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Medmind:Smart Medicine Management System and Emotionally Adaptive AI for Elderly Care

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Abstract - As the elderly population grows, managing medication adherence and overall well-being becomes increasingly critical. "Medmind: Smart Medicine Management System and Emotionally Adaptive AI for Elderly Care" addresses this challenge by integrating IoT technology, artificial intelligence, and wearable health monitoring into a unified platform. The system consists of a Wi-Fi-enabled smart medicine box that tracks medication levels, a mobile app for real-time management and reminders, and an AI-powered wearable device that monitors vital signs and emotional states. The smart medicine box ensures timely medication refills and intake by sending notifications and alerts to both users and caregivers.

The AI-powered reminders are personalized, adapting to the user's health status and emotional well-being, which is continuously monitored by the wearable device. This integration of emotional and physical health data allows the system to provide holistic care, enhancing medication adherence, reducing errors, and offering proactive health management. Additionally, the system tracks medication expiration dates using entered data, alerting caregivers and guardians when a medication is nearing or has passed its expiry and refill. In addition, Medmind facilitates seamless integration with healthcare providers, ensuring accurate medication lists and timely updates. The system also includes emergency protocols, automatically alerting caregivers or emergency services in critical situations. By combining medication management with emotionally adaptive AI, Medmind aims to improve the independence, health outcomes, and overall quality of life for elderly individuals, while providing peace of mind for caregivers and family members.

Key Words: AI, IoT, Medication Adherence, Real-time Monitoring

1.INTRODUCTION

As the global elderly population continues to rise, medication adherence and health monitoring have become critical challenges in healthcare. Many elderly individuals struggle with managing multiple medications, leading to missed doses, overdosing, or medication errors, which can result in severe health complications. Additionally, age-related health issues such as fluctuations in heart rate, oxygen levels, and cognitive decline further complicate their medical needs. To address these concerns, we propose MedMIND: A Smart Medicine Management System and Emotionally Adaptive AI for Elderly Care, an IoT-integrated, AI-powered healthcare solution designed to enhance medication adherence and remote health monitoring.

The MedMIND system consists of two primary components: a smart medication dispenser and a wearable health monitoring device. The ESP32-controlled dispenser automates medicine administration using a stepper motor, buzzer, and LCD display, ensuring timely medication reminders and adherence tracking. Simultaneously, the wearable device, powered by NodeMCU ESP8266, integrates a MAX30102 sensor to continuously monitor vital signs like heart rate and SpO2 levels. This health data is transmitted in real-time via Wi-Fi/cloud integration, enabling caregivers and healthcare providers to remotely monitor patient well-being and intervene if necessary. The system also employs emotionally adaptive AI algorithms that analyze health trends and trigger emergency alerts when abnormal vitals are detected, ensuring a proactive healthcare approach.

By integrating IoT, cloud computing, and AI-driven emotional adaptation, MedMIND enhances elderly independence, reduces medication errors, and improves emergency response. This paper discusses the design, implementation, and impact of MedMIND, highlighting its potential to revolutionize elderly healthcare by providing an affordable, efficient, and intelligent medicine management system.

2. LITERATURE REVIEW

1. Medication Adherence and Smart Dispensers

Medication non-adherence is a major concern among the elderly, leading to serious health complications and increased hospitalization rates. According to Bhatti et al. (2024)**,** IoT-enhanced medicine transport and monitoring systems significantly improve adherence by using real-time data tracking and secure communication protocols. Various studies have explored automated pill dispensers integrated with AI and IoT for personalized medication management. Luan et al. (2020) introduced MEMO Box, a health assistant for depression patients, incorporating AI-driven medication reminders and exercise adjustments. However, these systems often lack **r**eal-time health monitoring and caregiver integration**,** which MedMIND addresses.

2. Wearable Health Monitoring Technologies

Wearable devices play a crucial role in continuous health monitoring**,** providing real-time physiological data. Long &

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Chung (2022) discuss wearable wrist-based Photoplethysmography (PPG) sensors, like MAX30102, for accurate heart rate and SpO2 monitoring. Similarly, Rashid et al. (2023) highlight stress detection using sensor fusion techniques to analyze contextual health data. While these technologies provide valuable insights, most lack integration with medication management, a gap that MedMIND fills by linking vital sign fluctuations with medication alerts.

3. Emotionally Adaptive AI in Healthcare

AI-powered emotion recognition has been gaining attention for enhancing healthcare interactions. Dwijayanti et al. (2022) explored real-time emotion recognition in humanoid robots using CNN-based deep learning models. Similarly, Panula et al. (2023) discuss AI-driven, non-invasive blood pressure measurement techniques for improved patient care. MedMIND leverages such AI advancements to analyze vital sign trends, detect stress or abnormal health conditions, and trigger emergency alerts, making elderly care more responsive and adaptive.

4. IoT and Cloud Integration for Remote Monitoring

Cloud-based healthcare solutions enable real-time patient monitoring and remote caregiver access. Manahil et al. (2023) presented an IoT architecture for smart wearable devices, enabling secure remote access for caregivers and healthcare providers. Similarly, MEMO Box employs edge computing for AI-driven medicine scheduling. MedMIND builds upon these frameworks by ensuring seamless integration between wearable devices, medication dispensers, and a cloud-based platform, allowing caregivers to monitor health parameters and medication adherence remotely.

5. Challenges and Future Scope

While existing systems provide partial solutions to elderly healthcare, they lack a unified approach that integrates medication management, real-time health tracking, and AI-driven emotional adaptation. MedMIND addresses this gap by combining automated dispensing, wearable health monitoring, and cloud-based caregiver support. Future advancements could focus on AI-driven predictive analytics, detecting potential health issues before they become critical, and further enhancing emergency response mechanisms.

3. METHODOLOGY

Medmind is a wearable IoT-based health monitoring and medication management system designed to provide comprehensive care for elderly individuals. The system leverages AI and various sensors to track vital signs, detect emotions, and enable remote caregiver access, allowing for proactive health interventions. The central design approach involves integrating hardware and software components to monitor body temperature, heart rate, SPO2 levels, and emotional states, while offering caregivers real-time insights via a mobile app.

At the core of the Medmind system is the Controller Unit, which acts as the primary processing hub. The Controller Unit manages inputs from various sensors and outputs to different modules, ensuring smooth data flow. It coordinates the collection of health data from sensors, controls the medication dispenser motor, and facilitates communication with the Internet Interface Module, which allows the system to connect to a cloud server. This cloud server serves as the primary backend for data storage and processing, enabling historical data analysis and generating health insights and personalized reminders. The system incorporates several sensors that continuously monitor the user's vital signs. The Temperature Sensor tracks body temperature, the Heart Rate Sensor measures the patient's pulse, and the SPO2 Sensor monitors blood oxygen levels.

Additionally, an Emotion Detection Model uses a Camera Module to analyze the patient's facial expressions through AI-based facial recognition. This model helps caregivers understand the patient's emotional state, providing a more personalized level of care. Data from the Emotion Detection Model is processed in real-time on the Controller Unit and shared with caregivers through the Android app. For communication, the Internet Interface Module connects the Controller Unit to a cloud server using Wi-Fi or cellular connectivity. This module transfers data from the sensors and emotion detection model to the cloud for further processing and analysis. The cloud server uses this data to generate actionable insights, track health trends, and send timely reminders based on the patient's health and emotional state. The Android Mobile App serves as the primary interface for caregivers and healthcare professionals, providing real-time alerts and updates that enable remote monitoring and timely intervention.The system also includes an LCD Display on the smart medicine box, which displays important information, such as medication reminders and vital sign updates. The Dispenser Motor within the box is responsible for releasing medication according to a preset schedule, managed by the Controller Unit. This feature ensures that the patient receives the correct dosage at the appropriate time without needing caregiver intervention.In terms of critical care, MedMIND implements Emergency Protocols.

The system continuously monitors the patient's vital signs, and if readings go beyond safe thresholds, it triggers an immediate alert to caregivers through the Android app. This feature ensures that in the event of a health emergency or signs of emotional distress, caregivers or healthcare providers are notified instantly, enabling them to respond quickly.Each component undergoes rigorous testing and calibration to ensure accuracy and reliability. The sensors are calibrated to minimize errors, and the Emotion Detection Model is optimized for real-time performance and low-power consumption. The entire system is tested across different scenarios to ensure the smooth interaction between components and reliable activation of emergency protocols. Medmind offers a holistic approach to elderly care by combining IoT, AI, and real-time monitoring. This cohesive, adaptive system enhances the quality of life for elderly users by ensuring both physical and emotional well-being, while providing caregivers with the tools they need for remote, responsive, and personalized care.

4. SYSTEM ARCHITECTURE

4.1 BLOCK DIAGRAM

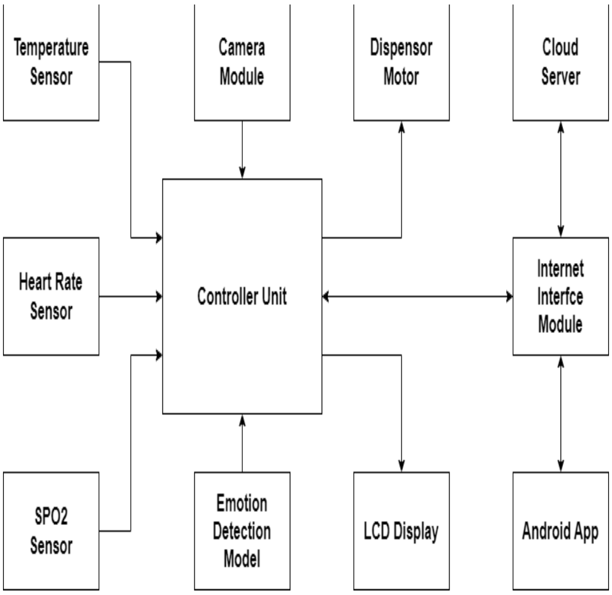

Figure1: Block diagram

The MedMIND illustrates the integration of various components to create an intelligent medicine management system for elderly care. At the core is the Controller Unit, which receives inputs from multiple sensors, including a temperature sensor, heart rate sensor, and SPO2 sensor, to continuously monitor the user's vital signs. An Emotion Detection Model processes this data to assess the user's emotional state. The Camera Module aids in facial recognition or activity monitoring**,** ensuring medication compliance. The Controller Unit communicates with an Internet Interface Module**,** which transmits data to a Cloud Server**,** allowing caregivers to monitor real-time health status via an Android App**.** The system includes an LCD Display for local notifications and a Dispenser Motor that automatically dispenses medicine at scheduled times. This interconnected approach enhances medication adherence, real-time health tracking, and caregiver intervention**,** ensuring better elderly healthcare management**.**

4.2 SOFTWARE REQUIREMENTS

To develop an efficient and user-friendly MedMIND: Smart Medicine Management System, we have carefully selected the appropriate technologies for each component. The Android app features a clean and intuitive interface, designed using Adobe Illustrator for seamless navigation. Development is done using Kodular, a no-code platform that allows for quick and flexible app creation without requiring complex programming. The backend is powered by Firebase, which manages real-time data storage, user authentication, and cloud-based communication. Together, these technologies enable medication tracking, smart reminders, caregiver alerts, and health monitoring, improving medication adherence and elderly care. Below is a detailed overview of each software component:

1. Adobe Illustrator

Adobe Illustrator plays a crucial role in designing the app’s user interface (UI), ensuring that elements like buttons, icons, and layouts remain sharp and visually appealing across all screen sizes. This is essential for creating an app that is easy to use, especially for elderly users. Features such as Artboards allow us to design multiple app screens in a single workspace, ensuring a smooth and consistent layout. Pen Tool and Shape Builder help create clear and intuitive icons, while Color and Gradient tools enhance visibility and accessibility. Illustrator’s integration with Adobe XD and Photoshop simplifies prototyping and refining before implementation in Kodular. Since Kodular supports high-quality images, assets can be exported in PNG, SVG, or WebP formats for seamless integration. Smart guides, layers, and responsive resizing ensure that the UI remains well-organized and adaptable across different screen sizes. Additionally, Adobe Cloud Sync enables collaboration and real-time updates. By using Illustrator, we create an app that is not only functional but also visually appealing and easy to navigate, enhancing the medication management experience for users and caregivers.

2. Kodular

Kodular, a no-code app development platform based on MIT App Inventor, enables fast and efficient app creation without requiring programming expertise. Its drag-and-drop interface allows for easy arrangement of UI elements and logic setup using block-based coding. This simplifies the development of the MedMIND app, allowing for the integration of medication reminders, user authentication, real-time health monitoring, and caregiver notifications without extensive coding. Kodular provides a range of pre-built components, such as buttons, notifications, sensors, and database connectivity, ensuring a smooth user experience. For additional functionalities, custom extensions can be incorporated. The Kodular Companion app allows real-time testing, reducing the need for frequent installations. Its seamless integration with Firebase ensures instant data exchange, keeping medication tracking and health alerts accurate and timely. By leveraging Kodular, we can quickly develop an efficient and user-friendly app that enhances medication adherence and elderly care.

3. Firebase Server

Firebase, a cloud-based platform by Google, serves as the core of our MedMIND system, handling real-time data updates, user authentication, and instant notifications. Since the system must track medication schedules, stock levels, and health status, Firebase’s Realtime Database ensures that any changes—such as low medicine stock, missed doses, or abnormal health readings—are instantly updated in the app. This allows caregivers and users to take timely action. Firebase Authentication secures the system, ensuring that only authorized users (such as family members or healthcare providers) can access sensitive data. For urgent alerts, Firebase Cloud Messaging (FCM) delivers push notifications

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directly to the app, ensuring prompt action in case of missed medications or health emergencies. Its seamless integration with Kodular eliminates the need for complex backend coding, making data handling efficient. If the system expands to include a web-based dashboard, Firebase Hosting can support it, while Firebase Analytics provides insights into app usage and user behavior. With real-time synchronization, robust security, and scalability, Firebase ensures that MedMIND operates smoothly, keeping users and caregivers well-informed and enhancing medication management for elderly individuals.

4.3 ALGORITHM

Step 1: Start
Step 2: Initialize Components
- Connect the wearable device to WiFi.
- Connect the pill dispenser to WiFi.
- Establish a connection with Firebase for data synchronization.

Step 3: Wearable Device Setup
- Activate sensors to monitor SpO2, temperature, and pulse rate.
- Begin capturing facial emotions using the ML unit.
- Set data transmission frequency (e.g., every minute or based on significant change).

Step 4: Collect Health Data
- Measure SpO2, body temperature, and pulse rate.
- Run facial emotion recognition algorithm to detect the emotional state.
- Bundle the collected data (vital signs and emotions) for transmission.

Step 5: Transmit Health Data
- Send the bundled data to Firebase.
- Update data in the Android app for real-time monitoring by caregivers.

Step 6: Notification and Alerts
- Check for abnormal health parameters.
- If any parameter is abnormal:
  - Send an immediate alert to the caregiver's Android app.
  - Notify the user via wearable device (e.g., vibration or sound).

Step 7: Tablet Dispenser Setup
- Synchronize tablet details and dispense times with the Android app.
- Set up schedules for dispensing tablets: morning, afternoon, and night.

Step 8: Dispense Tablets
- At each scheduled time:
  - Activate the automated pill dispenser.
  - Dispense the correct tablet(s).
  - Send a notification to the caregiver and user about the dispensing.

Step 9: Check Tablet Stock and Expiry
- Monitor stock levels in the dispenser after each dispense.
- Check tablet expiry dates at regular intervals.

Step 10: Notifications for Stock and Expiry
- If tablets are low on stock:
  - Send a notification to the Android app to prompt refilling.
- If tablets are nearing expiry:
  - Send an alert notification to replace expired tablets.

Step 11: Update Status on Android App
- Update all information (vital signs, emotional state, dispensing records, stock, and expiry) in real-time on the Android app.

Step 12: Repeat Monitoring and Dispensing Process
- Continue looping through Steps 4–11 for ongoing monitoring and timely dispensing.

Step 13: End.

5. CIRCUIT DESIGN

5.1 DISPENSER UNIT

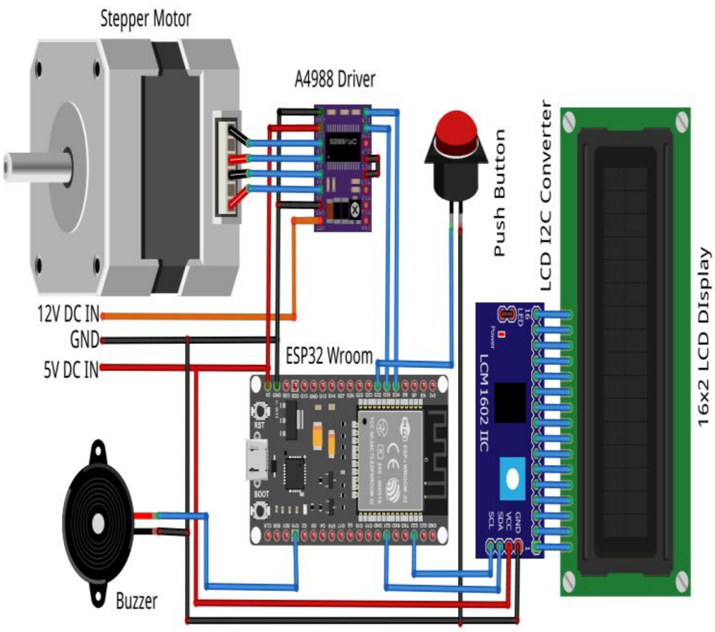

Figure 2: Circuit Diagram of Dispenser unit

5.2 WEARABLE DEVICE

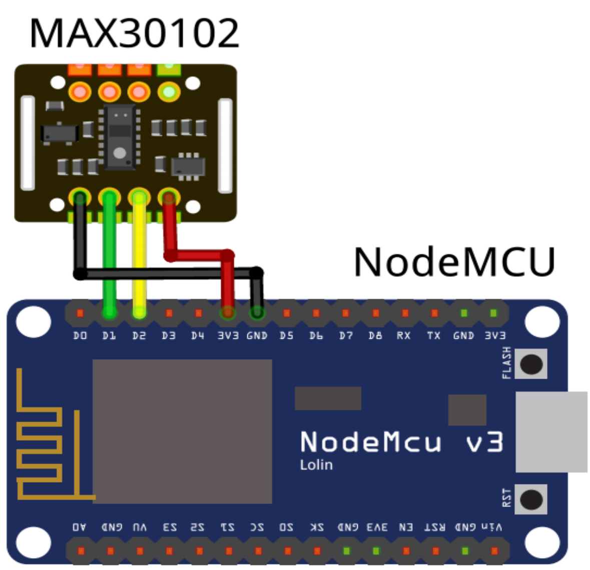

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Figure 3: Circuit Diagram of Wearable Device

To design and implement this circuit, begin by creating a schematic in a design tool like Fritzing, connecting the ESP32 microcontroller to key components: an A4988 driver for stepper motor control, an I2C LCD for displaying information, a push button for user input, and a buzzer for sound alerts. The stepper motor requires a 12V power supply through the A4988 driver, while the ESP32 and peripherals operate on 5V power. The STEP and DIR pins of the A4988 are linked to the ESP32's GPIO for motor control, while the LCD's SDA and SCL pins connect to the ESP32's I2C pins for communication. The push button and buzzer are also assigned to separate GPIO pins. Once assembled on a breadboard or PCB, the ESP32 is programmed to manage motor movement, display data, detect button presses, and activate the buzzer as needed. Additionally, for health monitoring in MedMIND, the MAX30102 heart rate and SpO2 sensor is integrated with a NodeMCU ESP8266, where the sensor's VCC and GND connect to the 3V3 and GND pins of the NodeMCU. Its SCL and SDA pins connect to D1 (GPIO5) and D2 (GPIO4), respectively, enabling communication via I2C protocol. This setup allows the NodeMCU to collect and process heart rate and oxygen saturation data from the MAX30102, which can then be used for remote health monitoring, ensuring real-time tracking of vital signs within the MedMIND system.

6.WORKING AND IMPLEMENTATION

6.1 SOFTWARE PART WORKING

The MedMind application, developed using Kodular, features several essential screens to support health monitoring and medication management. The initial splash screen displays the app's logo and branding. It has a clean layout, possibly including navigation symbols or settings icons. Next is the login screen, where users enter their username and password to gain secure access to personalized features, which is crucial for an app handling sensitive health data. The home screen is designed to provide critical health-related alerts, such as notifications for a high pulse rate and an emotion indicator (e.g., "Sad"), alongside real-time monitoring of health metrics like pulse count, temperature, and liquid level status. This layout allows users or caregivers to quickly check essential health information. Additionally, the pill dispenser screen includes numbered buttons (1-15) to represent different medication slots. Users can select specific slots to dispense medication, and a reset button allows for easy adjustments. This functionality helps users manage their medication schedule effectively, ensuring they take their prescribed pills at the right times. Kodular, a no-code platform, was used to build this application, enabling developers to design an intuitive UI, manage data, and incorporate features like user authentication and real-time health updates without extensive coding. The use of color—such as red for alerts and green for inputs—enhances readability and directs attention to important information, making the MedMind app both functional and user-friendly.

Figure 4: Frontend of App developed

7. CONCLUSIONS

In conclusion, MedMind offers a holistic solution for elderly care by integrating IoT, AI, and wearable health monitoring to improve medication adherence, provide real-time health updates, and enhance caregiver support, ultimately improving the quality of life for elderly individuals. While challenges like initial setup costs and internet dependency exist, MedMind's benefits in personalized care and proactive health management make it a promising tool. For future development, enhancements such as increased AI personalization, offline functionality, telemedicine integration, improved battery life, and stronger data security will further strengthen its effectiveness and accessibility, making it an even more reliable and user-friendly solution in elderly healthcare.

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