HARDWARE AND SOFTWARE SYSTEM DESIGN OF A SMART PILLBOX MANAGEMENT SOLUTION

MBARKI Mohamed Achraf , Wael Waer , Mohamed Slah Bouafif , Ala Kamoun Mohamed Daoud

Abstract : This paper details the development of a novel pillbox management system integrating a Flutter mobile application with an embedded solution utilizing ESP32 and Raspberry Pi boards. The system is designed to streamline medication adherence and enhance therapeutic compliance for patients. The architecture, hardware configuration, and software customization pertinent to the system's functionality are elaborated upon in this paper.

The customization of the generic pillbox controller for specific medication management tasks is exemplified herein. The system incorporates sensors to monitor medication intake, environmental conditions such as temperature and humidity, and employs artificial intelligence for voice recognition and chatbot interaction. This paper demonstrates the seamless integration of hardware and software components to achieve a comprehensive pillbox management solution.

I-Introduction :

The effective management of medications is crucial for patient well-being, yet it often presents challenges such as dosage tracking and adherence. Traditional methods have proven inadequate in addressing these challenges, prompting the exploration of technological solutions. This paper explores the development of an innovative pillbox management system leveraging the capabilities of modern mobile applications and embedded systems.

The customization of the pillbox controller for specific medication management tasks is a central focus of this paper. By integrating sensors for medication intake monitoring and environmental sensing, alongside artificial intelligence for voice interaction, the system aims to provide a user-friendly and proactive approach to medication management. This paper elucidates the system's architecture, hardware setup, and software development process to achieve these objectives.

II-Hardware Description

The medication management system comprises a range of key components enabling its efficient operation. The main hardware elements include:

1. **TCRT5000 Sensor**:
    - An infrared sensor capable of detecting the presence of objects nearby, ideally suited for verifying medication intake in the pillbox.

2. **DHT22 Sensor**:
    - A high-precision temperature and humidity sensor that provides essential data for monitoring the pillbox environment, ensuring proper storage conditions for medications.
3. **RTC Clock Module**:
    - A Real-Time Clock (RTC) module ensures accurate tracking of time and date, enabling precise management of medication intake schedules, regardless of Internet connectivity.
4. **ESP32 Board**:
    - The ESP32 board acts as the brain of the embedded solution, providing Wi-Fi and Bluetooth connectivity for communication with the mobile application and other smart devices. It is responsible for managing the sensors and coordinating monitoring and notification tasks.
5. **Raspberry Pi**:
    - The Raspberry Pi board serves as the core of the solution's artificial intelligence. It runs voice recognition and chatbot algorithms, enabling natural interaction with users. Additionally, it can act as a data gateway for sending and receiving information between the system and the cloud, if needed.

These hardware components are carefully selected and integrated to create a robust and versatile medication management solution capable of meeting various patient needs while ensuring ease of use and optimal therapeutic adherence.

III-System Design and Implementation :

The pillbox management system is comprised of two main components: a Flutter mobile application and an embedded solution utilizing ESP32 and Raspberry Pi boards. The mobile application serves as the user interface, allowing patients to schedule medication doses and receive personalized reminders. Meanwhile, the embedded solution incorporates sensors such as TCRT5000 for medication intake detection and DHT22 for environmental monitoring.

Furthermore, the system employs artificial intelligence for voice recognition and chatbot interaction, enhancing user engagement and accessibility. The integration of these components is crucial for providing a comprehensive medication management solution that addresses the diverse needs of patients.

IV-Software Architecture :

The software architecture for the smart pillbox management solution combines multiple programming languages to leverage their respective strengths and optimize system performance. The primary languages utilized include C for the embedded controller, Dart for the mobile application, and Python for the artificial intelligence component.

Embedded Controller (C): The firmware for the embedded controller is developed predominantly in C. This choice offers low-level hardware access and efficient memory management, crucial for the controller's real-time operation. Additionally, assembly language is employed when specific control over hardware is required or

when speed optimization is essential. This hybrid approach ensures both precise hardware control and ease of programming.

Mobile Application (Dart): The mobile application, built using Dart programming language, serves as the user interface for the smart pillbox management system. Dart's compatibility with the Flutter framework facilitates rapid development of cross-platform applications with a native look and feel. The mobile app allows users to schedule medication doses, receive reminders, and interact with the pillbox system seamlessly.

Artificial Intelligence (Python): Python is utilized for the artificial intelligence component of the system, running on the Raspberry Pi board. Python's versatility and extensive libraries make it well-suited for tasks such as voice recognition and chatbot interaction. The AI module enhances user engagement by enabling natural language interaction and intelligent responses to user queries or commands.

This combination of programming languages enables the smart pillbox management solution to leverage the strengths of each language while ensuring compatibility and seamless integration across different components of the system.

This combination of programming languages enables the smart pillbox management solution to leverage the strengths of each language while ensuring compatibility and seamless integration across different components of the system.

Conclusion : In conclusion, the development of the pillbox management system represents a significant advancement in healthcare technology. By combining the convenience of mobile applications with the capabilities of embedded systems and artificial intelligence, the system offers a holistic approach to medication management. Future enhancements and optimizations will further refine the system's functionality, ultimately improving medication adherence and therapeutic outcomes for patients.