Smart Health Guardian: IOT-Based Real-Time Remote Health Monitoring System

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Abstract—This project presents a low-cost, real-time health monitoring system using an ESP32 microcontroller, designed to continuously track critical health parameters such as heart rate/pulse rate, and body temperature. The system integrates biomedical sensors and displaying real-time data.A core feature of this system is its ability to detect abnormal health conditions and immediately send SMS alerts to predefined family members. This is achieved using internet connectivity via ESP32 and IFTTT Webhooks to trigger SMS through the IFTTT platform. The alert system ensures that caregivers and family members are notified in real time, enabling quicker response and better patient outcomes.This project is ideal for remote health monitoring, especially for elderly or chronically ill patients, and is a step forward in building smart healthcare systems using IoT (Internet of Things) technology.

Index Terms—Internet of Things (IoT), Remote Health Moni- toring, ESP32, Heart Rate Monitoring, Temperature Sensor, SMS Alert System, Smart Healthcare

1. INTRODUCTION

Health emergencies can occur suddenly, especially for el- derly people and patients who require continuous observation. Delay in providing medical assistance may lead to serious health risks. Continuous monitoring of vital parameters such as heart rate and body temperature helps in identifying abnormal conditions at an early stage and allows caregivers to take necessary action in time.

With the advancement of Internet of Things (IoT) technol- ogy, smart healthcare monitoring systems have become more common for remote patient supervision. IoT-based devices use sensors and microcontrollers to measure physiological param- eters and transmit the data through wireless communication. These systems reduce the need for frequent hospital visits and allow monitoring from home. However, many existing monitoring systems are expensive and depend on cloud con- nectivity, which makes them difficult to use in rural areas.

To overcome these limitations, a simple and low-cost mon- itoring system is required that can work in real time without complex infrastructure. The Smart Health Guardian system is designed using an ESP32 microcontroller with biomedical sensors to measure heart rate and body temperature. The measured values are displayed on an OLED screen, and the controller checks the readings with predefined limits to detect abnormal conditions.

When the measured values cross the safe range, the system automatically sends an SMS alert to the caregiver using internet connectivity through IFTTT Webhooks. This auto- matic alert feature helps in providing quick response during emergency situations without requiring manual operation. The proposed system is portable, reliable, and suitable for home healthcare monitoring.

2. BODY OF THE PAPER

2.1 RELATED WORK

Remote health monitoring systems have received consider- able attention with the development of Internet of Things (IoT) technology. Many existing systems are designed to monitor vital parameters such as heart rate, body temperature, and blood oxygen level using different types of sensors connected to microcontrollers. In most cases, the collected data is trans- mitted to cloud platforms or mobile applications so that the patient's health condition can be observed remotely. Although these systems provide continuous monitoring, they often re- quire complex hardware and stable internet connectivity, which increases the overall cost.

Several IoT-based healthcare solutions use cloud-based ar- chitecture for storing and analyzing patient data. This approach makes remote monitoring possible, but it also increases power consumption and depends heavily on network availability. In rural areas or home environments, continuous internet connection may not always be available, which affects the

performance of the monitoring system. In addition, cloud processing may introduce delay, which is not suitable during emergency situations.

Some existing monitoring devices include alert mechanisms, but in many systems the alert must be activated manually by the patient. This method is not reliable in critical conditions where the patient may not be able to respond. Inaccurate sensor readings and improper threshold settings may also lead to false alerts, reducing the effectiveness of the system.

To overcome these problems, recent research focuses on using local processing in the controller to analyze sensor data and generate alerts automatically. Microcontrollers such as ESP32 are commonly used because of their built-in Wi- Fi support and low power consumption. However, there is still a need for a simple and low-cost monitoring system that can continuously observe vital parameters and send automatic alerts without depending completely on cloud services. The proposed Smart Health Guardian system is developed to address these limitations.

2.2 PROPOSED METHODOLOGY

The proposed Smart Health Guardian follows a real-time remote monitoring methodology where vital health parameters of the patient are continuously sensed and processed using an ESP32-based IoT device. The MAX30100 pulse oximeter measures the heart rate/pulse rate and the LM35 sensor measures body temperature. These sensor readings are sent to the ESP32 controller, which performs threshold-based analysis to identify abnormal conditions. The processed values are displayed locally on an OLED screen for immediate monitoring. If any vital crosses the safe limit, the ESP32 triggers an emergency alert through IFTTT Webhooks, which sends an SMS notification to the family/caregiver and optionally to a doctor, enabling quick response during emergencies.

A. System Architecture

Fig. 1 shows the architecture of the Smart Health Guardian system. It consists of sensing, processing, local display, and alerting modules working together to provide continuous monitoring and instant emergency notifications.

Components / Modules Explanation:

- **Patient:** The person whose vital signs are monitored continuously.
- **Smart Health Guardian Device (ESP32):** The core IoT device that integrates sensors, display, and communica- tion features.
- **Sensors:** Used to collect real-time physiological parameters from the patient.
- **MAX30100 Pulse Oximeter:** Measures pulse/heart rate using fingertip-based sensing.
- **LM35 Temperature Sensor:** Captures body temperature using analog voltage output.
- **ESP32 Controller:** Processes the sensor data, checks thresholds, and decides whether to trigger an alert.
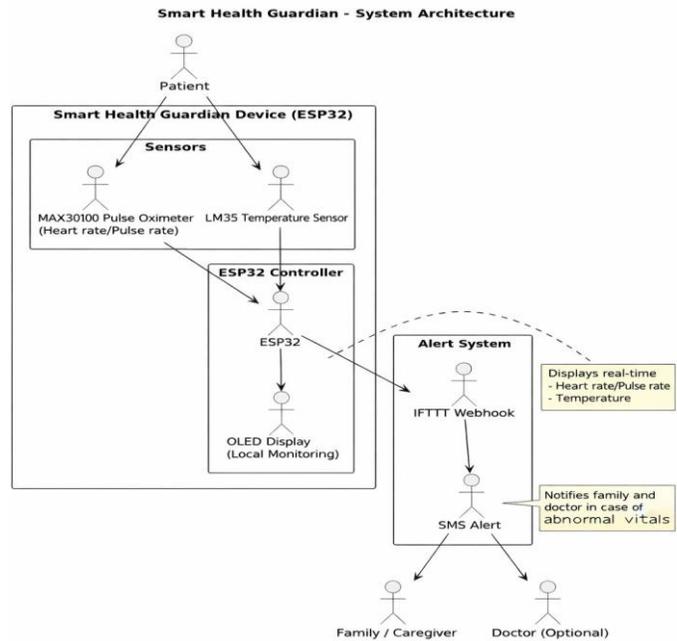- **OLED Display (Local Monitoring):** Shows real-time heart rate and temperature values locally.

Fig. 1. Smart Health Guardian - System Architecture

- **Alert System:** Responsible for sending emergency notifications during abnormal readings.
- **IFTTT Webhook:** Receives trigger request from ESP32 and activates the SMS service.
- **SMS Alert:** Sends emergency messages to caregivers/doctor with vital abnormality information.
- **Family/Caregiver:** Primary receiver of SMS alert for immediate support.
- **Doctor (Optional):** Can receive alerts for medical assistance and guidance.

B. Algorithm

The step-by-step working procedure of Smart Health Guardian is given below:

1) **Start:** Power ON the Smart Health Guardian device.
2) **Initialize Modules:** Initialize ESP32, MAX30100 sen- sor, LM35 sensor and OLED display.
3) **Wi-Fi Connection:** Connect ESP32 to the available Wi- Fi network.
4) **Set Thresholds:** Define safe threshold ranges for heart rate and temperature.
5) **Read Heart Rate:** Acquire pulse/heart rate values from the MAX30100 sensor.
6) **Read Temperature:** Acquire body temperature from LM35 sensor using ESP32 ADC.
7) **Display Values:** Show heart rate and temperature continuously on OLED display.
8) **Check for Abnormality:**

- If temperature exceeds threshold, mark as abnormal.
- If heart rate is below or above threshold, mark as abnormal.

9) **Trigger Alert:** If abnormal condition is detected, generate emergency alert.

10) **Send SMS Notification:** Trigger IFTTT Webhook request to send SMS alert to caregiver/family (and doctor if required).

11) **Repeat:** Continue monitoring and repeat Steps 5–10 continuously.

C. Connection Diagram

The connection setup of the Smart Health Guardian proto- type is shown in Fig. 2. The system is developed using an ESP32 microcontroller as the main control unit, integrated with biomedical sensing modules and an OLED display. The MAX30100 pulse oximeter communicates with ESP32 through the I2C protocol using SDA and SCL lines, en- abling real-time heart rate monitoring. The LM35 temperature sensor provides analog output voltage proportional to body temperature, which is read using the ESP32 ADC pin. The OLED display is also interfaced using I2C, allowing the live monitoring of both heart rate and temperature values on the display. Proper VCC and GND connections are provided to all components to ensure stable operation. This connection design ensures a compact, low-cost, and reliable real-time monitoring system suitable for home healthcare use.
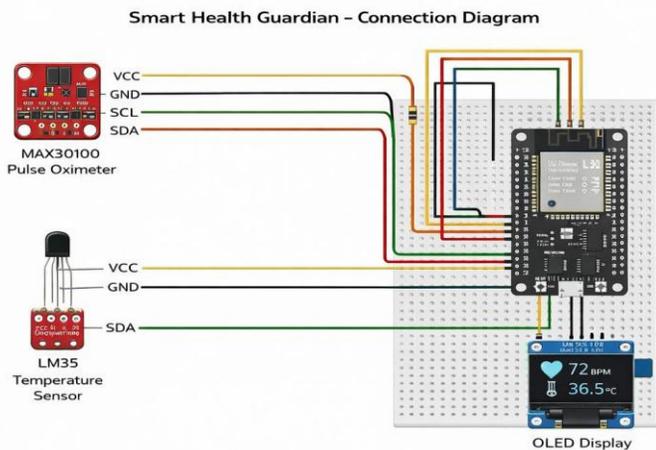

Fig. 2. Smart Health Guardian - Connection Diagram

Connection Details:

- **MAX30100 Sensor:** Connected to ESP32 using I2C lines (SDA and SCL) along with VCC and GND for power supply.
- **LM35 Temperature Sensor:** Connected to ESP32 through analog input (ADC) pin; VCC and GND provide power.
- **OLED Display:** Connected using I2C interface (SDA and SCL) to display temperature and heart rate readings in real time.
- **ESP32 Board:** Acts as the main controller that reads sensor values, processes them, and triggers alert communication when needed.

2.3 RESULT ANALYSIS

The Smart Health Guardian prototype was tested under multiple real-time scenarios to evaluate monitoring accuracy and alert response. During experimentation, the MAX30100 sensor consistently measured pulse/heart rate values, and the LM35 sensor provided stable body temperature readings, which were displayed continuously on the OLED screen. The ESP32 successfully processed the sensor data and compared it with predefined threshold limits to detect abnormal conditions. Whenever critical values were observed, the system triggered the IFTTT Webhook instantly and SMS notifications were de- livered to the caregiver within a few seconds, confirming low- latency emergency alerting. Overall, the obtained results show that the proposed system is reliable for continuous monitoring, supports quick emergency response, and is suitable for home- based and rural healthcare supervision.
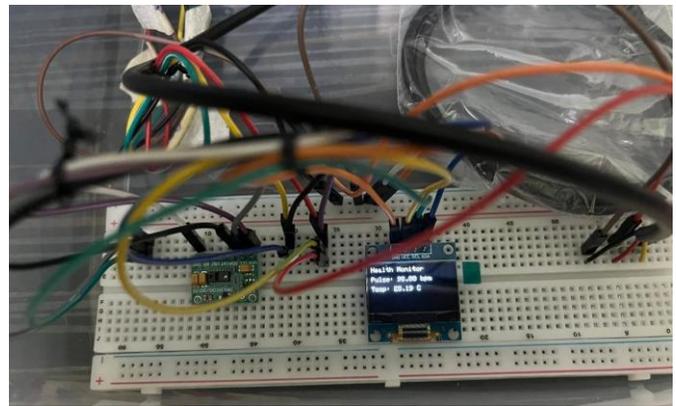

Fig. 3. Output showing real-time pulse rate and temperature on OLED display.

2.4 ADVANTAGES

The proposed Smart Health Guardian system provides sev- eral advantages in continuous remote healthcare monitoring and emergency alerting. The main advantages of the system are explained below:

A. Low-cost and Affordable Design

Smart Health Guardian is developed using low-cost compo- nents such as ESP32, MAX30100, LM35 sensor, and OLED display. Compared to hospital-based monitoring systems, the overall implementation cost is very low. This makes the solution affordable for home healthcare and rural areas. It can be deployed for wider use without high investment.

B. Continuous Real-time Monitoring

The system continuously monitors vital parameters such as body temperature and heart rate in real-time. This ensures early detection of abnormal health conditions and reduces risk during emergencies. Continuous monitoring is very useful for elderly people, chronic patients, and individuals under supervision. It improves safety without requiring hospital admission.

Fig. 4. SMS alert notification received on mobile after abnormal health condition detection.

C. Automatic Emergency Alert Mechanism

A key advantage of the system is the automatic SMS alert generation during emergency conditions. The ESP32 checks threshold values and triggers IFTTT Webhooks automatically without requiring any manual action. This feature is highly reliable in critical conditions where the patient cannot respond. It ensures timely alert delivery to caregivers for quick assistance.

D. Portable and Easy to Deploy

The proposed system is compact, lightweight, and portable, making it suitable for home usage. It does not require complex infrastructure or skilled installation procedures. The system can be set up with minimal wiring and operates with simple power supply. This portability makes it practical for rural and remote monitoring scenarios.

E. Local OLED Display for Instant Access

The OLED display provides real-time health parameter readings directly on the device. This allows patients and caregivers to view vital signs instantly without depending on mobile applications. Even in cases of poor internet connec- tivity, the monitoring values remain accessible locally. This increases usability and reliability.

F. Reduced Cloud Dependency and Faster Response

Unlike cloud-dependent systems, Smart Health Guardian performs processing locally on the ESP32. This reduces latency and avoids continuous data uploading, making the system more efficient. Internet is mainly required only to send emergency alerts. Therefore, the system works effectively even in low-network environments.

2.5 DISCUSSION

The Smart Health Guardian system provides a practical approach for real-time health monitoring using IoT technology. By combining the ESP32 controller with MAX30100 and LM35 sensors, the system is able to measure important vital parameters such as pulse rate and body temperature continu- ously. The readings are displayed on the OLED screen, which allows the patient or caregiver to observe the values directly without using any external device. The overall design is simple and suitable for home monitoring.

One of the important features of the system is the automatic alert generation during abnormal conditions. The ESP32 com- pares the sensor readings with predefined threshold values, and when the values exceed the safe range, the system sends an SMS alert using IFTTT Webhooks. This method reduces the need for manual operation and helps in providing faster response during emergency situations. The use of Wi-Fi com- munication makes the alert system quick and reliable.

During testing, the system worked properly under different conditions and was able to detect abnormal values correctly. However, small variations in readings may occur due to sensor placement or environmental conditions. The alert feature also depends on internet connectivity, but the local display contin- ues to show values even if the network is not available. With further improvements and additional sensors, the system can be made more useful for real-time healthcare monitoring.

2.6 FUTURE SCOPE

In future, the Smart Health Guardian system can be en- hanced by integrating additional biomedical sensors such as SpO_2, ECG, and blood pressure sensors to provide more comprehensive health monitoring. A mobile or web-based dashboard can be developed for real-time visualization, long- term storage, and trend analysis of patient vitals. The alert mechanism can also be improved by including multiple no- tification modes such as voice calls, mobile push notifica- tions, and location-based emergency support. Furthermore, machine learning-based prediction models can be incorporated to detect early warning signs of health risks before critical conditions occur. These improvements can make the system

more intelligent, reliable, and useful for large-scale healthcare applications.

3. CONCLUSION

The Smart Health Guardian system presents a simple and low-cost solution for real-time health monitoring using IoT technology. The system uses an ESP32 microcontroller along with MAX30100 and LM35 sensors to continuously measure pulse rate and body temperature. The measured values are processed by the controller and displayed on the OLED screen, allowing the user to observe the health condition directly without the need for complex medical equipment.

The main feature of the system is the automatic alert mechanism, which sends an SMS notification to the caregiver when the measured values cross the predefined safe limits. This helps in providing quick response during emergency situations and reduces the need for constant manual supervision. The use of local processing in ESP32 makes the system faster and more reliable compared to cloud-dependent monitoring systems.

Overall, the proposed Smart Health Guardian is portable, easy to use, and suitable for home healthcare and remote monitoring applications. The system can be further improved by adding more sensors and advanced features to make it more useful for real-time medical support.

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