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IoT-Based Patient Health Monitoring and Emergency Alert System

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Abstract: *Healthcare monitoring has become increasingly important in modern society, particularly for patients with chronic illnesses, elderly individuals, and those requiring continuous supervision. Traditional monitoring systems are often limited to hospital environments, restricting mobility and delaying emergency response. With the advancement of Internet of Things (IoT) technologies, it is now possible to design portable, real-time health monitoring systems that transmit patient data wirelessly to caregivers and healthcare providers.*

This project proposes an IoT-based patient health monitoring and emergency alert system using the ESP32 Wi-Fi microcontroller, MAX30100 heart rate, DHT11 temperature and humidity sensor, and a 1.8" TFT (SPI-ST7735) display. The system collects vital health parameters, displays them locally, and transmits the data to the Blynk IoT platform for remote monitoring. Emergency alerts are generated when abnormal conditions are detected, ensuring timely intervention.

The system is cost-effective, portable, and efficient, offering real-time monitoring and emergency response capabilities. It demonstrates how IoT can revolutionize healthcare by reducing risks, improving patient safety, and enabling faster medical intervention.

Keywords: Patient Health Monitoring, Internet of Things(IoT), ESP32 Microcontroller, MAX30100 Sensor, DHT11 Sensor, 1.8" TFT display, Blynk IoT Platform

I. INTRODUCTION

Continuous patient monitoring is one of the most critical aspects of healthcare, especially for the elderly and those with chronic illnesses. Traditional health monitoring systems mainly depend on fixed bedside monitors, which restrict patient mobility and require constant manual observation by healthcare professionals. With the advancement of modern technologies such as the Internet of Things (IoT), it has become possible to develop smarter and more flexible monitoring systems.

The IoT-Based Patient Health Monitoring and Emergency Alert System proposed in this project aims to provide an effective solution for real-time health tracking. The system uses an ESP32 microcontroller as the main processing unit, integrated with a MAX30100 sensor to measure heart rate and a DHT11 sensor to monitor surrounding room temperature and humidity (or approximate body temperature variations). These sensors continuously monitor the patient's vitals and environmental conditions. The ESP32 processes this data and displays it locally on a 1.8" TFT display (SPI-ST7735). Simultaneously, utilizing its built-in Wi-Fi, the ESP32 transmits this critical health data to the Blynk IoT platform. This allows doctors and caretakers to monitor the patient remotely. If any vital sign crosses a safe threshold, the system immediately triggers an emergency alert via the Blynk app, enabling a much faster response to potential health crises.

Real-Time Monitoring: Real-time monitoring is the core functional requirement of this system. Unlike intermittent manual checks, the integration of high-precision sensors with the ESP32 allows for a persistent data stream. The MAX30100 utilizes photodetectors to capture pulse waves at high frequencies, while the DHT11 tracks environmental stability. By processing this data in real-time, the system ensures that the bedside 1.8" TFT display reflects the patient's current physiological state with minimal latency, providing immediate clinical insights to anyone in the room.

Wireless Data Transmission: A significant limitation of existing systems is the "wired" nature of medical equipment. This project overcomes this by leveraging the ESP32's integrated Wi-Fi stack. Wireless data transmission via the Blynk IoT protocol allows for the seamless migration of data from the hardware layer to the cloud layer. This removes the necessity for physical proximity between the patient and the healthcare provider, enabling "Tele-health" capabilities where data can be accessed securely across different network infrastructures.

Early Detection Of Health Parameters: The ultimate goal of this IoT framework is the early detection of life-threatening anomalies. By defining "Safe Zones" for BPM within the software logic, the system acts as a 24/7 diagnostic assistant. Early detection of irregular heart rhythms allows for medical intervention before a condition escalates into a critical emergency. The automated alert system integrated into the Blynk App ensures that these detections are communicated to the relevant authorities instantly, bridging the gap between diagnosis and treatment.

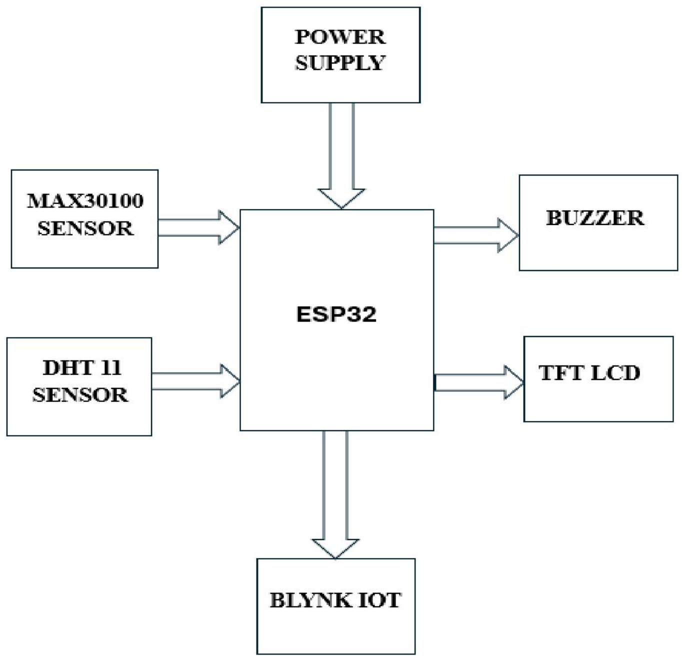

Figure 1: Block Diagram of the Proposed System

II. EXISTING SYSTEM

Traditional health monitoring systems in many clinics and homes still rely on manual, intermittent checks by nursing staff or family members using standalone devices (like basic thermometers or pulse oximeters).

Manual Data Logging: Vitals are often recorded on paper or simple digital logs, leading to human error.

Lack of Remote Access: To check a patient's status, a caretaker must be physically present in the same room.

Delayed Alerts: In the event of a sudden drop in heart rate spike, there is no automated mechanism to notify a doctor who is off-site, leading to dangerous delays in medical intervention.

Wired Constraints: Most high-end monitors are bulky and keep the patient tethered to a bedside power outlet.

III. PROPOSED APPROACH

The proposed IoT-Based Patient Health Monitoring and Emergency Alert System integrates high-precision bio-sensing technology, local graphical visualization, and cloud-based IoT communication to track patient vitals efficiently. The system consists of an ESP32 Dual-Core microcontroller, a MAX30100 pulse oximeter and heart rate sensor, a DHT11 temperature and humidity sensor, a 1.8" TFT (ST7735) SPI display, and a wireless communication framework connected to the Blynk IoT platform.

The MAX30100 sensor utilizes photodetectors and red/infrared LEDs to measure the pulse rate from the patient's fingertip through photoplethysmography. Simultaneously, the DHT11 sensor monitors the ambient thermal conditions or approximate body temperature variations. These sensors continuously capture physiological and environmental data, transmitting digital signals to the ESP32 microcontroller for high-speed processing.

The ESP32 processes the incoming sensor data, applying noise-filtering algorithms to ensure the accuracy of the health metrics. It utilizes its high-speed SPI bus to drive the 1.8" TFT display, providing a real-time local interface that allows the patient or bedside staff to view color-coded health status updates instantly. Concurrently, the ESP32 utilizes its built-in WiFi module to transmit this data to the Blynk IoT cloud server. This enables healthcare providers to monitor the patient's live vitals remotely via the Blynk mobile dashboard or web interface from any geographical location.

The integration of intelligent threshold logic within the ESP32 allows the system to act as an automated emergency responder. If the heart rate or oxygen levels deviate from safe clinical parameters, the system triggers a "Critical Alert" event. This event is pushed through the Blynk cloud to provide instant emergency notifications on the caretaker's smartphone. This dual-layered approach combining local visual monitoring with global cloud-based alerting ensures a rapid response to potential health crises, significantly enhancing patient safety in home-care and clinical environments.

IV. RESULTS AND DISCUSSIONS

The implementation of the IoT-Based Patient Health Monitoring and Emergency Alert System successfully generated continuous real-time monitoring of critical physiological parameters, including heart rate (BPM), and ambient temperature. During experimental testing, the MAX30100 sensor reliably detected pulse waves variations from the patient's fingertip. The sensor recorded consistent data strings, confirming its high sensitivity to arterial blood flow changes. Simultaneously, the DHT11 sensor accurately tracked environmental temperature levels, providing a comprehensive overview of the patient's immediate surroundings. The ESP32 microcontroller efficiently processed these multi-sensor readings and utilized its high-speed SPI interface to update the 1.8" TFT display locally while transmitting the collected data to the Blynk IoT cloud platform via its built-in Wi-Fi.

Experimental observations showed that the transmitted data appeared correctly on the Blynk mobile dashboard in both graphical and numerical formats. When physiological levels exceeded or dropped below the predefined clinical thresholds (e.g., BPM > 100), the system successfully triggered the emergency alert logic. This demonstrated reliable wireless communication, low-latency data visualization, and a robust fail-safe mechanism for remote medical supervision.

Real-Time Vital Sign Tracking

The combination of the MAX30100 and ESP32 enables the system to identify medical anomalies, such as tachycardia or hypoxia, in their earliest stages. The MAX30100's dual-LED (Red and IR) sensing approach ensures that oxygen saturation is calculated with clinical precision, while the DHT11 identifies thermal stress that could affect a patient's recovery. This continuous tracking provides a much higher resolution of health data compared to traditional periodic manual checks, allowing for a more proactive approach to patient care.

Remote Monitoring and Cloud Integration

The ESP32 utilizes its dual-mode Wi-Fi capability to maintain a persistent connection with the Blynk IoT cloud. The cloud platform stores the incoming data and displays it on a user-friendly mobile interface, featuring live gauges and historical charts. This capability allows doctors or family members to monitor the patient's condition from any geographical location. The real-time synchronization between the hardware and the mobile app ensures that abnormal changes in vitals are observed immediately, facilitating rapid clinical decision-making.

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Local Visualization and User Interface

Integrating the sensing system with a 1.8" TFT (ST7735) display significantly enhances the system's usability compared to "headless" IoT devices that lack a local screen. The display provides high-contrast, color-coded feedback at the patient's bedside, making it easy for the patient or on-site caretakers to read vitals without needing a smartphone. This local interface acts as a critical backup, ensuring that the system remains useful even in scenarios where internet connectivity might be temporarily unavailable.

System Reliability and Power Efficiency

Experimental testing demonstrated that the ESP32 maintained stable communication between the sensors and the cloud without significant data packet loss. The dual-core architecture of the ESP32 allowed it to refresh the TFT display and manage Wi-Fi background tasks simultaneously without any system lag. The compact embedded design and the use of the Arduino 2.3.7 environment for code optimization ensured efficient power management, making the system suitable for long-term bedside deployment or portable use with an external 5V power bank.

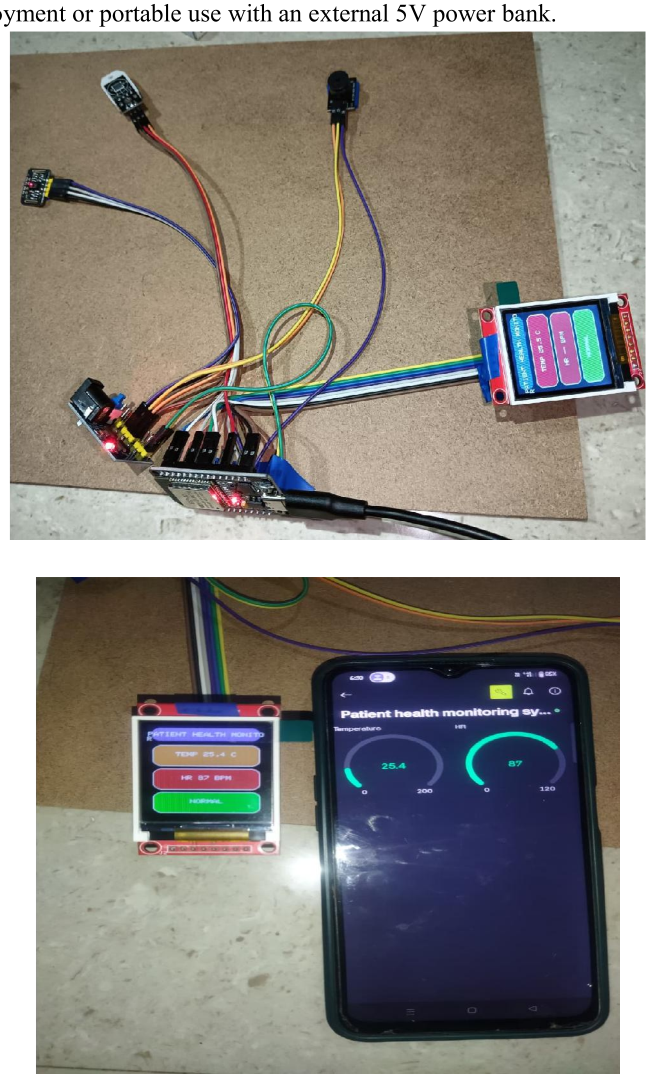

Figure 2: Experimental Setup

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V. CONCLUSION

The IoT Based Patient Health Monitoring and Emergency Alert System using Blynk IoT is designed to continuously monitor important health parameters such as heart rate and body temperature using the MAX30100 sensor and DHT11 sensor. The ESP32 Wi-Fi microcontroller collects the sensor data and sends it to the Blynk IoT platform, where it can be monitored in real time through a smartphone. The system also displays the measured values on a 1.8-inch TFT display for local monitoring. One of the main advantages of this system is its emergency alert feature, which automatically sends an email notification to the user's mobile device when the temperature exceeds the predefined threshold value. This helps in providing quick medical attention during critical situations. Overall, the proposed system is a low-cost, reliable, and efficient solution for remote patient monitoring, reducing the need for continuous manual supervision and improving healthcare accessibility through IoT technology.

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