Pill Track: A Voice-Enabled AI-Based System for Pill Identification and Elderly Healthcare Management

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***Abstract*—Medication adherence is a critical challenge in elderly healthcare, where incorrect dosage or wrong pill intake can lead to serious health complications. Existing medication re-minder systems primarily provide alerts but fail to verify whether the correct medicine is actually taken, creating risks of medication errors and reduced treatment effectiveness. To address these challenges, this paper presents Pill Track, an integrated and intelligent medication management system designed specifically for elderly care. The proposed system combines a cross-platform mobile application, artificial intelligence-based pill identification, and a Raspberry Pi-based hardware verification unit. The AI module utilizes a multi-stage pipeline consisting of YOLOv8 for real-time pill detection, Convolutional Neural Networks (CNN) for classification, and EasyOCR for imprint recognition, enabling accurate and reliable pill verification. In addition, the system incorporates automated medication reminders, push notifications, and voice-based alert calls using Twilio, along with caregiver monitoring and secure cloud-based Electronic Health Record (EHR) storage. Experimental evaluation demonstrates that the proposed system achieves a pill detection accuracy of 94.3 percent while maintaining efficient real-time performance. The system aims to reduce medication errors, improve adherence, and promote safe and independent healthcare management for elderly users.**

***Index Terms*—Pill Identification, YOLOv8, CNN, EasyOCR, Raspberry Pi, Medication Reminder, Elderly Healthcare, EHR**

I. INTRODUCTION

A. Present Gaps in Medication Management

Medication management remains a critical challenge in elderly healthcare, particularly for individuals who rely on multiple prescriptions and complex dosage schedules. With age-related factors such as memory decline, reduced vision, and limited digital literacy, elderly patients are more prone to medication errors, including missed doses, incorrect timing, and consumption of the wrong medicine. These errors can lead to serious health risks, reduced treatment effectiveness, and increased dependency on caregivers.

Current solutions primarily focus on reminder-based systems such as alarms, mobile notifications, and basic healthcare applications. While these systems help users remember when to take medicines, they fail to ensure whether the correct medication is actually taken. This creates a significant gap between *medication scheduling* and *medication verification*. Additionally, most existing systems lack real-time monitoring, caregiver support, and integration with secure medical records. The absence of an intelligent verification mechanism makes these solutions insufficient for ensuring safe and reliable medication management.

B. Contributions

To address these limitations, this paper proposes *Pill Track*, an intelligent and integrated medication management system designed specifically for elderly users. The system combines mobile technology, artificial intelligence, hardware-assisted verification, and cloud-based healthcare services to provide a comprehensive solution.

The primary contributions of this work are as follows:

1) AI-Based Pill Verification:
A multi-stage verification pipeline using YOLOv8 for pill detection, Convolutional Neural Networks (CNN) for classification, and EasyOCR for imprint recognition, ensuring accurate identification of medicines.

2) Integrated Reminder System:
A robust reminder mechanism with push notifications and automated voice alert calls using Twilio to improve medication adherence.

3) Hardware-Assisted Validation:
A Raspberry Pi-based hardware unit with controlled lighting and camera integration for real-time pill image capture and verification.

4) Caregiver Monitoring and EHR Integration:
A cloud-based system that enables caregivers to track medication adherence and securely store Electronic Health Records for better healthcare management.

II. RELATED WORKS

In recent years, medication management and pill identification systems have gained significant research attention due to the growing need for safer and more reliable healthcare support, especially for elderly populations. Early medication reminder systems primarily focused on simple alarm-based notifications that helped users remember dosage timings. Al-though such systems improved adherence to some extent, they did not include mechanisms for verifying whether the correct medicine was actually taken. As a result, these approaches were insufficient for preventing medication errors in real-world scenarios.

Research in pill identification has advanced with the adoption of deep learning and computer vision techniques. Kim et al. proposed the MCIR-YOLO framework for pill classification using multi-band infrared imaging, demonstrating the ability to distinguish visually similar pills. However, the dependence on specialized infrared hardware limits its practicality for consumer healthcare applications. Zhang et al. explored Fast R-CNN-based drug classification and reported strong accuracy under controlled conditions, but the approach showed limited robustness in diverse real-world environments. Other studies have also shown that performance often degrades under variations in lighting, orientation, and image quality.

An important direction in recent research is the use of multimodal approaches that combine multiple sources of information for better reliability. Visual appearance, pill shape, color, and imprint text have been used together to improve identification accuracy. Similarly, cloud-based Electronic Health Record systems have been introduced to improve storage, retrieval, and accessibility of medical information. Despite these developments, most existing systems remain fragmented and focus only on individual tasks such as reminders, identification, or record storage. Very few systems integrate pill verification, caregiver monitoring, reminder support, and health record management into a single platform designed specifically for elderly users. This gap motivates the development of the proposed Pill Track system.

III. SYSTEM ARCHITECTURE

The proposed system, *Pill Track*, is designed as an integrated medication management platform that combines mobile technology, artificial intelligence, and hardware-assisted verification. The system aims to ensure both timely medication reminders and accurate pill identification before consumption. Unlike traditional systems that rely only on alerts, the proposed solution introduces a verification-based approach to reduce medication errors and improve patient safety.

A. System Overview

As shown in Fig. 1, the system integrates mobile application, AI processing, hardware verification, and cloud storage. The system consists of three major components: a mobile application, an AI-based pill identification module, and a hardware-assisted verification unit. The mobile application allows users to schedule medications, receive reminders, and track adherence. Caregivers can monitor patient activity and receive alerts for missed doses.

The hardware unit, built using a Raspberry Pi and camera module, captures images of pills under controlled lighting conditions. These images are processed by the AI module to verify whether the correct medicine is being taken. The system also integrates cloud-based storage for maintaining Electronic Health Records (EHR) and medication history.

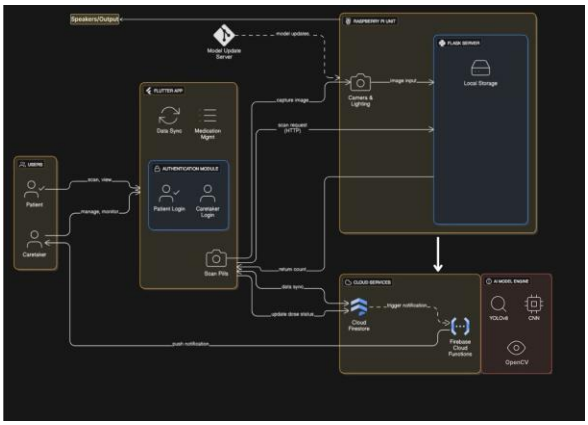

Fig. 1. System Architecture of Pill Track

B. Pill Identification Pipeline

The pill verification process is carried out using a multi-stage artificial intelligence pipeline. Initially, YOLOv8 is used for real-time pill detection from captured images. The detected pill region is then passed to a Convolutional Neural Network (CNN) for classification based on visual features such as shape and color.

To further improve accuracy, EasyOCR is applied to extract imprint text from the pill surface. The combination of detection, classification, and text recognition enables robust and reliable identification, even for visually similar medicines. The final output is matched with the stored medication database to confirm correctness.

C. Reminder and Monitoring System

The system includes a comprehensive reminder mechanism to ensure medication adherence. Users receive push notifications at scheduled times, and automated voice alerts are triggered using Twilio services. If a dose is missed, alerts are sent to caregivers for immediate attention.

Additionally, the system maintains logs of medication intake and updates adherence status in real time. This allows care-givers and family members to monitor patient health remotely and take necessary actions when required.

IV. IMPLEMENTATION

The implementation of the proposed system focuses on developing a scalable and efficient platform that integrates mobile applications, artificial intelligence models, and hard-ware components. The system is designed using a modular architecture, ensuring smooth interaction between different components and real-time performance.

A. Mobile Application

The frontend of the system is developed using Flutter, enabling cross-platform compatibility for both Android and iOS devices. The application provides an intuitive interface for elderly users, featuring large fonts, simplified navigation, and voice assistance. Users can add medications, set schedules, receive reminders, and confirm intake through the application. Firebase is used for user authentication, real-time database management, and cloud storage. Push notifications are implemented to alert users about medication timings, while caregiver
access is provided to monitor adherence remotely.

B. Hardware Integration

The hardware unit is developed using a Raspberry Pi integrated with a high-resolution camera and LED lighting system. The controlled lighting environment ensures consistent image quality, which is essential for accurate pill recognition. The captured images are either processed locally or transmitted to a backend server for further analysis.

The hardware unit acts as a verification system, allowing users to scan pills before consumption and ensuring that the correct medicine is taken.

C. AI Processing Pipeline

The AI module is responsible for pill detection, classification, and verification. The pipeline begins with YOLOv8, which detects the pill from the captured image in real time. The detected region is then passed to a Convolutional Neural Network (CNN) for classification based on visual features.

To enhance accuracy, EasyOCR is applied to extract imprint text from the pill surface. The extracted text is compared with stored medication data to validate correctness. The combination of object detection, classification, and text recognition ensures reliable identification even in challenging conditions.

D. Algorithm Workflow

Algorithm 1 Pill Identification Workflow

1) Input: Captured pill image
2) Detect pill using YOLOv8
3) Extract pill region

4) Classify pill using CNN
5) Extract imprint text using OCR
6) Match with database
7) Output: Verified pill information

V. RESULTS AND EVALUATION

The performance of the proposed Pill Track system is evaluated based on accuracy, reliability, and real-time efficiency of its core modules, including pill identification, reminder system, and hardware-assisted verification. Both quantitative and qualitative analyses are conducted to validate the effectiveness of the system in real-world scenarios.

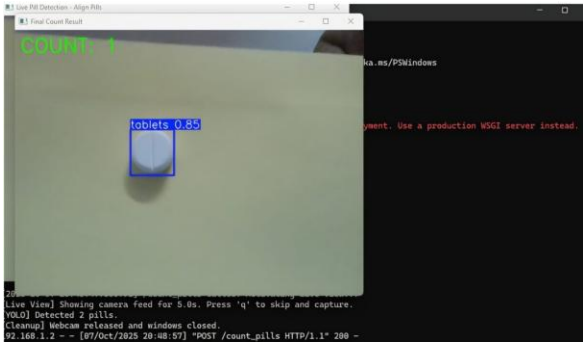

Fig. 2. Pill Detection and Identification Result

A. Pill Identification Performance

Fig. 2 shows the output of the pill identification system using YOLOv8 and OCR. The AI-based pill identification module is evaluated using standard performance metrics such as accuracy, precision, and recall. The YOLOv8 detection model achieved an accuracy of 94.3% in identifying pills under varying lighting conditions and orientations. The integration of CNN classification and EasyOCR text recognition further improved the robustness of the system by reducing misclassification of visually similar medicines.

The multi-stage verification approach ensures higher reliability compared to single-model systems. Experimental results indicate that combining detection, classification, and text recognition significantly enhances identification accuracy and consistency.

B. System Functionality and Reliability

Functional testing was conducted to verify the performance of different system components, including medication re-minders, automated voice alerts, caregiver monitoring, and cloud-based data storage. The system successfully delivered notifications at scheduled times and triggered voice calls using Twilio when required.

The hardware unit demonstrated reliable performance in capturing pill images under controlled lighting conditions. The integration between mobile application, hardware, and backend processing ensured seamless operation and accurate real-time verification.

C. Performance and Efficiency

Fig. 3 illustrates the end-to-end latency breakdown of the proposed system, highlighting the time consumed by different processing stages. The results show that model inference on the Raspberry Pi contributes the highest latency, followed by audio generation, while image capture and cloud communication are relatively efficient.

The overall system performance was evaluated in terms of response time and real-time usability. The system is capable of processing pill verification requests within a short time frame, making it suitable for practical deployment. Efficient communication between the mobile application, backend server, and AI module ensures minimal latency.

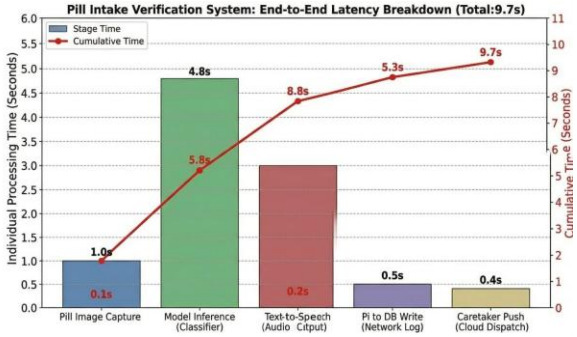

Fig. 3. End-to-End Latency Breakdown of the System

The modular architecture allows the system to scale efficiently with increasing users and data. The results confirm that the proposed system achieves a balance between accuracy, speed, and usability, making it a reliable solution for elderly medication management.

VI. DISCUSSION

The proposed Pill Track system presents a comprehensive approach to addressing the challenges

associated with medication management in elderly healthcare. The integration of artificial intelligence, mobile technology, and hardware-assisted verification provides a significant improvement over traditional reminder-based system. By introducing a verification mechanism before medication intake, the system effectively reduces the risk of errors such as incorrect pill consumption and missed doses.

One of the key strengths of the system lies in its multi-stage AI pipeline, which combines object detection, classification, and text recognition. This approach enhances accuracy and ensures reliable identification even for visually similar pills. Additionally, the inclusion of automated reminders and care-giver monitoring improves adherence and provides an added layer of safety.

However, the effectiveness of the system is influenced by factors such as image quality, lighting conditions, and dataset limitations. Variations in pill appearance or incomplete imprint data may affect recognition accuracy. Furthermore, the reliance on hardware components such as the Raspberry Pi may introduce additional cost and setup complexity for users. From a system perspective, scalability and real-time performance remain important considerations. While the current implementation demonstrates efficient performance, further optimization and cloud integration can enhance system responsiveness for larger user bases.

Overall, the proposed system demonstrates strong potential in improving medication safety and adherence. Continuous improvements in AI models and system design can further enhance reliability and user experience in real-world healthcare applications.

VII. CONCLUSION

The proposed system, Pill Track, presents an intelligent and integrated solution for improving medication management in elderly healthcare. By combining a mobile application, artificial intelligence-based pill identification, hardware-assisted verification, and cloud-based health record management, the system addresses the limitations of existing reminder-based solutions.

The multi-stage AI pipeline, incorporating YOLOv8, Convolutional Neural Networks, and EasyOCR, enables accurate and reliable pill verification, reducing the risk of medication errors. The inclusion of automated reminders, voice-based alerts, and caregiver monitoring further enhances medication adherence and patient safety.

Experimental results demonstrate that the system achieves high accuracy and efficient real-time performance, making it suitable for practical deployment. The integration of multiple components into a unified platform provides a comprehensive approach to elderly healthcare management.

Overall, Pill Track contributes to the development of smart healthcare systems by promoting safe, reliable, and independent medication practices. Future improvements can focus on enhancing model accuracy, expanding multilingual support, and integrating wearable health monitoring devices to further improve system capabilities.

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