlled by a stepper motor) their enrolled fingerprint should be linked to. This selection provides additional security and personalization. Users can choose between stepper motors 1, and 2, or dispense from both motors simultaneously (depending on the system configuration). The selected stepper motor ID is stored alongside the user's fingerprint data and ID number in the EEPROM memory for later retrieval.
- **Fingerprint Enrollment Process:** The system guides the user through the fingerprint enrollment process. The user is instructed to place their finger on the sensor twice to capture a high-quality fingerprint image. The system utilizes the Adafruit_Fingerprint library functions to capture, convert, and store fingerprint data securely within the sensor's internal memory. Additionally, the user's chosen stepper motor selection is linked to their fingerprint ID and stored in the EEPROM memory, ensuring the system retrieves the correct medication compartment when dispensing. A visual representation of the registration process is depicted in Fig. 3.

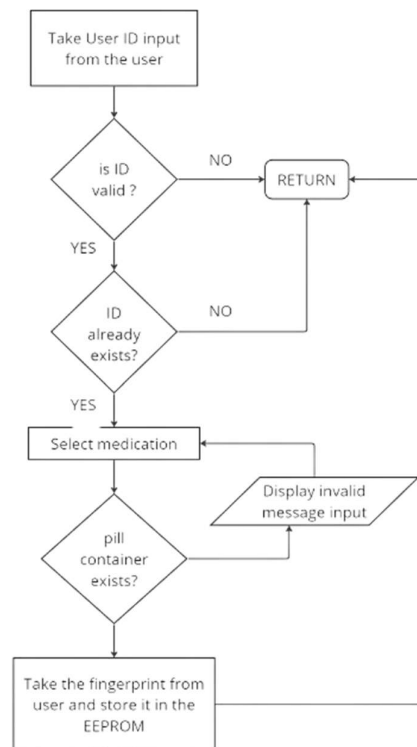


Fig. 3: Flow of user registration

C. Dispense Medicine Operation

The Dispense Medicine operation allows authorized users to access their designated medication using their previously enrolled fingerprints.

- **Fingerprint Verification:** Security is paramount during medication dispensing. The system prompts the user to place their finger on the fingerprint sensor for verification. The `'finger Print. Get Image()'` function captures a live fingerprint image from the sensor. This captured image is then converted into a format suitable for comparison using the `'fingerPrint.image2Tz()'` function. Finally, the `'fingerPrint.fingerFastSearch()'` function compares the converted image against the fingerprint templates stored within the sensor's database. If a successful match is found, the system proceeds with medication dispensing. The code also displays the identified user ID and confidence score for additional verification transparency.
- **Retrieve Stepper Motor Selection:** Upon successful fingerprint recognition, the system retrieves the user's associated stepper motor selection from the EEPROM memory. This stored information specifies which medication compartment (controlled by a particular stepper motor) should be activated for dispensing. The `'EEPROM.read()'` function is used to access the data linked to the user's ID, retrieving the stepper motor selection value.
- **Dispense Limit Check:** To prevent medication misuse and ensure responsible usage, the system enforces a daily dispense limit. The `'checkDispenseLimit()'` function is responsible for this critical check. This function retrieves the user's last dispense date stored in the EEPROM memory. It then compares this date with the current system date (obtained using time libraries). If the dates differ, signifying a new day has begun, the dispense limit is reset. The function also reads the current dispense count for the user from the EEPROM. If the dispense count hasn't reached the predefined daily limit, the system authorizes medication dispensing.
- **Dispense Medicine:** If the user's fingerprint is verified, their dispense limit hasn't been reached, and the appropriate stepper motor selection is retrieved, the system proceeds with medication dispensing. The `'stepper1.setSpeed()'` and `'stepper1.step()'` functions (or corresponding functions for stepper 2) are used to control the designated stepper motor. By specifying the number of steps the motor needs to rotate, the system precisely dispenses a single dose of medication from the chosen compartment. After successful dispensing, the `'incrementDispenseCount()'` function updates the user's dispense count in the EEPROM, keeping track of their daily medication usage. Fig. 4 is a visual representation of this section.

IV. RESULTS AND DISCUSSIONS

This research implemented a fingerprint-based medicine dispenser system using the Arduino platform. The code utilizes various libraries to achieve functionalities like fingerprint enrollment, medicine dispensing with dispense limit control, data storage using EEPROM, and timekeeping.

These are the key functionalities of the prototype:

- Users can enroll their fingerprints with a designated ID (1-127) and associate them with a specific stepper motor (1, 2, or both) for pill dispensing.
- **Fingerprint Verification:** During medicine dispensing, user verification is done through fingerprint recognition. A successful match triggers the corresponding stepper motor(s) for pill dispensing.
- **Dispense Limit:** The system incorporates a daily dispense limit (maximum 3 dispenses) to prevent accidental overdoses. The counter resets automatically at the beginning of each new day.
- **Data Storage:** EEPROM is employed to store user ID-motor associations, dispense count, and the last dispense date for each user. This ensures data persistence even after power cycles.
- **Time Integration:** The `'TimeLib.h'` library is included to track the current date and enforce the daily dispense limit.
- **User Interface:** The code interacts with the user through a serial monitor on a computer, providing instructions and displaying relevant information.

This project offers several advantages for a medicine dispenser system. Fingerprint recognition provides a significant security improvement over keypad-based systems, making it more difficult for unauthorized individuals to access medication. Additionally, the ability to link a fingerprint to a specific motor allows for personalized dosing. This means that users can be assigned different medication dispensers based on their needs. Furthermore, the system incorporates a daily dispense limit to prevent accidental overdoses or misuse. This limit resets automatically each day, ensuring that users cannot dispense more than the intended amount of medication within a 24-hour period. Finally, the code utilizes EEPROM to store important information such as user IDs,

motor associations, dispense counts, and dispense dates. This ensures that even if the device loses power, this critical data is retained. Overall, these features contribute to a more secure, reliable, and personalized medicine dispensing system.

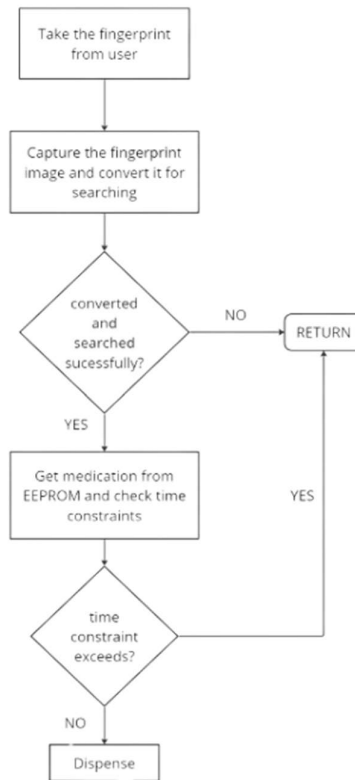


Fig. 4: Process flow for dispenser mechanism

V. CONCLUSION AND FUTURE SCOPE

This prototype successfully developed a prototype for a secure and automated medication dispensing system utilizing fingerprint recognition technology. The system leverages an Arduino microcontroller, an Adafruit Fingerprint Sensor, and stepper motors to provide a user-friendly and secure solution for medication adherence. The core functionalities of fingerprint enrollment, verification, medication selection, controlled dispensing, and dispense limit enforcement were implemented. The system utilizes EEPROM memory for data persistence, allowing it to retain user-specific information and dispense counts across power cycles.

This prototype lays the foundation for further development and potential real-world application. Here are some possibilities for future enhancements:

- **Improved User Interface:** The current text-based user interface accessible through serial communication could be enhanced with visual elements like an LCD screen for a more user-friendly experience.
- **Multiple Dispensing Units:** The current design caters to just two dispensing units. The system could be expanded to manage and control multiple dispensing units within a network, potentially for use in pharmacies or care facilities.
- **Connectivity and Scalability:** While the current system utilizes EEPROM for data storage, implementing MySQL database connectivity could significantly improve scalability. This would allow for managing user data, medication information, and dispense logs for a larger number of users, making the system suitable for broader applications.

In conclusion, this prototype demonstrates the feasibility of a secure and automated medication dispensing system using fingerprint recognition. By incorporating the suggested advancements, the system has the potential to become a valuable tool for promoting medication adherence and improving medication management, particularly for individuals requiring assistance or those seeking a more secure medication dispensing solution.

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