IoT-Based Smart Monitoring System for Comatose Patients

Swati Rathore[1], Harmain Fathima Khan[2], Dhanush D[3], Bi Bi Safura[4], Deepika[5]
[1] *Assistant Professor, Electronics and Communication Atria Institute of Technology Bengaluru, India*
[2,3,4,5] *Electronics and Communication Atria Institute of Technology (VTU) Bengaluru, India*

***Abstract*—This literature survey presents an IoT-based smart monitoring system for comatose patients designed to provide continuous healthcare monitoring and reduce manual supervision in hospitals and home-care environments. The proposed system uses biomedical sensors such as heartbeat sensors, temperature sensors, pulse oximeter sensors, eye blink sensors, and MEMS sensors to monitor vital physiological parameters in real time. Microcontrollers including Arduino Uno, ESP32, Raspberry Pi, and NodeMCU ESP8266 are used for signal processing and wireless data transmission through Wi-Fi, GSM, and cloud platforms such as ThingSpeak and Blynk IoT. Several reviewed systems additionally integrate machine learning and deep learning techniques for predictive healthcare analysis and automatic emergency alert generation. The surveyed healthcare monitoring systems improve patient safety, support remote healthcare access, reduce hospital workload, and provide faster medical response during critical situations.**

***Index Terms*—IoT, Comatose Patients, Healthcare Monitoring, Biomedical Sensors, Cloud Computing, ESP32, NodeMCU, Real-Time Monitoring, Emergency Alerts.**

I. INTRODUCTION

Internet of Things (IoT) technology has rapidly transformed modern healthcare systems by enabling real-time patient monitoring and remote healthcare management.

Comatose patients require continuous observation because even small variations in physiological parameters such as heart rate, oxygen saturation, blood pressure, body temperature, respiration rate, and body movement may become life-threatening.

Traditional monitoring systems mainly depend on manual supervision by healthcare professionals, which increases workload and may delay emergency response during critical situations. Therefore, smart healthcare systems using IoT technology have become highly important in modern hospitals and intensive care units.

Recent developments in biomedical sensors, wireless communication systems, cloud computing, machine learning, and embrace systems have enabled the design of efficient healthcare monitoring system for comatose patients. Several researchers have developed IoT-enabled healthcare systems using Arduino Uno, Raspberry Pi, ESP32, NodeMCU ESP8266, GSM modules, Wi-Fi communication protocol things speak cloud platforms, and Blynk IoT applications.
These systems continuously monitor physiological parameters and provide real-time alerts to doctors and caregivers through smartphones, cloud dashboards, web applications, and mobile notifications.

Different biomedical sensors such as heartbeat sensors, pulse oximeter sensors, MEMS accelerometers, ECG sensors, eye blink sensors, ultrasonic sensors, PIR sensors, and temperature sensors are integrated into these healthcare systems for continuous patient monitoring.
Advanced systems additionally incorporate artificial intelligence, machine learning, deep learning algorithms, computer vision, and predictive healthcare analytics for
early detection for abnormal patient conditions.
These smart healthcare systems significantly improve patient safety, reduce hospital workload, enhance

emergency response time, and support remote healthcare monitoring.

This literature survey reviews different IoT-based smart healthcare monitoring systems developed for comatose patients and analyzes their technologies, biomedical sensors, communication methods, cloud integration techniques, emergency alert systems, and healthcare applications.

Furthermore, IoT-based healthcare monitoring systems help in maintaining continuous patient records and enable healthcare professionals to access patient information from remote locations at any time. The integration of cloud storage technologies allows efficient storage, analysis, and retrieval of patient health data for future medical reference and decision-making. Real-time monitoring systems also minimize human errors and improve the efficiency of healthcare services by providing immediate alerts during abnormal conditions.

Many healthcare monitoring systems are designed with low-power and portable embedded devices, making them suitable for both hospital environments and home healthcare applications. Wearable biomedical sensors improve patient comfort and mobility while enabling uninterrupted monitoring of critical physiological parameters. The implementation of smart healthcare technologies has also reduced the burden on healthcare workers and improve the quality of patient care in intensive care units (ICUs).

In recent years, artificial intelligence and machine learning techniques have played an important role in healthcare monitoring applications by supporting predictive analysis and early detection of critical health conditions. Deep learning algorithms, anomaly detection methods, and computer vision technologies are increasingly integrated with IoT systems to improve monitoring accuracy and healthcare decision-making. These advancements have contributed to the development of reliable, efficient, and intelligent healthcare monitoring systems for critically ill and comatose patients.

Several research papers reviewed in this survey mainly focus on real-time monitoring of vital physiological parameters such as heartbeat rate, blood pressure, oxygen saturation (SpO_2), body temperature, respiration rate, eye movement, and body movement using IoT-enabled healthcare systems. Most of the proposed systems use microcontrollers including Arduino Uno, ESP32, Raspberry Pi, and NodeMCU ESP8266 for processing biomedical sensor data and transmitting it through wireless communication technologies such as Wi-Fi, GSM, Bluetooth and cloud-based IoT platforms. Cloud services including ThingSpeak and Blynk IoT are widely used for remote healthcare monitoring, real-time data visualization, and patient history management.

Many researchers also integrated wearable biomedical sensors, MEMS accelerometers, eye blink sensors, ultrasonic sensors, pulse oximeter sensors, ECG sensors, and PIR sensors for continuous patient observation and emergency healthcare management. Some healthcare systems additionally support automatic SMS alerts, mobile notifications, buzzer alarms, and cloud-based emergency alerts whenever abnormal patient conditions detected. Advanced healthcare monitoring systems further incorporate machine learning, deep learning algorithms, computer vision technologies, and predictive healthcare analytics for improving monitoring accuracy and assisting doctors in critical healthcare decision-making.

The reviewed literature clearly indicates that IoT-enabled smart healthcare monitoring systems provide reliable, low-cost, portable, and efficient healthcare solutions for comatose patients. These systems significantly improve patient safety, support remote healthcare access, reduce manual supervision, and enhance emergency medical response in hospitals, ICUs, and home health care environments.

II. ARCHITECTURE

The architecture of the IoT-based smart monitoring system for comatose patients mainly consists of biomedical sensors, embedded processing units, communication modules, cloud platforms, and remote healthcare monitoring devices. The system is designed continuously observe and the physiological parameters of comatose patients and provide real-time healthcare information to doctors, caregivers, and healthcare professionals during critical situations. The

proposed healthcare monitoring architecture improve patient safety, reduces manual supervision, and supports immediate medical response through IoT-enabled technologies.

Medical sensors continuously monitor important physiological parameters such as heart rate, oxygen saturation (SpO_2), blood pressure, body temperature, respiration rate, eye blink activity, and body movement. Different healthcare monitoring systems reviewed in this survey use heartbeat sensors, pulse oximeter sensors, ECG sensors, MEMS accelerometers, eye blink sensors, PIR sensors, ultrasonic sensors, temperature sensors, and flex sensors for collecting patient healthcare information. These sensors continuously acquire physiological signals from the patient and transmit them to the processing unit for analysis and monitoring.

Embedded controllers such as Arduino Uno, ESP32, Raspberry Pi, and NodeMCU ESP8266 are widely used as the central processing unit in smart healthcare monitoring systems. These controllers process the collected sensor data and perform signal analysis for detecting abnormal patient conditions. Several reviewed systems additionally integrate low-power embedded devices and wearable biomedical sensors to improve portability, energy efficiency, and patient comfort during continuous monitoring.

Wireless communication technologies such as Wi-Fi, GSM, Bluetooth, Zigbee, and IoT communication protocols are used for transmitting patient health data to cloud servers and remote healthcare platforms. Cloud services including ThingSpeak and Blynk IoT provide real-time healthcare monitoring, patient history management, cloud-based data storage, and remote access facilities for doctors and caregivers. Healthcare professionals can monitor patient conditions remotely through smartphones, web applications, cloud dashboards, and Android applications without remaining physically present near the patient.

Several healthcare monitoring systems additionally support automatic emergency alert mechanisms including SMS notifications, mobile alerts, buzzer alarms and email notifications whenever abnormal physiological conditions are detected. Advanced healthcare architectures further integrate machine learning algorithms, deep learning models, cloud analytics, and computer vision technologies for predictive healthcare analysis and anomaly detection. Some systems additionally use ESP32-CAM modules and eyeblink detection techniques for neurological activity monitoring and patient recover analysis.

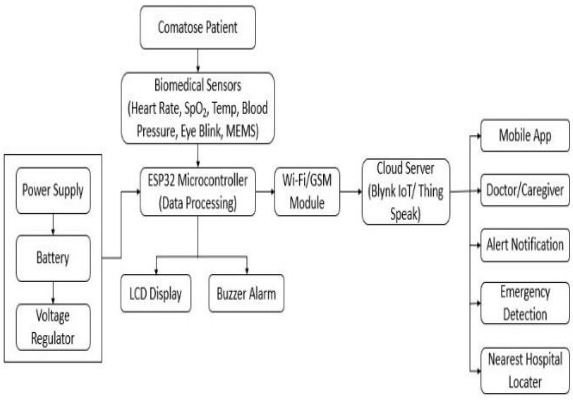

Fig.-1 Block diagram of IoT-Based Smart Monitoring System for Comatose Patients

The power supply section of the healthcare architecture consists of batteries, voltage regulators, and power management circuits for providing stable power to biomedical sensors, communication modules, microcontrollers, display units, and cloud communication systems. LCD displays and buzzer units are also integrated into several architectures for local patient monitoring and emergency indication.

The reviewed healthcare monitoring architectures clearly demonstrate that the integration of IoT technologies, wearable biomedical sensors, cloud computing platforms, wireless communication systems, and artificial intelligence techniques significantly improves healthcare efficiency, patient safety, emergency response time, and remote healthcare management for comatose patients in hospitals, ICUs, and home healthcare environments.

III. CHARACTERISTICS

The IoT-based smart healthcare monitoring systems developed for comatose patients possess several important characteristics that improve healthcare efficiency and patient safety. One of the major characteristics is continuous real- time monitoring of

physiological parameters without human interruption. These systems provide remote healthcare access, allowing doctors and caregivers to observe patient conditions from distant locations using cloud platforms and mobile applications. Another important characteristic is automatic emergency alert generation whenever abnormal patient conditions are detected. Biomedical sensors continuously transmit patient data to cloud servers for analysis and storage. Many systems also support cloud-based healthcare management for maintaining patient medical history and recovery records.

The integration of multiple biomedical sensors improves monitoring accuracy and enables simultaneous observation of different health parameters. Advanced systems additionally use artificial intelligence, machine learning, deep learning algorithms and computer vision technologies for predictive healthcare analysis and patient recovery monitoring. Low power consumption, portability, scalability, wireless communication, and wearable healthcare devices further improve the performance of these systems.

These characteristics significantly reduce healthcare workload, improve patient safety, support faster medical response, and enhance overall healthcare management in hospitals and intensive care units.

IV. APPLICATION

IoT-based smart healthcare monitoring systems for comatose patients are widely used in modern healthcare applications. One of the major applications is continuous patient monitoring in Intensive Care Units (ICUs), where real-time observation of critical patients with highly important. These systems are also used for remote healthcare monitoring, allowing doctors to supervise patients without remaining physically present near hospital beds.

Home healthcare monitoring is another important application where patients receiving treatment at home can be continuously monitored using wearable biomedical sensors and cloud platforms. These systems are additionally used for elderly patient monitoring, paralysis patient monitoring, rehabilitation monitoring, and emergency healthcare management.

Several smart healthcare systems support cloud-based healthcare services and digital hospital management. Artificial Intelligence-based healthcare monitoring systems are also applied in predictive healthcare analytics for early detection of abnormal health conditions and patient recovery analysis. The integration of IoT technologies in healthcare has improved healthcare accessibility, patient safety, remote monitoring efficiency, and emergency medical response.

V. CHALLENGES

Continuous Internet Connectivity: Most IoT-based healthcare monitoring systems depend on uninterrupted internet connectivity for cloud communication and remote patient monitoring. Network failures or poor Wi-Fi connectivity may affect real-time healthcare monitoring and delay emergency alert generation during critical situations.

Sensor Accuracy Calibration: Biomedical sensors such as heartbeat sensors, SpO_2 sensors, ECG sensors, eye blink sensors, MEMS accelerometers, and blood pressure sensors require proper calibration for accurate physiological monitoring. Incorrect sensor reading may lead to false emergency alerts and improper healthcare analysis.

Data Privacy and Security: Healthcare monitoring systems continuously collect sensitive patient medical data including physiological parameters and healthcare records. Ensuring secure data transmission, cloud storage protection, and prevention of unauthorized access remains a major challenge in IoT healthcare applications.

Power Consumption and Battery Life: Continuous operation of biomedical sensors, ESP32 controllers, NodeMCU modules, Wi-Fi communication systems, cloud connectivity, LCD displays, and alert systems increases energy consumption. Maintaining long battery life and efficient power management is important for uninterrupted healthcare monitoring.

Cloud Storage and Network Delay: Most reviewed healthcare systems use cloud platforms such as

ThingSpeak and Blynk IoT for storing patient information and remote monitoring. Communication delay, cloud server dependency, and slow data synchronization may affect emergency healthcare response.

Hardware Integration Complexity: Integration of multiple biomedical sensors, wireless communication modules, embedded systems, control platforms, and artificial intelligence techniques increases overall system complexity. Purpose synchronization between hardware and software components necessary for reliable healthcare monitoring.

False Alert Generation: Sensor noise, communication errors, and abnormal environmental conditions may sometime generate false alarms and unnecessary emergency notifications. Reducing false alert generation remains and important challenge for healthcare monitoring systems.

Implementation Cost and Maintenance: Advanced healthcare monitoring systems integrating machine learning, deep learning algorithms, cloud analytics, wearable biomedical sensors, and IoT communication technologies may increase overall implementation cost and maintenance requirements, making deployment difficult in low-resource healthcare environments.

User Reliability and Scalability: Healthcare monitoring systems should support reliable long-term operation and scalability for monitoring multiple patients simultaneously in hospitals and Intensive Care Units. Maintaining stable performance with increasing healthcare data remains an important challenge.

Artificial Intelligence Integration: Several advanced healthcare systems integrate machine learning, deep learning, and predictive healthcare analytics for patient monitoring and anomaly detection. Training accurate healthcare prediction models and maintaining reliable AI-based decision-making requires large healthcare datasets and efficient computational resources.

VI. RELATED WORK

[1] Nava Rajan Jothilinga et al. proposed an IoT-based smart monitoring system for comatose patients using ESP32 controllers, heartbeat sensors, MEMS accelerometers, and cloud communication technologies. The system continuously monitors patient physiological parameters and transmits healthcare data to doctors and caregivers through IoT platforms for remote healthcare management.

[2] Kheya Bharadwaj et al. developed an IoT-enabled healthcare monitoring system integrating pulse oximeter sensors, blood pressure sensors, and infrared eye blink sensors for continuous patient monitoring. The system improves healthcare accessibility by generating real-time emergency alerts and remote notifications.

[3] Jayadevappa R. S. et al. implemented a smart healthcare monitoring system using biomedical sensors and wireless communication technologies for observing heartbeat rate, oxygen saturation, and body temperature of critically ill patients. The collected data are transmitted through cloud platforms for remote healthcare analysis.

[4] Sai Srinivas Vellela et al. proposed an IoT-based ICU patient monitoring system integrating ECG sensors, NodeMCU ESP8266 controllers, and cloud communication technologies. The system continuously monitors cardiac activity and supports real-time healthcare analysis for ICU patients.

[5] Ashraf et al. designed and implemented an open-source IoT-based healthcare monitoring system using ESP32 controllers, MAX30100 pulse oximeter sensors, DHT11 temperature sensors, and GPS modules. The proposed system continuously monitors body temperature, oxygen saturation, humidity, and heart rate for remote healthcare applications.

[6] Dr. S. K. Manju Bargavi et al. proposed a comatose patient monitoring system using heartbeat sensors, oxygen saturation sensors, and machine learning algorithms for continuous healthcare monitoring and predictive healthcare analysis. The system automatically generates emergency alerts during abnormal patient conditions.

[7] Mohammed Shaibaz Khan et al. developed an IoT-based healthcare monitoring system for comatose and paralysed patients using NodeMCU ESP8266, MAX30102 sensors, ultrasonic sensors, and Blynk IoT platforms. The proposed system improves remote healthcare accessibility and patient monitoring efficiency.

[8] V. Baby Shalini proposed a smart healthcare monitoring system based on IoT using heartbeat sensors, blood pressure sensors, Arduino Uno controllers, GSM modules, and GPS technologies. The system automatically transmits patient information and emergency notifications to doctors and caregivers.

[9] Ninet Varghese et al. developed a health monitoring and observatory system for paralysed patients using Blynk applications and biomedical sensors for monitoring patient movement and physiological parameters. The proposed system improves communication between patients and caregivers through IoT technologies.

[10] Wong Chiew Hong et al. proposed an IoT-based healthcare monitoring system using Blynk cloud platforms, heart rate sensors, GPS modules, and NodeMCU controllers for real-time healthcare monitoring and emergency healthcare assistance.

[11] D. Laxma Reddy et al. implemented a healthcare monitoring system using ESP32 controllers, pulse oximeter sensors, and cloud communication systems for continuous observation of body temperature, oxygen saturation, and heart rate. The proposed system supports real-time healthcare monitoring through mobile applications.

[12] Sujitha V et al. developed an IoT-based healthcare monitoring and tracking system using ESP32 controllers, temperature sensors, GPS modules, and wireless communication technologies. The system continuously monitors health conditions and transmits patient information to healthcare centers for emergency assistance.

[13] Nor Shahanim Mohamad Hadis et al. proposed an IoT-based patient monitoring system using Arduino Mega controllers, ESP8266 Wi-Fi modules, and biomedical sensors for monitoring body temperature and respiration rate. The system improves remote healthcare monitoring efficiency through wireless communication technologies.

[14] Hoe Tung Yew et al. developed an IoT-based real-time remote patient monitoring system using ECG monitoring technologies and MQTT communication protocols. The proposed system continuously transmits patient ECG data to healthcare professionals through cloud-based web servers.

[15] Mohammad Salah Uddin et al. proposed a real-time patient monitoring system based on IoT for ICU healthcare monitoring applications. The system integrates biomedical sensors, cloud communication systems, and mobile applications for continuous healthcare monitoring and emergency alert generation.

[16] Alexandru Archip et al. designed an IoT-based remote patient monitoring system using EKG sensors, SpO_2 sensors, movement sensors, and RESTful web services for continuous physiological monitoring and remote healthcare assistance.

[17] Tamilselvi V et al. developed an IoT-based healthcare monitoring system integrating biomedical sensors and wireless communication technologies for remote healthcare observation and emergency healthcare management.

[18] Subha R et al. proposed a coma patient healthcare monitoring system using IoT technologies and cloud communication systems for continuous monitoring of physiological parameters and healthcare data transmission.

[19] M. Maharaja et al. implemented an IoT-based monitoring system for comatose patients using MEMS accelerometers, eye blink sensors, ultrasonic sensors, and cloud-based communication technologies for emergency healthcare management.

[20] Pradeep Katta et al. proposed a coma patient healthcare monitoring and observatory system using heartbeat sensors, SpO_2 sensors, MEMS accelerometers, and IoT cloud services for monitoring body movement and patient recovery conditions.

VII. COMPARISON TABLE

Parameter	Paper 01 IoT Based Health Monitoring System for Comatose Patients	Paper 02 Coma Patient's Health Monitoring and Observatory System using IoT	Paper 03 A Comatose Patient Monitoring System Based on IoT	Paper 04 IoT Based Monitoring System for Comatose Patients	Paper 05 IoT Based Health Monitoring System for Comatose and Paralysed Patient	Paper 06 IoT Based Smart Monitoring System for Comatose Patient
Core Purpose	Continuous monitoring of vital signs in comatose patients	Monitor body movement and patient recovery conditions	Real-time patient monitoring with machine learning analysis	Detect abnormal patient conditions and provide alerts	Remote monitoring of comatose and paralysed patients	Smart low-power monitoring of heartbeat and respiration
Monitoring Method	Real-time IoT healthcare monitoring	Cloud-based healthcare monitoring	Machine learning-based health analysis	ThingSpeak cloud monitoring	Blynk IoT remote monitoring	ESP32 real-time monitoring
Key Sensors	Heartbeat, Temperature, BP, SPO2 sensors	Flex sensor, MEMS, Heartbeat, SPO2, IR sensor	BP, Pulse, Temperature, PIR sensors	MEMS, Eye Blink, Ultrasonic, BP sensors	DHT11, MAX30102, Flex, Ultrasonic sensors	Heartbeat, MEMS, Breath level sensors
Processing Unit	Arduino Uno	Arduino Controller	IoT Controller + ML Algorithms	NodeMCU ESP8266	NodeMCU ESP8266	ESP32 Microcontroller
Communication	GSM, Wi-Fi	Cloud Communication	Wireless Communication	Wi-Fi + ThingSpeak	Wi-Fi + Blynk IoT	Wi-Fi, Bluetooth
Alert System	Emergency SMS alerts	Cloud-based notifications	Automatic emergency alerts	Alert message to doctors	Mobile app notifications	Instant abnormality alerts
Special Features	Continuous vital sign monitoring	Body movement observation	AI-based patient monitoring	Urine level monitoring	ESP32-CAM live monitoring	Low power healthcare monitoring
Limitations	Internet dependency	Sensor calibration issues	Complex implementation	Cloud delay issues	High hardware integration	Limited sensor range

VIII. CONCLUSION

The literature survey on IoT-based smart monitoring systems for comatose patients shows that modern healthcare technologies have significantly improved patient monitoring and emergency healthcare management. Traditional healthcare systems mainly depend on manual supervision by healthcare professionals, which increases workload and may delay medical response during critical situations. To overcome these limitations, researchers developed smart healthcare monitoring systems using Internet of Things (IoT), cloud computing, biomedical sensors, wireless communication technologies, and artificial intelligence techniques.

Different healthcare monitoring systems reviewed in this survey use biomedical sensors such as heartbeat sensors, pulse oximeter sensors, MEMS accelerometers, ECG sensors, eye blink sensors, ultrasonic sensors, PIR sensors, blood pressure sensors, and temperature sensors for continuous patient monitoring. Microcontrollers including Arduino Uno, Raspberry Pi, ESP32, and NodeMCU ESP8266 are widely used for signal processing and wireless data transmission. Cloud platforms such as ThingSpeak and Blynk IoT provide real-time healthcare monitoring and remote access for doctor and caregivers.

Several researchers additionally integrated machine learning, deep learning algorithms, computer vision technologies, and predictive healthcare analytics for early detection of abnormal patient conditions and improved healthcare decision-making. Emergency alert systems using SMS notifications, mobile applications, email alerts, and cloud dashboards help

doctors provide immediate medical assistance during critical situations.

The survey concludes that IoT-enabled healthcare monitoring system provides reliable, cost effective, low-power, and real-time healthcare solutions for comatose stations. These systems improve patient safety, reduce hospital workload, enhance emergency response time, and support remote healthcare management. Future healthcare monitoring system can achieve better performance using advanced artificial intelligence techniques, wearable healthcare devices, secure cloud platforms, and smart hospital integration technologies.

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