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Intelligence Mediation System with Face ID

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Abstract-- Medication adherence plays a crucial role in effective patient care, especially for elderly or chronically ill individuals who often forget or mistime their prescribed doses. This paper presents an Intelligent Medication System with Face ID, designed to automate and monitor medicine dispensing using facial recognition technology. The proposed system integrates Raspberry Pi, Pi Camera, Arduino Uno, servo motors, and MySQL database to identify patients, manage dosage schedules, and dispense the correct medicine tray at the right time. The ultrasonic sensor detects patient presence, triggering face detection and authentication through OpenCV. Once verified, the system checks the patient's medication schedule and activates the corresponding servo motor to open the respective tray (morning, afternoon, or evening). A buzzer and display unit alert the patient in case of missed doses, and caretaker notifications ensure remote monitoring and adherence tracking. For emergencies, an RFID-based override allows caretakers to access all trays for refilling or urgent intervention. Experimental validation demonstrates that the system operates reliably with accurate face recognition and timely dispensing. This solution provides a cost-effective, contactless, and intelligent approach to medication management, enhancing patient safety and reducing human error.

I. INTRODUCTION

Medication adherence is a critical factor in ensuring successful treatment outcomes, particularly for elderly and chronically ill patients who often struggle to follow prescribed medication schedules. Forgetting to take medicines, taking incorrect doses, or consuming them at inappropriate times can lead to serious health complications and increased healthcare costs. Traditional methods of medication management rely heavily on human supervision, which may not always be feasible, especially in situations where patients live independently or require continuous assistance.

With recent advancements in the Internet of Things (IoT), embedded systems, and computer vision, automated medication dispensing systems have gained significant attention. These systems aim to minimize human dependency by using sensors, actuators, and intelligent algorithms to ensure accurate and timely drug administration. However, many existing solutions depend on password-basedor manually operated mechanisms, which can be inconvenient and prone to misuse or user error.

To address these challenges, this research introduces an Intelligent Medication System with Face ID, a smart and secure solution that automates the process of medicine dispensing using facial recognition technology. The system employs Raspberry Pi, Arduino Uno, Pi Camera, and MySQL database to identify patients, verify their medication schedule, and automatically open the corresponding tray (morning, afternoon, or evening) at the correct time. The integration of OpenCV-based face detection, ultrasonic sensors, and servo-controlled trays ensures a fully automated and contactless process.

In addition, the system features an RFID-based caretaker override for emergency or maintenance purposes, along with notification alerts in case of missed doses. All patient interactions and medication logs are stored in the database, allowing caretakers or healthcare professionals to monitor adherence patterns remotely. The proposed system aims to enhance medication compliance, improve patient safety, and reduce manual intervention through a cost-effective, intelligent, and user-friendly design.

The rest of this paper is structured as follows: Section II presents the related work and existing systems; Section III describes the system architecture and methodology; Section IV discusses the hardware and software implementation; Section V provides the results and validation; and Section VI concludes the paper with future scope and recommendations.

II. LITERATURE SURVEY

Recent years have witnessed increasing efforts to automate the process of medication dispensing and monitoring through smart systems. Researchers have explored various approaches using IoT devices, embedded systems, and artificial intelligence to enhance medication adherence, reduce human errors, and provide remote healthcare support.

In [1], an IoT-based smart pill dispenser was developed to remind patients of their medication time using alarms and notifications. While this system successfully improved adherence, it lacked a secure authentication mechanism, making it unsuitable for environments where multiple patients share the same device. Similarly, [2] introduced a Bluetooth-enabled dispenser that sent notifications to mobile devices when doses were missed. However, this method still relied on user interaction and did not automate the dispensing process.

In [3], a RFID-based medicine management system was implemented to identify and track medicine containers. Although effective for inventory management, it did not ensure that the correct patient received the correct dosage. Another study [4] designed a microcontroller-based automatic medicine box with real-time clock (RTC) integration to dispense medicine at fixed intervals. Despite its simplicity, the system lacked intelligence and could not adapt to user-specific schedules or verify patient identity.

Recent advancements in computer vision and machine learning have introduced face recognition for security-sensitive healthcare applications. In [5], a facial recognition–based access control system was proposed for medical laboratories, which provided high accuracy in identity verification. Inspired by such work, the proposed system integrates facial recognition with medicine dispensing to ensure that only authorized patients can access their designated medication trays.

While the aforementioned systems addressed different aspects of medication management—such as reminders, scheduling, and access control—none provided a complete, secure, and automated dispensing mechanism combining facial recognition, IoT communication, and real-time tracking**.** The proposed *Intelligent Medication System with Face ID* fills this gap by introducing a hybrid solution that integrates Raspberry Pi for processing, Arduino for control, MySQL for data management, and OpenCV for identity verification. This system not only automates the dispensing process but also enables monitoring, emergency access, and caretaker notifications**,** thereby enhancing reliability and safety in medication adherence.

III. METHODOLOGY

The proposed Intelligent Medication System with Face ID follows a structured methodology that integrates hardware components, software algorithms, and database management to ensure secure and automated medicine dispensing. The system architecture combines Raspberry Pi, Arduino Uno, Pi Camera, and MySQL database, coordinated through serial communication and Python-based control logic. The methodology is divided into several functional stages, as illustrated below.

System Workflow Overview: The system operates in sequential stages from patient detection to medicine dispensing:

1. Patient Detection: The process begins when an ultrasonic sensor (HC-SR04) detects the presence of a person in front of the system. Once the distance is within a predefined threshold, the Raspberry Pi is triggered to activate the Pi Camera module.
2. Face Detection and Recognition: The Pi Camera captures the image of the patient, and OpenCV's Haar Cascade and LBPH algorithms are used for face detection and recognition. The captured face is compared with the pre-registered facial data stored in the local database.
3. Identity Verification: If a match is found, the system verifies the patient's identity and retrieves the corresponding medication schedule from the MySQL database. If no match is found, the system denies access and displays a message indicating that the user is unregistered.
4. Schedule Validation: The Raspberry Pi checks the real-time clock (RTC) and compares it with the patient's medication schedule (morning, afternoon, or evening). Based on the current time, the appropriate tray is identified.
5. Tray Operation: Once the correct time slot is verified, the Raspberry Pi sends a serial command to the Arduino Uno, which then activates the corresponding servo motor to open the designated tray. The patient can now access the medication.
6. Missed Medication Handling: If the patient does not appear during their scheduled time, the system activates a buzzer and sends a notification to the caretaker. The patient's name and missed dose information are displayed on the screen for tracking purposes.
7. Emergency Override: In case of emergencies or medicine refilling, a caretaker can use an RFID card to override the system and access all trays manually. This ensures safety and flexibility in critical situations.
8. Data Logging: Every event — including successful access, missed medication, and override actions — is stored in the MySQL database, enabling the caretaker to monitor patient adherence and system performance.

Hardware–Software Integration: Raspberry Pi 4: Serves as the main control unit, performing image processing, decision-making, and communication with the database.

1. Arduino Uno: Handles physical components like sensors, RFID, and servo motors.
2. Communication Protocol: Raspberry Pi and Arduino communicate via Serial (UART) interface at a baud rate of 9600 bps.
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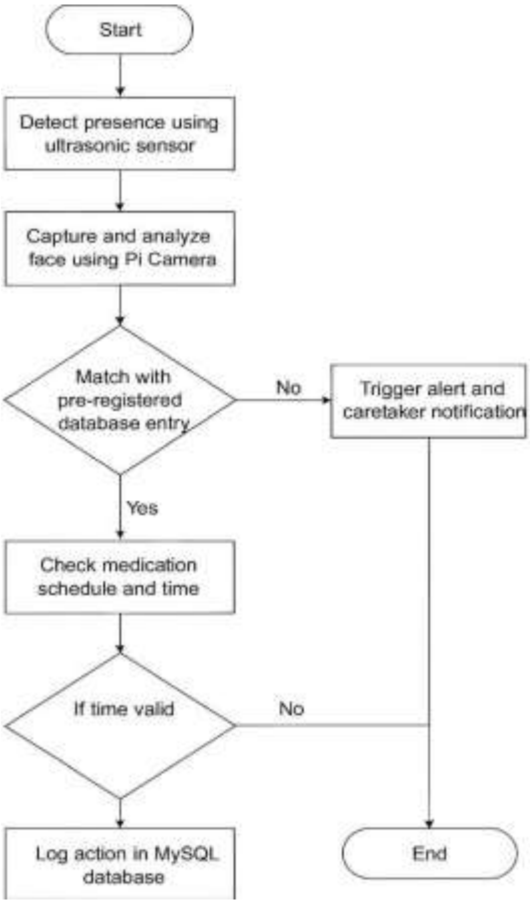
Software Stack: Python for control logic and OpenCV face recognition. C/C++ for Arduino motor control and sensor handling. MySQL for patient and schedule data storage.

Algorithmic Flow:

1. Start.
2. Detect presence using ultrasonic sensor.
3. Capture and analyse face using Pi Camera.
4. Match with pre-registered database entry.
5. If match → Check medication schedule and time.
6. If time valid → Send tray open command to Arduino.
7. Log action in MySQL database.
8. If missed → Trigger alert and caretaker notification.
9. End.

Validation and Testing: Each stage of the methodology was tested individually and in integration. Real-time trials confirmed smooth operation of face recognition, accurate timing control, and secure access to medicine trays. The system's modular approach allows easy scalability for multiple patients and extended medication schedules.



IV. HARDWARE & SOFTWARE IMPLEMENTATION.

Hardware Implementation: he proposed system integrates multiple hardware components to achieve automated and intelligent medicine dispensing. The Raspberry Pi 4 serves as the main processing unit, responsible for image processing, face recognition, and communication with peripheral devices. A Pi Camera is interfaced with the Raspberry Pi to capture facial images of the patients in real time. The Arduino Uno microcontroller acts as an actuator controller, managing servo motor movements that open and close the medication trays.

An ultrasonic sensor detects the presence of a person in front of the system and triggers the Raspberry Pi to initiate face recognition. The servo motors are attached to each tray, allowing them to open and close according to the patient's medication schedule. An RFID module provides an emergency override feature, allowing caretakers to access all trays during refilling or urgent situations. Additionally, a buzzer and LCD/LED display are integrated to alert the patient about missed medication and to display relevant notifications.

The entire setup is powered through a regulated 5V DC power supply, ensuring safe and stable operation of all components. The interconnection between Raspberry Pi and Arduino is established through serial communication (UART), enabling synchronized control between recognition logic and physical actuation.

Software Implementation: The software component is designed to ensure efficient data processing, face recognition, and communication between modules. The Raspberry Pi OS provides the environment for executing Python scripts that utilize OpenCV for real-time face detection and recognition. Pre-registered patient facial data are stored in a MySQL database, which also maintains the medication schedule, patient details, and intake history.

When a patient is detected, the system captures the facial image and compares it with stored data using OpenCV's LBPH (Local Binary Pattern Histogram) algorithm for recognition. Upon a successful match, the system checks the current time against the database schedule to determine which tray should open. The Raspberry Pi then sends a command to the Arduino, which activates the corresponding servo motor.

If a mismatch occurs or if the patient attempts to access the system outside their scheduled time, the system displays a notification and denies access. Missed medication events trigger an alert via the buzzer and caretaker notification. The RFID-based access control is managed through Arduino programming, providing manual control when required.

The software modules are developed in Python and C/C++, ensuring efficient communication between the high-level decision-making (Raspberry Pi) and low-level actuation (Arduino Uno). The integration of hardware and software results in a robust, automated, and intelligent system capable of real-time medication management and tracking.

V. RESULTS AND DISCUSSION

The Intelligent Medication System with Face ID is expected to function as a fully automated, secure, and efficient medication dispensing system. Upon completion and full integration of both hardware and software components, the system will be capable of identifying patients accurately and dispensing their prescribed medicines at the correct scheduled times without human intervention.

When a patient approaches the device, the ultrasonic sensor will detect their presence and activate the Pi Camera. The captured image will be processed using OpenCV's LBPH algorithm, ensuring accurate face detection and recognition even under varying lighting conditions. Once the patient is identified successfully, the system will fetch their medication schedule from the MySQL database and open the respective tray (morning, afternoon, or evening) using servo motors controlled by the Arduino Uno.

In the event of a mismatch or unregistered user, the system will deny access and display an appropriate notification on the screen. This ensures that only authorized patients can access their medication, maintain security and prevent misuse. The RFID-based caretaker override will allow emergency access to all trays, providing flexibility during medicine refilling or urgent medical situations.

The expected performance metrics include:

- High facial recognition accuracy (above 90%) under normal conditions.
- Error-free tray actuation and synchronized operation between Raspberry Pi and Arduino.
- Real-time medication tracking and database updates with each dispensing event.
- Effective alert mechanism for missed doses through buzzer sound and caretaker notification.
- User-friendly operation with clear on-screen instructions and minimal human intervention.

Furthermore, the system is expected to demonstrate excellent reliability in maintaining medicine schedules for multiple patients. Each patient's intake data will be stored and accessible to caretakers, allowing efficient health monitoring and adherence tracking. The integration of real-time data logging ensures accountability and transparency, which is particularly beneficial in healthcare environments.

The discussion phase also anticipates improvements in healthcare automation by reducing manual dependency and medication errors. Compared to conventional methods, this system offers better accuracy, increased safety, and enhanced patient compliance, all within a low-cost, IoT-based design.

Overall, the system aims to serve as a prototype for intelligent healthcare automation, combining computer vision, embedded systems, and IoT to support patient-centred care. Once fully implemented and tested, it can be expanded to support cloud connectivity, voice alerts, and integration with hospital management systems.

VI. CONCLUSION AND FUTURE SCOPE

Conclusion: The proposed *Intelligent Medication System with Face ID* offers a secure, reliable, and automated solution for improving medication adherence among patients. By integrating facial recognition, IoT components, and embedded control, the system ensures that only authorized individuals can access their prescribed medicines at scheduled times. The combination of Raspberry Pi, Arduino Uno, Pi Camera, ultrasonic sensors, servo motors, and RFID module allows seamless coordination between patient identification, medicine dispensing, and caretaker supervision.

This system minimizes human intervention, reduces medication errors, and enhances the efficiency of healthcare delivery, especially for elderly or chronically ill patients who require strict dosage management. The use of OpenCV for face recognition and MySQL for data storage provides both accuracy and scalability, ensuring that the system remains adaptable to different patient and institutional requirements.

Overall, the project demonstrates how embedded systems and artificial intelligence can be effectively combined to address real-world healthcare challenges, promoting patient safety and autonomy while easing the workload of medical staff and caretakers.

Future Scope: While the current model successfully implements the core functionalities of intelligent medication dispensing and patient identification, several enhancements can be incorporated in the future to improve its usability, scalability, and intelligence:

1. Cloud Integration: Linking the system to cloud databases for remote monitoring and real-time caretaker or doctor access to medication logs.
2. Mobile Application: Developing an Android/iOS app to notify patients and caretakers about upcoming or

missed doses, and to manage schedules remotely.
3. AI-Based Health Analytics: Implementing machine learning algorithms to analyse patient intake patterns and provide predictive alerts for missed or irregular doses.
4. Voice Assistance & Accessibility: Adding voice instructions and speech feedback for visually impaired patients to make the system more user-friendly.
5. Enhanced Security: Integrating biometric options such as fingerprint or iris recognition for multi-level authentication.
6. Scalability for Hospitals: Expanding the design to serve multiple patients simultaneously within hospital wards or old-age homes, with centralized monitoring.
7. Smart Medicine Refill Alerts: Using sensors to detect tray emptiness and automatically alert caretakers when medicines need to be refilled.

By implementing these future upgrades, the *Intelligent Medication System with Face ID* can evolve into a comprehensive healthcare automation platform, capable of delivering personalized and efficient medication management for individuals and institutions alike.

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