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Enhancing Elderly Safety Using Innovative Smart Monitoring Systems

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Abstract— This paper presents a smart healthcare monitoring system that utilizes the ESP32 microcontroller along with multiple sensors to measure vital health parameters such as heart rate, body temperature, and ECG. The collected data is transmitted to a cloud platform, Supabase for real-time storage and analysis. The system also provides a web-based interface for users to monitor their health trends and past readings in a structured format. The proposed system aims to enhance remote healthcare capabilities by offering an affordable, scalable, and efficient health monitoring solution**.**

Keywords— ESP32, healthcare monitoring, cloud computing, IoT, real-time monitoring, wearable sensors**,** etc.

1. INTRODUCTION

As the global elderly population increases, ensuring their safety, independence, and well-being has become a major concern. Many elderly individuals prefer to live independently, but this often comes with challenges such as health risks, delayed emergency responses, and lack of continuous monitoring. To address these issues, advancements in technology have enabled the development of smart health monitoring systems that can significantly improve the quality of life for the elderly.

This project focuses on designing and implementing an innovative smart monitoring system tailored to elderly care. By integrating biomedical sensors with an ESP32 microcontroller and IoT technology, the system continuously monitors vital parameters such as body temperature, heart rate, ECG signals, and blood oxygen levels. In case of abnormal readings or emergencies, the system instantly alerts caregivers or family members via GSM communication, ensuring quick response and timely intervention.

SYSTEM DESIGN

The proposed real-time healthcare monitoring system is designed to collect, process, and store vital health data using a custom designed ESP32 PCB, biomedical sensors, and cloud integration with Supabase. The methodology is structured into several key components, including hardware design, sensor integration, data processing, cloud storage, and web visualization.

1.1 Block Diagram:

Fig 2.1 shows the block diagram of the system. The block diagram mainly consists of the four main components required for the proper functioning of the project.

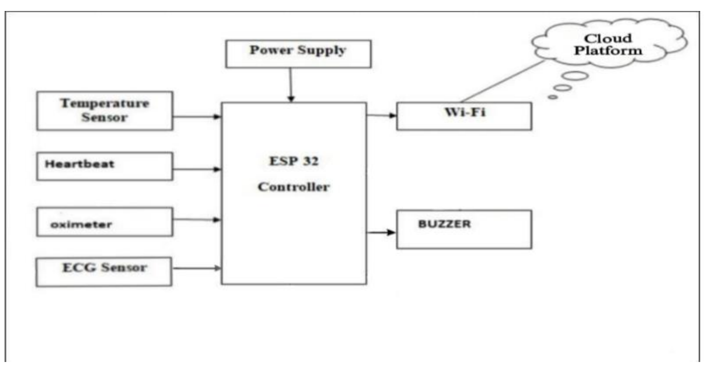


Fig 2.1 System Design

The block diagram illustrates the architecture of a real-time healthcare monitoring system.

1 **Sensors**: These sensors (temperature, heart rate, ECG, and blood pressure) collect vital health data from the user.
2 **ESP32**: the ESP32 gathers all sensor data, it displays essential parameters on the **LCD screen**, enabling users

or caregivers to easily monitor health status in real time. If any reading exceeds the normal threshold, the **buzzer** is activated by the ESP32 to alert the user or nearby caregivers immediately. For broader safety and remote monitoring
3 **WiFi**: the ESP32 utilizes its **Wi-Fi module** to transmit the collected data to a **cloud platform**. This enables family members or healthcare professionals to access the information from anywhere, analyze trends, and take timely actions when needed.

1.2 Methodologies:

The healthcare monitoring system is built using **a** custom designed ESP32 PCB, integrated with LM35 temperature, heart rate, and ECG sensor**s** for real-time data collection. The ESP32 processes sensor readings, applies filtering, and transmits the data to Supabas**e**, a cloud-based PostgreSQL database. A web interface allows users to view real-time and historical health data, with a "History" button fetching the last 10 records for trend analysis. This setup ensures continuous monitoring, remote accessibility, and early anomaly detection, making it a scalable and efficient healthcare solution.

1.2.1 Hardware Design and ESP32 Integration: Unlike conventional systems that use pre-assembled microcontroller modules, this project features a *customdesigned PCB based on the ESP32 microcontroller*, ensuring optimized hardware integration. The *ESP32* was chosen for its *built-in Wi-Fi and Bluetooth capabilities, low power consumption, and high processing efficiency*, making it ideal for IoT-based real-time health monitoring applications. Fig 2.2 shows the custom designed ESP32 PCB, designed to accommodate multiple sensor connections, power management circuits, and communication interfaces, ensuring seamless data

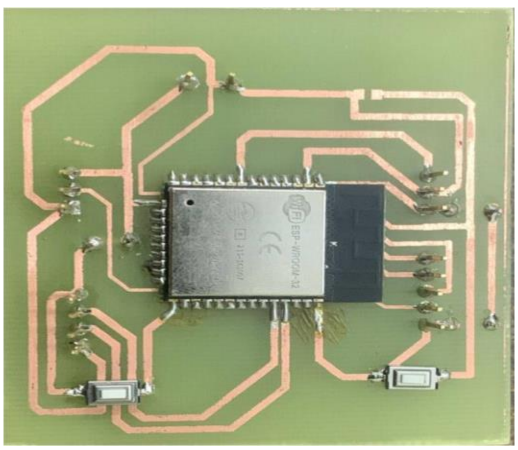


Fig. 2.2 Custom-Designed ESP32

1.2.2 Sensor Integration and Data Acquisition: The system integrates multiple biomedical sensors to track *essential health parameters*:

- **LM35 Temperature Sensor** – Provides accurate body temperature readings with an analog voltage output proportional to temperature changes.

- **Heart Rate Sensor** – Uses photoplethysmography (PPG) technology to detect blood flow variations and calculate heart rate in beats per minute (BPM).
- **ECG Sensor** – Measures the electrical activity of the heart, enabling real-time monitoring of cardiac health.

1.2.3 Data Processing and Transmission: Once sensor data is acquired, the ESP32 *processes the data locally* before sending it to the cloud. The system implements:

- **Analog-to-Digital Conversion (ADC)** – For processing analog signals from the temperature and ECG sensors.
- **Noise Filtering** – To improve signal quality and remove unwanted fluctuations.
- **Threshold-Based Alerts** – If a health parameter exceeds normal limits, the system triggers an alert for real-time monitoring.

2.2.4. Cloud Integration with Supabase: For *real-time data storage and remote access*, *Supabase* is used as the cloud database as shown in Fig 2.3. The ESP32 *directly interacts with Supabase's PostgreSQL database* to store health data securely. Supabase provides:

- **Real-time synchronization** – Allowing continuous updates of health records.
- **Scalability** – Handling large volumes of health data efficiently.
- **Secure authentication** – Ensuring only authorized users can access stored health records.

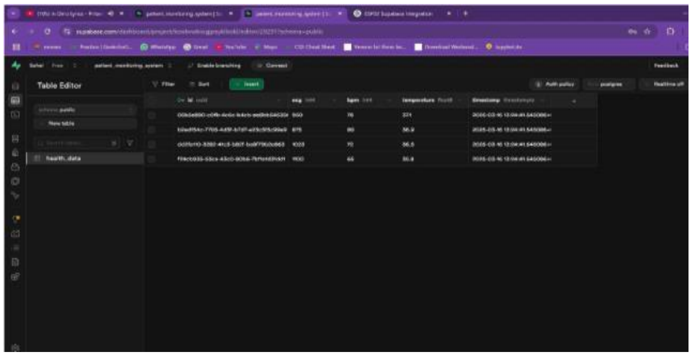


Fig. 2.3 Supabase Database

2.2.5 Web Interface for Data Visualization: To enhance accessibility, a *responsive web interface* was developed to display real-time and historical health data. The interface allows users to:

- View current sensor readings (ECG, BPM, temperature).
- Access previous health records through a "History" button, which retrieves the last 10 readings from Supabase and presents them in a tabular format.
- Receive alerts and recommendations based on recorded data.

2.2.6 **System Workflow:**

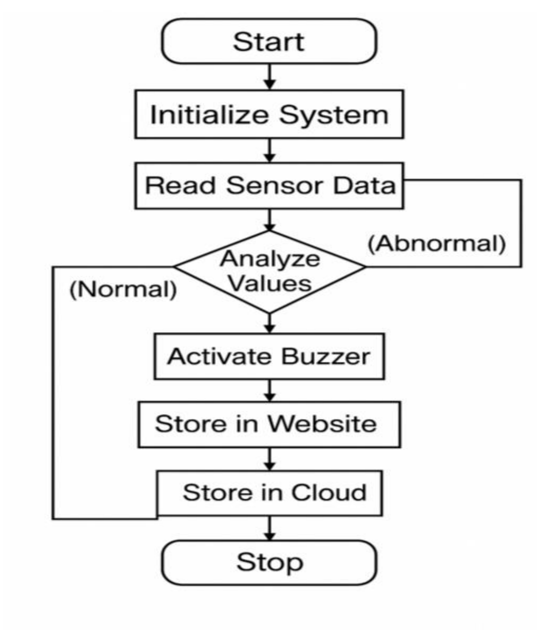


Figure 3.1: Flow Chart

Fig 3.1 Simulation

The ESP32 microcontroller was programmed to simulate readings from the ECG, temperature, and heart rate sensors. These simulated values were sent to the Supabase cloud database, and the data flow was visualized through the web dashboard. This simulation helped test system performance, data accuracy before deploying the actual hardware, ensuring smooth operation and reliable monitoring.

3.2 Hardware Results:

Fig 3.2 displays the hardware which is a custom-built health monitoring system designed for real-time tracking of vital signs.

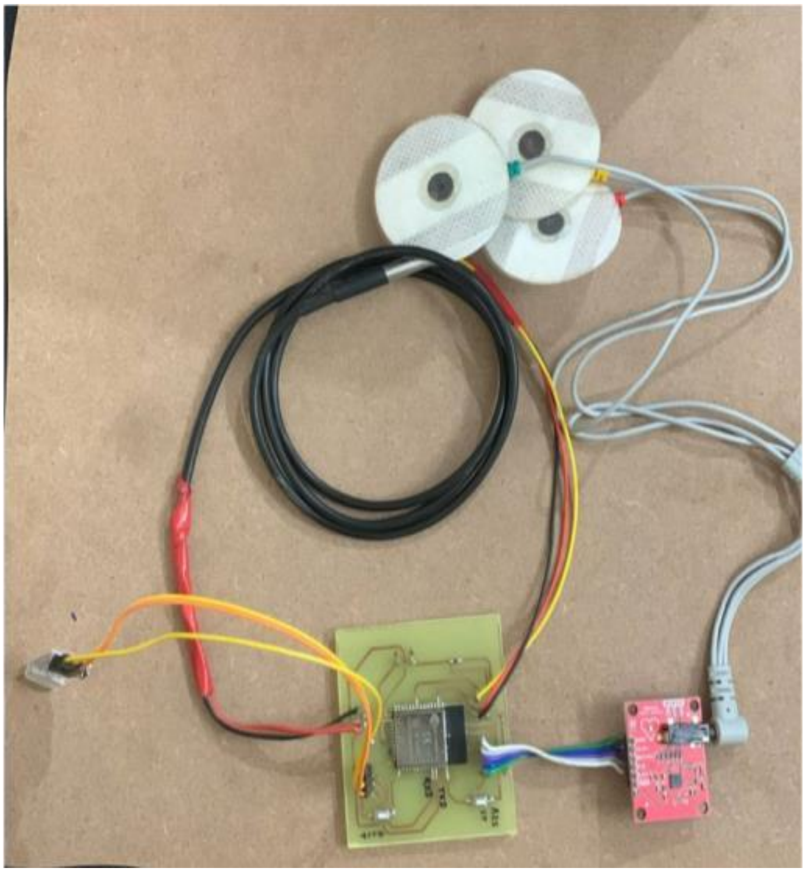
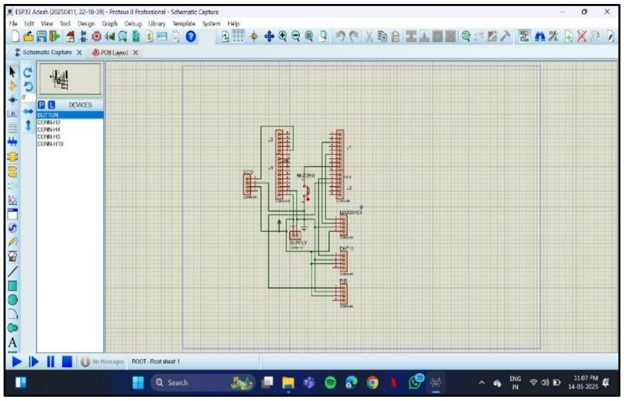


Fig.3.2Hardware

2. Results & Discussion

2.1 Simulation Result:

To validate the functionality of the proposed health monitoring system, a simulation was created as shown in Fig 3.1 using Proteus Simulator to emulate real-time data transmission from sensors to the cloud.



At its core is a custom-made PCB with an ESP32 microcontroller, which acts as the main processing and communication unit. Various health sensors are integrated into this setup:

1. **ECG Sensor (red module)** – Captures the electrical activity of the heart through electrode pads, providing essential data for heart health monitoring.

2. **Temperature Sensor (black probe)** – Measures body temperature accurately, a critical parameter in detecting fever and other health conditions.

3. **Heart Rate Sensor** – Detects pulse rate, helping in assessing cardiovascular health.

These sensors send data to the ESP32, which processes and transmits it wirelessly to a cloud platform for real-time storage and analysis. The stored data can be accessed via a web-based dashboard, allowing users and healthcare professionals to monitor health trends over time. This system is particularly useful for remote patient monitoring and preventive healthcare, providing a cost-effective and efficient solution for continuous health tracking.

3.3 Website Interface Result:

A dedicated website was developed as part of the project to display real-time health data collected by the sensors. The interface is simple, responsive, and user-friendly, allowing users to monitor key vitals such as ECG, heart rate, and temperature. The website is integrated with a cloud database (Supabase) to fetch and display live data and includes a "History" section where previous readings are shown in a tabular format.

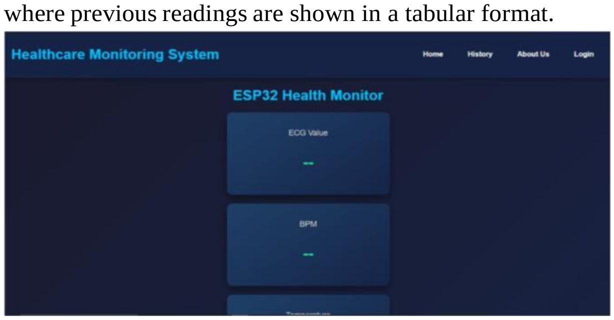


Fig 3.3 Website

This platform serves as a convenient tool for both patients and healthcare providers to access and analyze health information anytime, anywhere.

3. CONCLUSION

This paper presents a real-time healthcare monitoring system using a custom designed ESP32 PCB**,** biomedical sensors, and Supabase cloud integration for efficient health tracking. By continuously monitoring temperature, heart rate, and ECG data**,** the system enables early anomaly detection and remote access to health records. A web interface provides real-time visualization and historical data analysis, enhancing usability. This IoT-based solution offers a scalable, cost-effective approach to preventive healthcare and remote patient monitoring. Future enhancements include AI-driven analytics and chatbot integration for personalized health recommendations.

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