KLE Technological University
Creating Value, Leveraging Knowledge
Dr. M. S. Sheshgiri Campus, Belagavi

Department of Electronics and Communication Engineering

Report on Mini Project

REMOTE PATIENT MONITORING SYSTEM

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Semester: V, 2024-2025

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Creating Value, Leveraging Knowledge

Dr. M. S. Sheshgiri Campus, Belagavi

2024-2025

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that project entitled **"Remote Patient Monitoring System"** is a bonafide work carried out by the student team of **" Akash Potdar (02FE22BEC003), Ayan Kudachi (02FE22BEC013), Pallavi Lad (02FE22BEC046), Vaibhavi Patil (02FE22BEC048)"**. The project report has been approved as it satisfies the requirements with respect to the mini project work prescribed by the university curriculum for B.E. (V Semester) in Department of Electronics and Communication Engineering of KLE Technological University Dr. M. S. Sheshgiri CET Belagavi campus for the academic year 2024-2025.

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ACKNOWLEDGMENT

We would like to express our sincere gratitude to the following individuals and organizations who have played a significant role in the development of the Remote Patient Monitoring System.

We would like to express our sincere gratitude to our guide, Dr. Arun Tigadi, whose invaluable guidance and unwavering support have been instrumental throughout the entirety of our project.

We take the opportunity to thank our project coordinator Dr. U. L. Naik, for providing us motivation and encouragement.

We are grateful to our Head of the Department Dr. Dattaprasad Torse, for granting us the privilege to work on this project and for his valuable support throughout.

We take the opportunity to thank our Principal Dr. S. F. Patil, for providing us the opportunity to undergo the project.

We acknowledge the contributions of all the team members who participated in this project. Each team member brought unique skills and perspectives, contributing to the development of different elements of the project.

We extend our thanks to KLE Dr. MSSCET for providing the necessary resources and infrastructure to carry out this project. Their support was vital in enabling us to conduct the required research, acquire relevant knowledge, and access computing resources.

We take this opportunity to thank all the staff of Electronics and Communication Department for their cooperation and suggestions during the project.

-The project team

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Abstract

The patients in remote areas are unable to visit doctors frequently. The increasing demand for remote health monitoring systems has led to development of innovative solutions using Internet of Things(IoT) technology. This paper presents a remote health monitoring system , designed to collect vital health parameters like temperature ,ECG ,oxygen level ,heart rate and fall detection using different sensors .The data collected through the sensors is transmitted to microcontroller and then sent to mobile application. In case ,if abnormal health parameters are detected the system sends SMS alerts to the doctor ensuring timely intervention .To enable smooth communication between patients and healthcare providers mobile application is developed . This system aims to provide secure and flexible health monitoring system ,improve patients outcomes and allow timely medical intervention .The proposed system demonstrates the effective use of IoT in improving remote health monitoring.

1 Introduction

The patients with chronic diseases need to be monitor constantly,24 hours a day which is difficult to do either at hospitals or at home. So there is a need to develop a system to monitor health parameters. Traditional healthcare systems rely on frequent hospital visits and manual data collection which can be time consuming and expensive. By making remote health monitoring systems possible, the emergence of Internet of Things(IoT) technology has completely transformed the healthcare sector .IoT refers to network of physical devices, vehicles, appliances and other items connected with sensors, software and connectivity which allows to connect and exchange the data. Recent trends in IoT have enabled the development of remote health monitoring systems that can collect and share the real-time health data. These systems uses different sensors embedded with microcontroller. In case when abnormal signs are detected, these systems send alerts to healthcare provides which enables timely medical intervention. This systems provide to raise the general quality of life for people with chronic illness, lower healthcare costs and improves patients outcomes.

This paper presents a remote health monitoring systems which allows to collect vital health parameters like body temperature, ECG, oxygen level, heart rate and fall detection. The health data is collected through different sensors and the data gathered by sensors is then sent to the microcontroller .The microcontroller forwards the collected information on the app. When any abnormal signs are detected in health parameters ,SMS alerts are sent to doctors and patients enabling timely intervention .A mobile application is developed to facilitate the smooth communication between patients and doctors or healthcare providers.

There have been multiple researches on this particular topic in last few years and many researchers have come up with various techniques to develop most efficient and effective health monitoring system .The models have been developed using ECG sensors[12][10]. They have attached the ECG sensor on patients body and the recorded data is saved to cloud server database for further analysis. Some approaches[3] also used acclerometer to detect the motion of the body .The commonly used sensor is temperature sensors which continuously monitors the body temperature and is saved for further processing.

1.1 Motivation

The motivation for developing remote health monitoring systems lies in addressing the challenges of managing chronic diseases, which require continuous, real-time health monitoring that is difficult to achieve through traditional healthcare methods reliant on frequent hospital visits and manual data collection. IoT technology offers a transformative solution by integrating sensors, microcontrollers, and connectivity to collect, analyze, and share vital health data such as body temperature, ECG, oxygen levels, and heart rate. These systems enable timely detection of abnormalities, facilitate communication between patients and healthcare providers, improve patient outcomes, reduce healthcare costs, and enhance the overall quality of life for individuals with chronic illnesses, thereby addressing the limitations of conventional healthcare approaches.

1.2 Objectives

- To design an IoT-based remote health monitoring system that continuously tracks vital health parameters like body temperature, ECG, oxygen levels, and heart rate for efficient chronic disease management.

- To enhance patient outcomes and quality of life by enabling timely alerts for abnormal health signs and seamless communication between patients and healthcare providers through a mobile app.

2 Literature Survey

Remote patient monitoring is not new in modern technology but research trends in IoT based monitoring system makes it better equipped to solve practical problems .As a result numerous exciting system prototypes were developed.

Julhas Hussain et al.[7] explores IoT based health monitoring systems for e-health applications. The goal is to integrate IoT device and sensors to monitor key health parameter, enabling timely intervention ,reducing hospital visits. The sensors used here are temperature and pulse. Arduino is used to control and interface with sensors. Cloud-interface is used to process, store and analyse the date and notification are sent via SMS. This system is restricted to basic sensors which may not provide detail sufficient health data and the cloud system also lacks the data security.

Megha Arakeri et al .9951928[6] and Salma Sultana et al.[13] highlights the advancements and challenges in IoT based remote health monitoring. It illustrates need for better sensors, accurate use of algorithm and secure cloud-based system. It provides a overview of existing technology and also emphasize on limitation and challenges. The machine learning model proposed here is SVM which shows limited accuracy (86%).

Alvee Rahman et al.[11]have proposed the system that measures and monitors body temp and ECG signals . The system is built using using Auduino Uno, Raspberry bi and is integrated with the cloud and web interface. The Raspberry pi and basic sensors used here find it difficult for monitoring multiple patients simultaneously. The system relies manual inputs i.e patient should press button during emergences, which may not be feasible in all cases . Nasser M et al.[1] developed a system which includes wearable device that monitors vital health parameters like body temperature, heart beat blood pressure. The sensors collects the data and is sent to cloud servers and stored in MySQL database. It offers opportunities for future improvements which includes adding more sensors and introducing ML for predictive analysis.

Ananda Mohon et al.[4] have focused on designing a system for remotely monitoring patients using IoT. IoT is envolved in collecting and sharing health data between patients and healthcare providers. The aim is to reduce anxiety among patients guardians by providing timely updates about patients health. The model is capable to measure up to 9 health parameters using different sensors and Arduino. For collecting data regarding health parameters web application is developed using PHP and Java Script which allows remote monitoring .

Md. Masnun Hossain et al.[9] also focused on developing, health monitoring using IoT. The system proposed here uses IoT to monitor body temperature, blood pressure, heart rate, ECG, fall detection and location tracking. The system continuously monitor health parameters and send data to a cloud-based server via Wi-fi for remote access. The model uses 3.7 V Li-ion battery which may require frequent charging for continuous operation.

Some other researchers[8][2][14][5] also focused on similar parameters which includes heart rate, temperature, ECG, blood. level, fall detection for health monitoring system. Some of them are not portable and if portable proper power system is not explained and also some cloud based severs lacks security which leads to data leakage and hinders privacy of the users.

3 Project Planing

Project planning is critical for ensuring project success by clearly defining objectives, identifying tasks, and setting timelines. A well-structured plan enables efficient resource allocation, ensuring that the right personnel, tools, and materials are available at the right time to meet project demands. It also facilitates effective risk management by anticipating potential challenges and devising strategies to mitigate them, thereby minimizing disruptions. Additionally, project planning helps maintain focus and alignment among team members, ensuring everyone understands their roles and responsibilities, which fosters collaboration and accountability. By enhancing communication, it allows for smooth coordination across departments or stakeholders, enabling quick resolution of issues and ensuring transparency. Furthermore, a comprehensive plan ensures that project milestones are achieved within budget and scope, reducing the likelihood of scope creep and cost overruns. Ultimately, project planning lays the foundation for delivering high-quality outcomes while meeting stakeholder expectations.

3.1 Gantt Chart

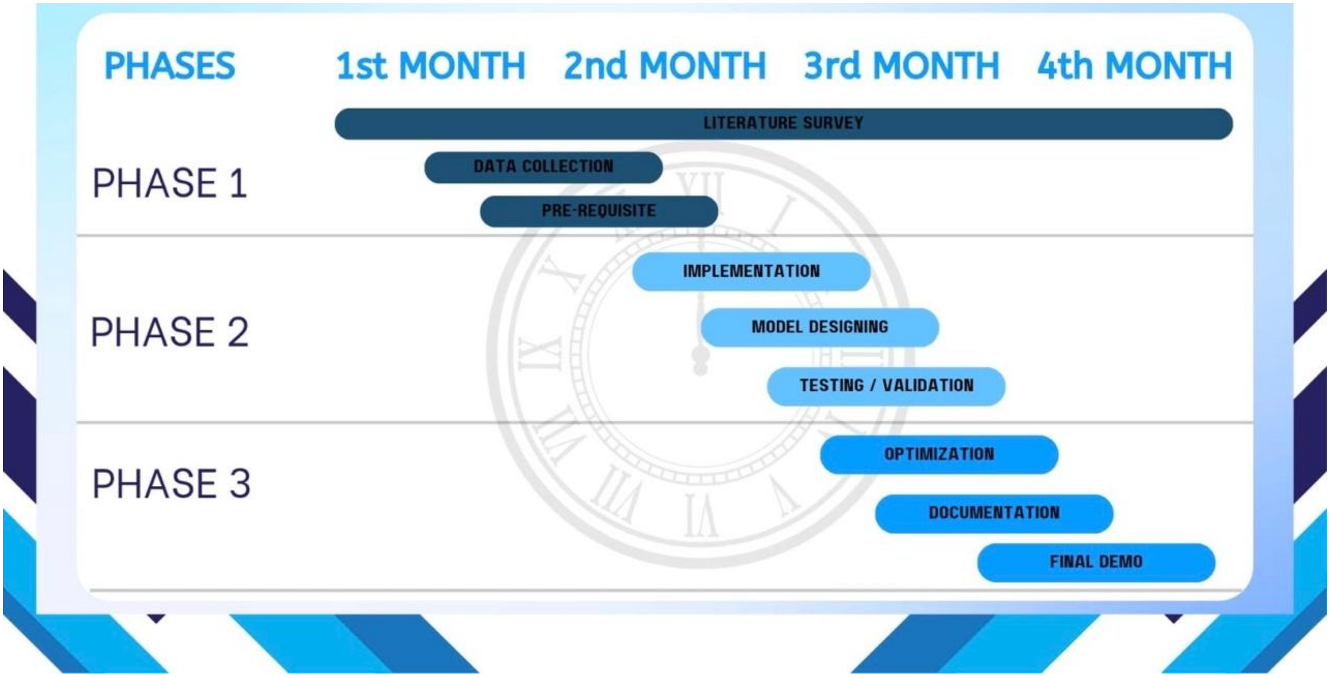


Figure 1: Gantt Chart

A Gantt chart is a visual project management tool that represents the timeline of a project. It displays tasks or activities as horizontal bars along a timeline, with the length of each bar indicating the duration of a task.The Gantt chart helps project managers track progress, manage deadlines, and visualize how tasks overlap or depend on one another. It is widely used for scheduling, resource allocation, and ensuring timely completion of projects.

3.2 Work Breakdown Structure

A Work Breakdown Structure (WBS) is a project management tool that divides a project into smaller, manageable components or tasks. It organizes the work into a hierarchy, making it easier to plan, assign resources, and track progress. The WBS helps clarify the scope of the project, ensuring that all required work is identified. It also enhances communication among team members andstakeholders, assigns responsibilities, and improves time and resource management. By breaking down complex projects into manageable parts, it makes it easier to estimate costs, schedule timelines, and monitor progress

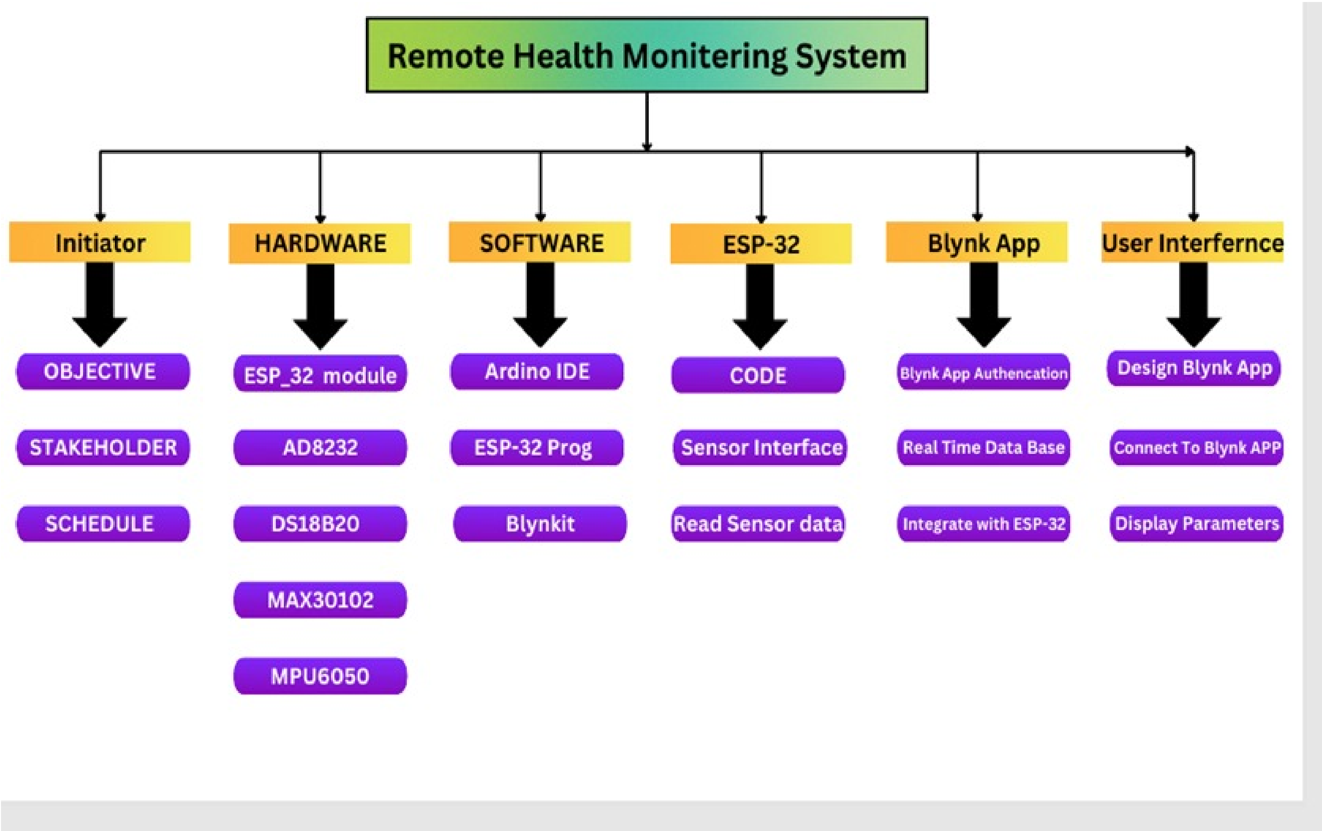


Figure 2: Work breakdown Structure

4 Components Specification

4.1 ESP32 Development Board

- Dual-core 32-bit LX6 processor, up to 240 MHz.
- 520 KB SRAM and 448 KB ROM.
- Supports Wi-Fi (2.4 GHz) and Bluetooth v4.2.
- Offers 34 programmable pins.

Figure 3: ESP-32

4.2 MAX30102 SpO Sensor

- Measures oxygen saturation (SpO) and heart rate.
- LED peak wavelengths: 660 nm (red) and 880 nm (infrared).
- Operates at 3.3 V to 5 V.
- Uses an I2C interface.

4.3 DS18B20 Temperature Sensor

- Operates via 1-wire communication protocol.
- Voltage range: 3 V to 5 V.
- Measures temperatures from -55°C to +125°C.

4.4 AD8232 ECG Sensor

- Voltage: 2.0 V to 3.5 V, current consumption: 170 A.
- High common-mode rejection ratio of 80 dB (60 Hz).
- Ideal for monitoring heart signals.

4.5 MPU6050 Sensor

- Combines a 3-axis accelerometer and a 3-axis gyroscope.
- Operating voltage: 3 V to 5 V.
- Communication via I2C or SPI.
- Full-scale range options: ± 2g, ± 4g, ± 8g, ± 16g.

4.6 Electrodes

In your cardiac monitoring project, the three electrodes are critical for accurately capturing ECG signals. The positive electrode is placed on a specific location on the chest or limb to detect electrical activity from the heart, while the negative electrode is positioned nearby to measure the potential difference. The reference electrode, placed on a neutral, stable area (like the torso or another limb), helps eliminate noise and stabilize the signal. Together, these electrodes enable differential measurement, reduce external interference, and provide a clean, amplified signal for further analysis.

Figure 4: Elctrode Wire

Figure 5: Electrodes

5 Methodology

This section presents the methodology, where in a system that integrates various sensors, a microcontroller. The overall framework of the system is included in the figure 6. The whole block diagram has 4 sensors, those are Temperature sensor, Pulse sensor, Motion tracking Sensor and ECG sensor

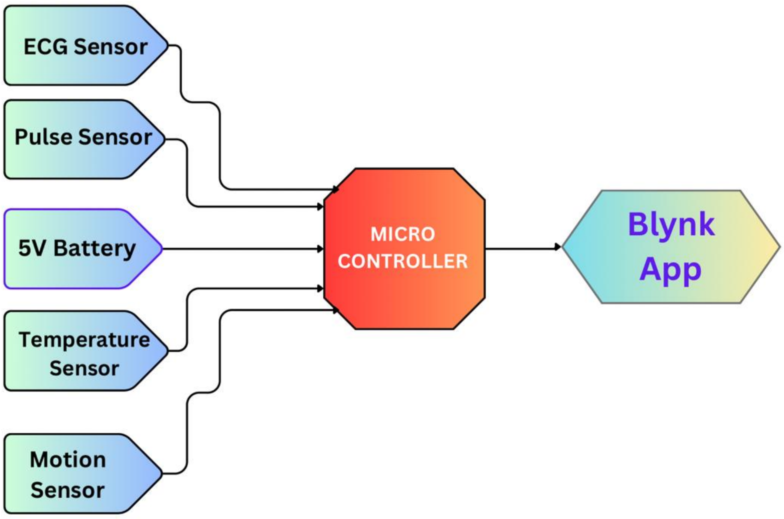


Figure 6: Block Diagram

5.1 Sensors

- **Temperature Sensor:** The main function of temperature sensor is to measure the temperature of the human body. The data is given to the sensor, it converts the temperature into an electrical signal proportional to the measured value. Temperature sensor used here is DS18B20. Temperature sensors works on a principle which depends on a physical changes in material because of temperature variation in material like as a resistance voltage or expansion there are many types of temperature first one, thermocouples which measures the voltage change between the two metals, thermistors used for the resistance change in a ceramic resistance, temperature detectors which detects the resistance change in metal and infrared sensor this is a sensor which is used for measuring of an infrared radiation. The applications of the temperature sensors are industrial process medical devices HVAC system and variable devices, and more advanced applications are Automotive system to monitor engines and a cabin temperature.

- **Pulse Sensor:** Pulse sensor function or detect the heart rate or pulse of a given information by sensing blood flow changes. The output of pulse sensors signals analog or digital signals representing the pulse rate. It is used in Critical in healthcare system for monitoring cardiovascular health. Pulses works on a principle of photoplethysmography. There are key components of pulses based on the principles are light source that is LED shines a light on to the skin of the human a photo detector which measures the light intensity of the reflected or a transmitted light variation in light intensity corresponds to blood flow changes which causes by the heartbeats. The application of pulses is heart rate monitoring in variable devices sports and fitness working stress monitoring and medical diagnosis. The advanced features of pulses are that this sensor is integrated with the spot measurement in a sensor the compact has and has a low power design because of the variable fitness devices.

- **Motion Tracking Sensor:**Motion tracking sensor involves recording the movement orientation of a person or object. The motion tracking can be done by using sensors like accelerometers, gyroscopes, or magnetometers. The output of the motion tracking sensor is data related to change in position speed or rotation. The application of motion tracking sensors is commonly used in fitness application posture correction system, activity recognition to monitor physical activities like walking, running or excising. Motion tracks are widely used in applications like virtual reality robots and fitness tracking this sense depends on the working principle of the accelerometer which measures the acceleration of forces gyroscope which takes the measure of the angular velocity and Magneto meter which measures the orientation of Earth's magnetic field .Applications of the motion tracking sensors are used in smartphone orientation, gaming fitness tracking, robotics AR/ VR are systems and some more advanced applications are like navigation and drones and autonomous vehicles and health monitoring to detect the fall of the humans.

- **ECG Sensor:** ECG, stands for Electrocardiogram, this records the electrical activity of the heart. The output of ECG sensor that captures waveform such as P wave, QRS complex, T-wave. This is used in diagnosing cardiac conditions and monitoring heart health. ECG sensors work on the principle based on the heart generate electrical signals as its beat's electrodes placed on the skin detect these electrical signals. There are key components in the sensors that are electrode which conduct the electrical signals from the human body amplifier which boost the weak electrical signals and signal process unit this filter and analyzes the signals. The application of the ECG signals is monitoring heart health fitness and stress tracking in variable devices biomedical Research and tele medicines for remote heart monitoring. More advanced features of the ECG are multi-LED configuration for higher diagnostic accuracy and portable wireless devices for continuous monitoring.

5.2 Microcontroller (ESP32):

The main microcontroller use dis EPS32, it acts as the central unit & gathers data from all sensors & performs the basic signal processing such as filtering or normalization. The microcontroller is a central unit, and it controls communication with the power supply, and ensures all components operate correctly and sends the data to the display units.ESP32 is a microcontroller which is powerful and the versatile microcontroller this microcontroller is designed by the Espress if systems. This is widely used in IoT applications. This microcontroller has low-cost, low power and is highly flexible for user. This has dual core and has high performance GPIOs, ADCs, DACs, PWM and peripherals. This microcontroller supports multiple protocols like SPI, I2C, UART and CAN in the technical specifications of the processor memory wireless capabilities input interface, power and development environment. The microcontroller has some key features like dual connectivity, low power design with peripheral support, real time operating system security and integrated sensor. The application wireless communication robots, home Automation, data acquisition and monitoring. The advantage of ESP32 has this is affordable, time compact design and community support. The limitation of ESP32 is limited GPI opens or consumption Complex configuration and this as a many variants like ESP32 WROOM-32, ESP32-C3, ESP32-S3, ESP32-CA..

5.3 Data Flow

The microcontroller collects the raw data from all sensors as mentioned above. The process the analog to digitals signals while displaying the output. As microcontrollers ensure the power supply, it provides necessary electrical energy to all components of the system. The input data which represents the raw data from the sensors and it collected for data preprocessing which refines the raw sensor data to improve its quality for further analysis. It refines the noise reduction, filtering and missing data, further the relevant feathers or patterns is identified in the preprocessed data. Then, the data is analyzed to categorize the data into predefined classes. This involves machine learning algorithms such SVM, Random Forest, and Neural network. Further, the processed unit is sent to the display unit, which displays the health parameter like temperature, Pulse and ECG etc.

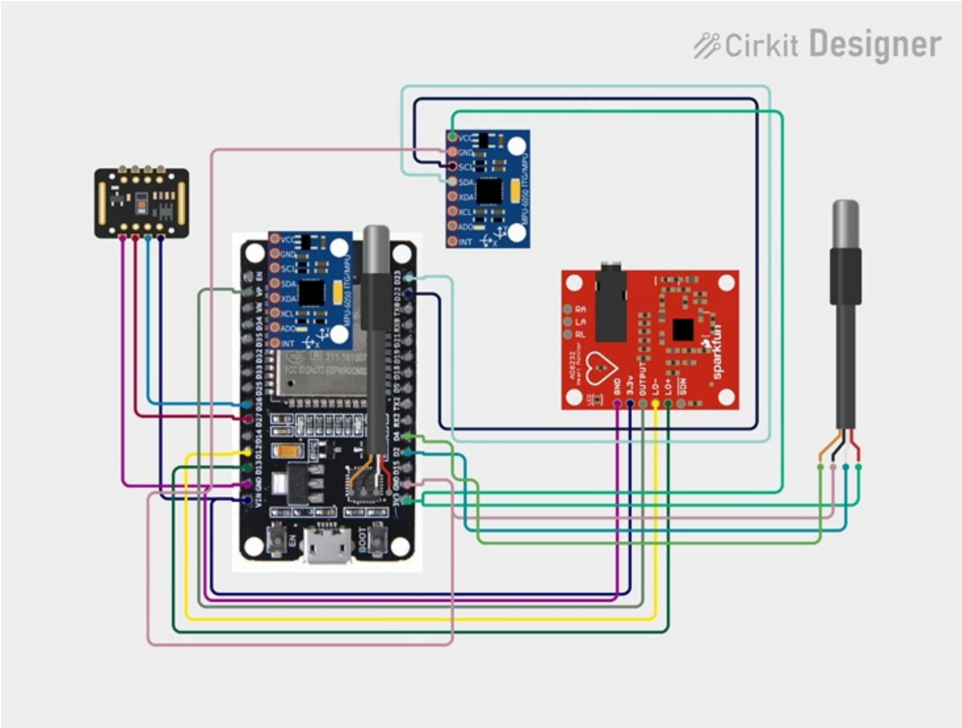
5.4 Mobile Application

A user-friendly mobile application was developed to facilitate real-time monitoring and communication between patients and doctors. It displays health parameters such as temperature, pulse rate, and ECG readings, ensuring timely intervention when needed.

5.5 Bill Of Materials

Sl. No	**Component**	**Quantity**	**Per Unit Cost**	**Total Cost**
1	ESP32 Microcontroller	1	400	400
2	MAX30102	1	150	150
3	DS18B20	1	150	150
4	MPU6050	1	150	150
5	AD8232	1	650	650
6	Header pins	2	15	30
7	PCB	1	50	50
8	Resistors	10	2	20
9	Jumper Wires	100	1	100
10	Case	1	100	100
11	Micro USB Cable	1	120	120
			Total =	**1920**

5.6 Simulation



6 Results and Discussion

The developed system was tested to measure multiple health parameters, including heart rate, SpO2, body temperature, and environmental temperature and humidity. The sensors demonstrated high reliability, with an accuracy of 80%, making the system comparable to standard medical equipment. The results highlight its capability to provide accurate and consistent health monitoring data, processed and transmitted with minimal latency.

The heart rate and SpO2 sensors produced consistent readings during testing. Heart rate values ranged from 88 to 125 bpm, while SpO2 levels showed significant variations depending on conditions. Occasional "Invalid reading" messages were observed, likely caused by improper sensor placement or environmental factors. The timing analysis for heart rate and SpO2 measurements revealed an average processing time of 3004 milliseconds, indicating the system's suitability for near-real-time monitoring.

The DS18B20 temperature sensor, used for measuring body temperature, exhibited reliable performance with stable readings ranging between 32.19°C and 37.25°C. The average processing time for temperature readings was approximately 61–62 milliseconds, demonstrating the sensor's rapid response and efficiency. These results suggest that the sensor is well-suited for continuous body temperature monitoring.

The microcontroller efficiently processed and transmitted data from all sensors to the mobile application, enabling real-time health monitoring. However, challenges were encountered, including occasional connectivity interruptions, likely caused by interference or weak wireless signals. Additionally, the system required frequent battery recharging, which could limit its use in remote settings. Addressing these issues will improve the system's reliability and usability.

User feedback highlighted the system's portability, ease of use, and ability to integrate multiple health parameters as significant strengths. However, users recommended improvements in battery life to support continuous usage and enhancements in data encryption to ensure the privacy of sensitive health data. These suggestions will be critical for future iterations of the system.

When compared to existing health monitoring solutions, the proposed system offers a cost-effective, portable, and user-friendly alternative. Its ability to operate in remote areas with limited healthcare access underscores its potential to transform patient care. The rapid processing times for all sensors ensure timely updates, which are essential for early detection and intervention. With further enhancements, the system is poised to play a vital role in improving health outcomes, particularly in underserved communities.

Name of the Person	**Temperature (°C)**	**SpO2 (%)**	**Heart Rate (BPM)**
Person 1	30, 31, 37, 30	85, 96, 67, 93	126, 126, 116, 100
Person 2	30, 34, 31, 32	73, 92, 91, 87	108, 106, 112, 120
Person 3	35, 33, 30, 30	96, 63, 71, 84	108, 116, 121, 103
Person 4	29, 28, 31, 31	81, 92, 96, 94	118, 121, 121, 103

Table 1: Health Monitoring Data Collected from Four Individuals

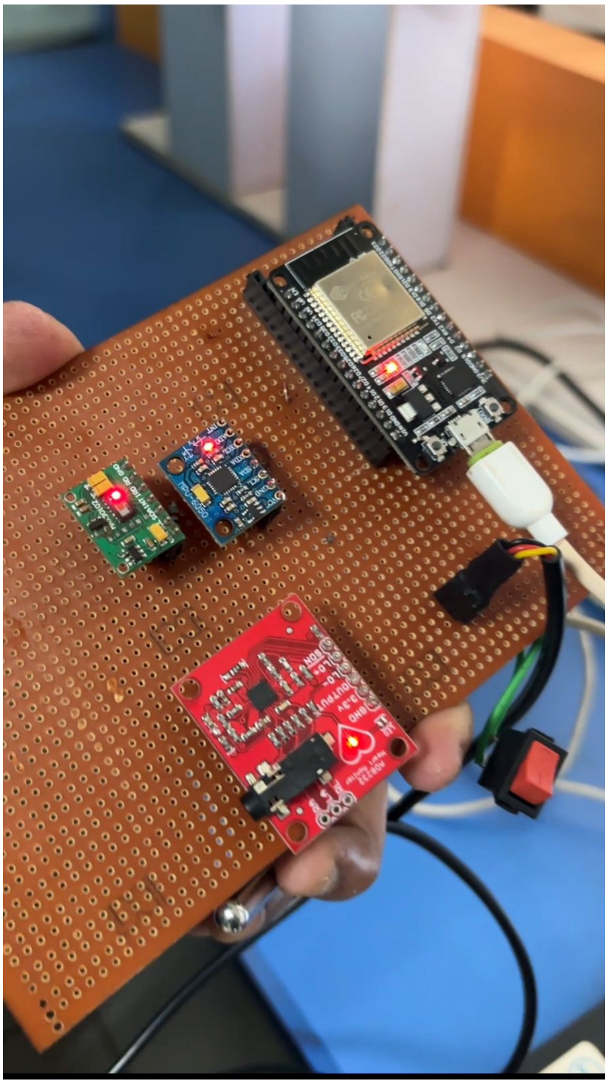


Figure 7: Hardware prototype

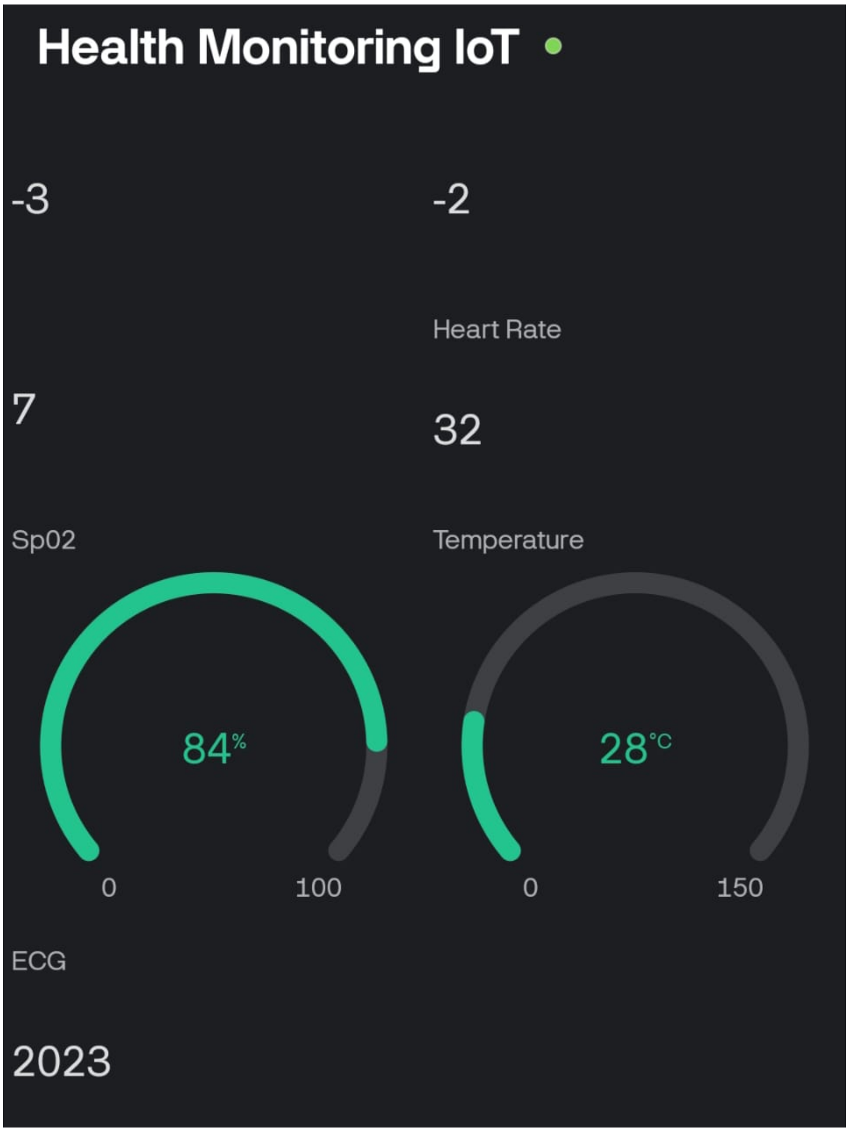


Figure 8: Blynk App Results

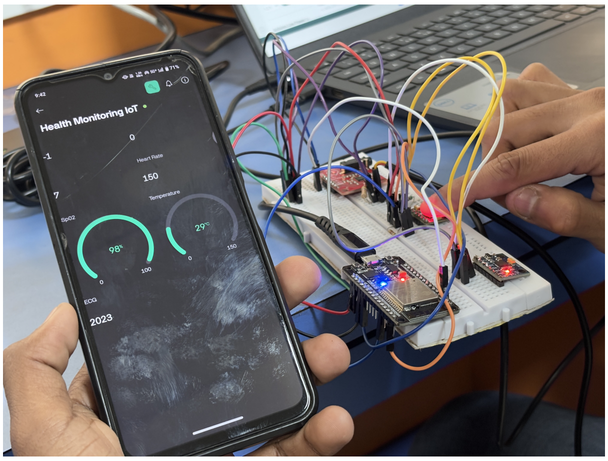


Figure 9: Hardware Setup

7 Applications

7.1 Real-Time Health Monitoring

Continuous tracking of vital signs like heart rate, SpO2, and skin temperature provides real-time insights into an individual's health. This is particularly useful for patients with chronic conditions such as cardiovascular diseases, asthma, or diabetes.

7.2 Fitness and Wellness Tracking

For fitness enthusiasts, the system can monitor physiological responses during exercise, helping track performance, detect overexertion, and optimize workout plans.

7.3 Early Detection of Health Anomalies

Abnormalities such as low oxygen saturation (SpO2), sudden temperature spikes, or irregular heart rates can be detected early, allowing for timely medical intervention.

7.4 Telemedicine and Remote Health Monitoring

With wireless connectivity (via ESP32), the system can send health data to healthcare professionals remotely, enabling telemedicine applications and reducing the need for frequent hospital visits.

7.5 Stress and Fatigue Monitoring

By analyzing trends in heart rate variability, temperature, and SpO2, the system can assess stress and fatigue levels, which is particularly useful for workers, athletes, and drivers.

7.6 Post-Surgery and Rehabilitation Monitoring

Patients recovering from surgery or undergoing rehabilitation can use this system to monitor vital signs and track progress without being confined to a hospital setting.

7.7 Elderly Care

The system is ideal for monitoring the health of elderly individuals, providing alerts in case of abnormal readings and ensuring their safety at home.

7.8 Sleep Monitoring

The system can track heart rate and SpO2 levels during sleep to detect issues like sleep apnea and provide valuable insights into sleep quality.

7.9 Sports Medicine

Athletes can use the system to track recovery times, detect dehydration (via temperature), and ensure optimal performance during training.

7.10 Pandemic Health Monitoring

During pandemics, the system can be used for early detection of fever and respiratory issues, aiding in identifying potential cases and reducing disease spread.

8 Advantages

- Real-Time Monitoring-Continuously tracks vital signs like heart rate, SpO2, and temperature, allowing immediate detection of health anomalies.
- Early Detection of Health Issues-Identifies potential health problems (e.g., low oxygen levels or irregular heart rates) early, enabling timely medical intervention.
- Portability and Convenience-Compact and wireless design makes the system easy to use at home, work, or during travel.
- Remote Monitoring and Telemedicine-Facilitates remote healthcare, allowing doctors to monitor patients from a distance and reducing the need for frequent hospital visits.
- Personalized Health Insights-Provides individuals with tailored data to understand their health trends and make informed decisions.
- Improved Chronic Disease Management-Assists in managing chronic conditions like diabetes or hypertension through continuous monitoring and timely alerts.

9 Future Work

Future enhancements of the system will focus on addressing current limitations and expanding its functionality. Improvements in battery technology will be prioritized to support extended usage in remote or underserved areas. Integration of advanced sensors, such as blood pressure and ECG monitoring, will further enhance the system's capabilities. To ensure robust and secure data transmission, advanced encryption protocols and a more reliable wireless communication framework will be implemented. Additionally, the use of machine learning algorithms for predictive analysis will be explored to provide early warnings and personalized health recommendations. Finally, clinical validation with a larger sample size will be undertaken to further verify the system's accuracy and reliability, paving the way for widespread adoption in healthcare applications. With these enhancements, the system is poised to play a vital role in improving health outcomes, particularly in underserved communities.

10 Conclusion

The remote health monitoring system presented in this work demonstrates the effective integration of IoT technology to overcome the challenges associated with continuous patient monitoring, particularly for individuals with chronic illnesses or those in remote areas. The system provides a reliable, real-time solution for collecting critical health parameters such as body temperature, ECG, oxygen levels, heart rate, and fall detection. By automating data transmission to a mobile application and enabling timely SMS alerts for healthcare providers, the system facilitates rapid medical intervention and reduces reliance on traditional hospital-centric healthcare models.

However, certain limitations must be addressed for the system to achieve its full potential. The need for frequent battery recharging poses a challenge in scenarios requiring uninterrupted operation. Connectivity issues, particularly in rural areas with limited network coverage, can also hinder the effectiveness of real-time data transmission and alerts. Addressing these challenges will require advancements in energy-efficient hardware, alternative power solutions such as solar-based charging systems, and optimized data transmission protocols for low-bandwidth environments. Future work could focus on integrating additional sensors, enhancing battery performance, and improving data security to protect patient privacy. Expanding the system's capabilities through cloud-based analytics and AI-driven predictive health monitoring could further revolutionize remote healthcare delivery.

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