REAL-TIME HEALTH MONITORING SYSTEM FOR COMA PATIENTS

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Introduction:

Coma is a prolonged state of unconsciousness in which a patient is alive but unable to respond to external stimuli, communicate distress, or self-regulate critical physiological functions. Patients in this state are entirely dependent on medical staff and caregivers for their survival, making continuous and accurate monitoring of vital parameters an absolute necessity.

Traditional monitoring approaches in hospitals rely heavily on periodic manual checks by nursing staff. This method is inherently limited it introduces gaps in observation during which dangerous changes in a patient's condition may go undetected. Critical parameters such as oxygen saturation (SpO2), heart rate, body temperature, and limb movement can deteriorate rapidly, and even short delays in intervention can result in irreversible harm or death.

Furthermore, ICU-grade monitoring equipment is expensive, bulky, and confined to well-equipped hospitals, making it virtually inaccessible for patients being cared for at home or in rural healthcare settings. Family members and remote caregivers have no means of accessing real-time patient data, limiting their ability to respond to emergencies.

The emergence of the Internet of Things (IoT) and affordable biomedical sensors has opened new possibilities for developing low-cost, non-invasive, and portable health monitoring solutions. By integrating microcontrollers with wireless connectivity, sensors can continuously collect vital signs and transmit them to cloud platforms for remote access and trend analysis.

This project proposes a real-time IoT-based health monitoring system specifically designed for coma patients. The system continuously tracks heart rate, SpO2, body temperature, environmental conditions, and limb movement using a set of biomedical sensors connected to an ESP32 microcontroller. Data is processed locally, displayed on an LCD, uploaded to the ThingSpeak cloud dashboard, and automatic alerts are triggered when readings cross predefined safe thresholds. The system is designed to be affordable, portable, and deployable in both hospital and home-care environments, bridging the gap in critical patient monitoring.

Objectives:

1. To provide continuous, 24x7 real-time monitoring of critical health parameters heart rate, SpO2, body temperature, and limb movement for coma patients without requiring manual intervention.
2. To enable early detection of health abnormalities such as oxygen desaturation, fever, or cardiac irregularities by implementing threshold-based alerting through a buzzer and cloud notifications
3. To facilitate remote monitoring by transmitting real-time sensor data to the ThingSpeak cloud platform, enabling doctors, caregivers, and family members to access patient health status from any location
4. To detect neurological recovery signals using a flex sensor that identifies subtle voluntary or involuntary limb movements, offering clinically relevant insights
5. To develop a cost-effective, non-invasive, portable monitoring system suitable for deployment in hospitals, rural clinics, rehabilitation centers, and home-care environments, reducing dependency on expensive ICU-grade equipment.

Methodology:

Step 1 — System Initialization:

The ESP32 microcontroller initializes all connected modules: Wi-Fi connection is established, the MAX30102 sensor is configured for heart rate and SpO2 measurement, DS18B20 is initialized for body temperature, DHT11 is set up for ambient temperature and humidity, the Flex Sensor is calibrated for limb movement detection, and the I2C LCD display is activated for local output.

Step 2 — Continuous Sensor Data Acquisition:

Once initialized, the system enters a continuous sensing loop. The MAX30102 optical sensor captures photoplethysmography (PPG) signals to compute heart rate (BPM) and blood oxygen saturation (SpO2%). The DS18B20 digital temperature sensor measures the patient's body temperature with high precision. The DHT11 sensor captures environmental temperature and relative humidity. The Flex Sensor reads the bending angle of the patient's limb to detect movement.

Step 3 — Data Processing:

Raw signals from sensors are processed by the ESP32 firmware. Signal filtering and averaging algorithms convert the raw PPG signals into stable heart rate and SpO2 values. Temperature readings are converted to degrees Celsius. Flex sensor values are converted to angular displacement to detect meaningful movement. The processed values are validated for plausibility before output.

Step 4 — Local Display:

The processed vital sign values are displayed in real time on a 16x2 I2C LCD screen placed at the patient's bedside. This allows nursing staff or caregivers physically present at the location to directly read all parameters without needing internet access.

Step 5 — Cloud Upload (Remote Monitoring):

The ESP32 uses its onboard Wi-Fi module to transmit all sensor readings to the ThingSpeak cloud platform using HTTP GET requests. Each parameter is assigned to a dedicated ThingSpeak field, enabling real-time visualization through graphs and dashboards accessible from any device with internet access. Historical data is preserved for trend analysis.

Step 6 — Threshold-Based Alerting:

The system continuously compares each measured value against predefined clinically safe threshold limits. For example: Heart Rate below 40 BPM or above 120 BPM, SpO2 below 90%, Body Temperature above 38.5 degrees Celsius or below 35 degrees Celsius, or abnormal limb movement. If any parameter exceeds its safe limit, the buzzer is immediately activated to alert the caregiver, and the anomaly is logged and flagged in the cloud dashboard.

Step 7 — Continuous Operation Loop:

The entire cycle (acquire — process — display — upload — check thresholds) repeats every few seconds in an infinite loop, ensuring uninterrupted 24/7 monitoring. The system is designed for long-term, stable operation powered by a regulated power supply unit.

Result and Conclusion:

The prototype of the Real-Time Health Monitoring System for Coma Patients was successfully tested. The following results were observed during the testing phase:

1. The MAX30102 sensor accurately measured heart rate in the range of 60-100 BPM and SpO2 levels in the 95-99% range under normal conditions, with readings stabilizing within 10 seconds of sensor contact.
2. The DS18B20 digital temperature sensor provided precise body temperature readings with minimal drift, consistently matching reference measurements within acceptable clinical tolerance.
3. The DHT11 sensor reliably tracked ambient temperature and humidity, providing supplementary environmental context for patient condition assessment.
4. The Flex Sensor successfully detected changes in limb bending angle, demonstrating its capability to identify subtle patient movements that could indicate neurological recovery.
5. All sensor readings were displayed in real time on the I2C LCD without noticeable lag, enabling immediate bedside observation.
6. Data transmission to the ThingSpeak cloud platform was confirmed, with all parameters appearing on the live dashboard within seconds of acquisition. Remote access to historical data and graphs was verified.
7. The threshold-based buzzer alert system triggered correctly when manually simulated abnormal conditions (e.g., low SpO2 simulation) were introduced, confirming the alert mechanism's reliability.

In conclusion, the system demonstrates that a low-cost, IoT-based, multi-parameter monitoring solution can effectively replicate several key functionalities of expensive ICU monitoring equipment. The integration of automated alerting, cloud connectivity, and continuous sensing establishes this system as a viable tool for improving coma patient care outcomes, particularly in resource-constrained environments.

Project outcome & industry relevance:

The primary outcomes of this project are:

1. A fully functional hardware prototype capable of real-time, uninterrupted tracking of heart rate, SpO2, body temperature, limb movement, and environmental parameters.

2. A cloud-connected monitoring dashboard enabling remote access to live and historical patient data for doctors and caregivers from any location.
3. An automated early-warning alert system that notifies caregivers immediately upon detection of abnormal vital signs, preventing delayed response to medical emergencies.
4. A scalable, affordable system architecture that can be extended to integrate additional sensors such as ECG, blood pressure (BP), or respiratory rate monitors in future iterations.

Continuous digital health records for each patient, supporting long-term clinical analysis and treatment planning.

Industry & Societal Relevance:

The healthcare industry increasingly demands affordable, connected patient monitoring solutions, particularly for critical and long-term care segments. This system aligns with the growing market for IoT-enabled medical devices, smart hospital infrastructure, and telemedicine. In rural India, where ICU-grade equipment is largely inaccessible, this system offers a practically deployable alternative. It is relevant to hospitals, nursing homes, rehabilitation centres, home healthcare service providers, and government health programs focused on critical care accessibility. The project's patentable novelty lies in the specific combination of multi-sensor biomedical monitoring with cloud-based alerting tailored for coma-specific use cases

Working model vs. simulation / study:

Aspect	Working Model (Proposed System)	Simulation / Study
Implementation	Hardware + Software	Only Software
Data Source	Real-time sensor data	Predefined / theoretical data
Validation	Tested in real conditions	Tested in virtual environment
Output	Live monitoring + alerts	Graphs / predicted results
Reliability	Practical and deployable	Limited to assumptions

Project outcomes and learnings:

1. Hands-on experience with biomedical sensor integration including optical sensors (MAX30102), digital temperature sensors (DS18B20), environmental sensors (DHT11), and resistive sensors (Flex Sensor)

2. Practical knowledge of ESP32 microcontroller programming, Wi-Fi connectivity, and HTTP-based cloud communication using the Arduino IDE environment
3. Understanding of IoT system architecture from edge sensing and local processing to cloud data visualization and remote alerting
4. Experience in designing threshold-based alert logic for real-time embedded systems and validating its correctness under simulated clinical conditions
5. Exposure to cloud platform integration (ThingSpeak) including channel configuration, field mapping, API usage, and data visualization through graphs and dashboards.
6. Appreciation for the clinical requirements and constraints of patient monitoring systems, including non-invasiveness, continuous operation, power reliability, and data accuracy
7. Collaborative engineering project management including timeline planning, milestone tracking, documentation, and presentation skills relevant to the KSCST SPP evaluation process.

References:

1. K. Sheikdavood, K. Soundar, M. G. Yashwanth, P. Tarun Kumar, “Smart Health Monitoring System for Coma Patients Using IoT,” in *Proc. IEEE ICCMC*, 2023, pp. 1342–1347. doi: 10.1109/ICCMC56507.2023.10084196.

2. K. Thivyabrabha, C. Saranya, R. Aakash, T. Abishek, and S. Mohamed Hussain, “Smart Health Monitoring for Comatose Patients: Integrating IoT and Real-Time Alerts,” in *Proc. IEEE ICECA*, 2024, pp. 462–466. doi: 10.1109/ICECA63461.2024.10801103.
3. V. Tamilselvi, S. Sribalaji, P. Vigneshwaran, P. Vinu, and J. Geetha Ramani, “IoT Based Health Monitoring System,” in *Proc. IEEE ICACCS*, 2020, pp. 386–389. doi: 10.1109/ICACCS48705.2020.9074192.
4. L. Virgin, K. Ananthalakshmi, P. Rajeswari, R. Narmatha Banu, and B. Kiruthiga, “Coma Patient Monitoring System,” in *IET Conference Proceedings*, 2023, pp. 229–235. doi: 10.1049/icp.2024.0929.

Future Scope:

The future scope of this project includes:

1. Integration of AI and Machine Learning: Future versions can incorporate AI algorithms to analyse historical sensor data patterns and predict health deterioration before it reaches a critical threshold, enabling proactive rather than reactive care

2. Additional Biomedical Parameters: The system architecture can be extended to include ECG (electrocardiography), non-invasive blood pressure (BP) monitoring, respiratory rate sensors, and EEG for brain activity monitoring, creating a more comprehensive patient profile
3. Mobile Application Integration: A dedicated Android/iOS application can be developed to deliver real-time push notifications, interactive dashboards, and alert management directly on the caregiver's or doctor's smartphone
4. Smart Wearable and Implantable Devices: Future iterations can explore wearable form factors (wristbands, patches) or implantable sensors that offer more precise and continuous physiological data without requiring external sensor attachment
5. IoT-Enabled Smart Hospital Environment: The system can be integrated with a broader smart hospital infrastructure to automatically adjust room parameters such as temperature, lighting, and noise levels based on the patient's condition, optimizing the recovery environment.