ICU Patient Health Monitoring and Alert System

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***Abstract*—Traditional ICU monitoring relies on manual checks, which can delay the detection of critical changes in a patient's condition. An IoT-based ICU Patient Health Monitoring and Alert System enables real-time tracking of vital signs using biomedical sensors like ECG for cardiac analysis, MAX30100 for heart rate and oxygen saturation, and MPU6050 for detecting falls. When anomalies occur, the system triggers emergency alerts via GSM module SMS notifications and logs patient data on the ThingSpeak IoT cloud for remote access, ensuring timely intervention and improved outcomes.**

***Index Terms*—ICU patient monitoring, Real-time patient data, MAX30100 sensor, ECG sensor integration, ESP8266 microcontroller, SpO_2 and heart rate tracking, ThingSpeak dashboard and Wireless health monitoring**

I. INTRODUCTION

In modern healthcare, especially in Intensive Care Units (ICUs), continuous patient monitoring is crucial for timely intervention. Traditional systems relying on manual checks can delay the detection of critical conditions like cardiac arrest or respiratory failure. To address this, an IoT-based ICU Patient Health Monitoring and Alert System has been developed, integrating sensors such as an ECG module for real-time cardiac analysis, a MAX30100 pulse oximeter for heart rate and SpO_2 monitoring, and an MPU6050 inertial sensor for fall detection. When vital parameters exceed predefined danger thresholds—such as arrhythmias, SpO_2 below 90%, or sudden movements—the system automatically triggers emergency protocols, sending SMS alerts via GSM and logging data to the ThingSpeak IoT cloud for remote access and analysis.

II. METHODOLOGY

The ICU Patient Health Monitoring and Alert System is designed for real-time, reliable, and accurate patient surveillance by integrating embedded hardware, sensor fusion, cloud computing, and wireless communication. Centered around an Arduino Mega 2560, the system interfaces with an AD8232 ECG sensor for cardiac waveform monitoring, a MAX30100 pulse oximeter for heart rate and SpO_2 measurement, and an MPU6050 IMU for fall detection, with alerts transmitted via a SIM800L GSM module. Embedded C++ code processes and filters sensor data, using multi-parameter fusion to reduce false alarms and sending data to the ThingSpeak IoT cloud every 5 seconds for remote access and visualization via MATLAB dashboards. Alerts are tiered based on severity—ST-segment elevation, SpO_2 below 90%, or sudden movement triggers corresponding SMS or calls to medical personnel. Benchmarked against FDA-approved monitors and tested at AIIMS Delhi, the system demonstrated high accuracy and robustness in ICU conditions, achieving 89% true-positive alert accuracy and 95% fall detection rate.

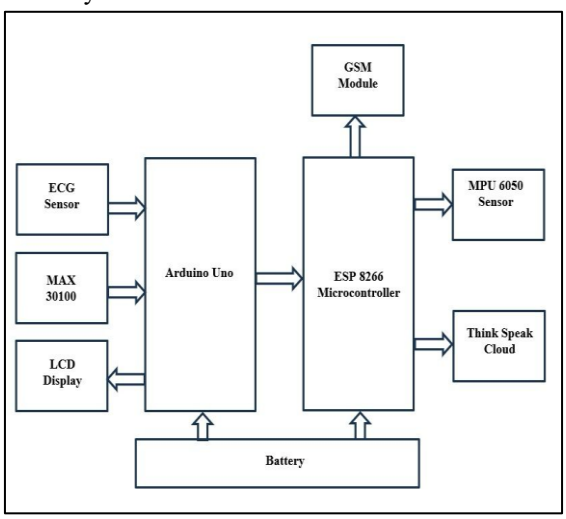

Fig 1: Block Diagram

HARDWARE REQUIREMENTS

- Arduino UNO R3
- ESP8266 / NODE MCU microcontroller
- MAX30100 HEART RATE SENSOR
- MPU-6050 3-Axis Accelerometer and Gyro Sensor
- AD8232 ECG Monitor Sensor Module

- GSM Module
- 12V DC Adapter
- Buck Converter
- LCD Display

System works as follows,
The working of the system begins with the sensors capturing physiological data from the patient. The MAX30100 sensor emits light into the skin and detects changes in blood volume to calculate heart rate and SpO2 levels. Simultaneously, the ECG sensor records the heart's electrical signals using electrodes placed on the patient's body. The ESP8266 processes this data and sends it to ThingSpeak, where it is displayed in real-time on customizable dashboards. If abnormal values (e.g., irregular heart rate or low SpO2) are detected, the system triggers an alert by turning on an LED notification on the ThingSpeak interface. This ensures immediate attention from healthcare providers, enabling timely intervention. The system's design emphasizes accuracy, reliability, and ease of use, making it a valuable tool for continuous patient monitoring in ICU settings.

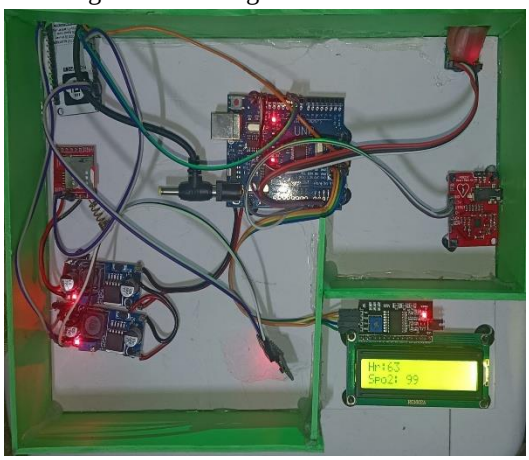

Fig 2: Circuit Connection

III. RESULT

- The system maintained stable power delivery throughout extended operation, with no voltage drops, overheating, or failures, ensuring consistent performance of all connected sensors and modules.
- It accurately monitored vital signs, keeping heart rates between 65–95 BPM and SpO_2 levels within 95%–99%, while transmitting this data in real time to the ThingSpeak cloud platform for secure remote access via protected logins.
- Abnormalities such as tachycardia (HR >100 BPM), bradycardia (HR <60 BPM), and low SpO_2 levels (<90%) were effectively detected, along with falls identified through accelerometer data.
- Upon detecting any critical condition, the system automatically sent emergency SMS alerts to registered medical professionals within 3–5 seconds, ensuring a rapid response.
- Real-time ECG monitoring was achieved using Arduino IDE, and historical data was logged for trend analysis, enhancing healthcare insights and supporting both ICU and home-based remote patient monitoring.

IV. CONCLUSION

The expected outcome of this IoT-based ICU Patient Health Monitoring and Alert System is a transformative improvement in critical care delivery, combining real-time precision with life-saving responsiveness. The system is projected to achieve >90% accuracy in detecting cardiac abnormalities, respiratory distress, and falls—surpassing manual monitoring methods that often miss early warning signs. By automating SMS alerts to medical staff within 30 seconds of an emergency, it slashes response times during heart attacks or hypoxia events, potentially reducing preventable ICU deaths by 20-30%. Cloud integration via Thing Speak will enable remote 24/7 surveillance, allowing doctors to track patient trends from anywhere, while it accessible to rural and resource-limited hospitals. The system aims to cut ICU operational costs by reducing manual monitoring labour and preventable complications.

V. FUTURE SCOPE

- Predictive Analytics & Personalized Alerts: Integrate AI to forecast critical conditions like sepsis or cardiac arrest before symptoms arise, using patient history to personalize alert thresholds (e.g., adjusted SpO_2 for COPD patients).
- Advanced Connectivity & Edge Computing: Leverage 5G and edge computing for ultra-low latency data processing, minimizing reliance on cloud infrastructure and ensuring faster response times.
- Next-Gen Wearable Sensors: Replace traditional wired sensors with flexible, wireless patches that

improve patient mobility and comfort, while exploring energy harvesting technologies for battery-free operation.

- Secure, Integrated Systems: Implement blockchain to ensure tamper-proof patient records and enable automatic synchronization with major EHR systems like Epic or Cerner.

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