International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 12 | Dec - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

IOT-Based Health Monitoring System For Paralysis (Quadriplegic) Patients

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Abstract - Paralysis, which is defined as the loss of muscle function in certain body parts, presents unique issues in healthcare. This necessitates technological and medicinal advances to improve patients' quality of life. This project, "IoT-Based Health Monitoring System for Paralysis (Quadriplegic) Patients," aims to improve the quality of life for paralysis patients by creating an easy-to-use, affordable device for their connectivity with caregivers and doctors. The wearable sensors track important health information such as heart rate, body temperature, blood pressure, and movement, sending it to healthcare providers via a cloud platform. This allows for quick responses as needed. The gadget lets patients communicate their needs with simple motions, making it much easier for them to converse despite their physical problems. This system reduces visits to hospitals and enables remote care of the patients, thus contributing to better health and independence for paralysis patients.

Key Words: **IoT, Paralysis, Health monitoring, Flex Sensors, ESP32 microcontroller.**

I. INTRODUCTION

Paralysis is the inability of one or more muscles to move. Even though paralysis usually only lasts a short while, it can potentially remain in the body forever. Affected areas may also suffer sensory loss, or lack of feeling, as a consequence of sensory injury, in addition to paralysis. Strokes are the most common underlying cause of partial or complete paralysis in patients. In partial paralysis, the patient retains some degree of control over the damaged muscle.[1]

This research proposes an "IoT-based Health Monitoring System for Partial Paralysis Patients that will be able to monitor in real time the heart rate, body temperature, ECG, and activity levels of the patient; access the cloud platform that caregivers and doctors can utilize through Wi-Fi and ESP32; store data in the cloud securely; get alerts if the health parameters are outside the normal range; allow for better decision making and less frequent hospital visits. The objective is to ensure that the system is non-invasive, easy to use and comfortable for patients; also making sure that the system is low-cost and scalable.[2]

Paralysis or loss of muscle function alongside sensory impairments creates significant challenges for the patient and those around the patient. Often, old-fashioned health care monitoring can be labor-intensively operated and impractically unfeasible as a model for long-term care. IoT technology offers a transformational solution by allowing the continuous, real-time monitoring of vital signs such as heart rate, body temperature, oxygen levels, and movement patterns. These systems include wearable sensors integrated with cloud platforms, providing remote access to health data and alerts for abnormalities in a timely manner. This research develops a user-friendly IoT-based health monitoring system for paralysis patients. Integrating sensors, including ECG modules, temperature sensors, and accelerometers, offers comprehensive health monitoring. Cloud integration along with real-time data visualization equips the caregivers with the capabilities of proactive care with an ability to give high-quality lives to patients. This helps keep the data safe in the cloud to simplify analysis of trends and even enable the detection of emerging problems early. Comfortably designed for ease of use, the system reduces the hospital visit and improves remote care through a more efficient, accessible approach to managing the patient's health.

II. LITERATURE REVIEW

A. IoT Solutions for Healthcare of Paralysis

This new innovative system based on IoT would transform the life of patients suffering from paralysis using wearable devices and mobile applications. Patients can simply bend a finger to request help using Flex-sensor gloves.
Cloud computing is used to monitor the health condition in real-time and to alert the caregivers in cases of emergencies such as falls or any abnormal vital sign. It can help reduce caregiver workload while promoting patient independence, which will help in the enhancement of care for conditions like paralysis and Parkinson's disease.

B. Real-Time Support for Paralysis Patients

This smart health monitoring system is based on wearable gloves that have sensors to detect gestures and falls. It continuously tracks the vital signs, such as heart rate and body temperature, and sends the data to a secure server for real-time access by caregivers.[1] The system also provides alerts for emergencies through an easy-to-use web interface. This tool is designed for accessibility and safety, empowering patients and improving their quality of life by ensuring timely support and proactive health management.

C. Affordable Health Monitoring in Quadriplegic Patients

This system monitors essential health data such as heart rate, oxygen levels, and blood pressure with advanced sensors. It includes Bluetooth for data sharing and SMS alerts for emergencies, so caregivers can react quickly to critical situations. The design is affordable and accessible, making it highly valuable for underserved communities. Its robust features are a reliable way to manage patient care while reducing caregiving stress.[2]

D. Face Mask Detection with Instant Alerts

This system ensures compliance with face mask regulations by using an IoT-enabled camera and a Telegram bot for notifications. In real-time, it can detect mask usage even in low-light conditions, and sends instant alerts along with images to a channel. The reliability and speed of the system make it an effective tool for the monitoring and promotion of safety in public spaces, depicting how technology can simplify compliance checks in real time.[8]

E. Driver Sleepiness Detection and Alert

The practical system to prevent accidents because of drowsy driving employs smartphone cameras and the utilization of machine learning that checks the activities in the eyes. At such moments, it sends alerts on driver details, the location, and alerts via the Telegram channel in real-time. This user-friendly approach eliminates the need for more hardware. It becomes an easy yet powerful tool in improving road safety with proper interventions at the correct time.[7]

III. TOOLS AND TECHNOLOGIES

A. ESP32 WROOM Microcontroller

The heart of the system is the ESP32-WROOM. It is a microcontroller with built-in Wi-Fi and Bluetooth, which allows for wireless communication with other devices. It is powerful and efficient, making it a perfect device to handle all the data coming from the sensors sending this to the cloud for healthcare providers to monitor the condition of a patient.

B. LM35 Temperature Sensor

The LM35 is an easy and accurate temperature sensor that tracks body temperature. It has an output which is linearly proportional to the temperature and hence very easy to read and monitor.

C. AD8232 ECG Sensor

The AD8232 is a small, low-power ECG sensor that captures heart activity. It amplifies weak signals and filters out noise, making it reliable for continuous health tracking. It alerts the caregivers in case of anomalies such as arrhythmias.

D. HMC5883L Accelerometer

HMC5883L is a 3-axis accelerometer that monitors movement in every direction. It helps detect any changes or movement in the body of the patient and alerts caregivers in case such a patient falls or starts showing unusual movement

E. Flex Sensors

Flex sensors are simply devices that detect bending or flexing. It measures the muscle movement of patients which alerts the caregivers in case the patient needs help which promotes easy communication with the caregivers.

F. Arduino IDE

The Arduino IDE simplifies the process of programming by adding syntax highlighting, built-in libraries, and integrated tools that assist with debugging and data communication. In a health tracking system for paralysis patients, it plays an important role in:

- Initializing and reading sensor data from heart rate monitors, accelerometers, and temperature sensors.
- Configuring Wi-Fi modules for cloud connectivity in remote health monitoring
- Anomaly detection and alerts for emergency cases

G. ThingSpeak

ThingSpeak is a cloud-based IoT platform that collects, stores, and visualizes data in real time from the connected devices. Integrating with MATLAB tools makes its data analysis work even stronger thus improving decision-making and healthcare efficiency. Important applications in care for paralysis are:

- Visualize patient health metrics such as heart rate and temperature through live dashboards.
- Enable remote monitoring, so caregivers can access data from anywhere.
- Generate alerts for anomalies such as sudden temperature spikes or a fall, ensuring timely interventions.[1]

H. Telegram Bot API

Telegram Bot API enables the development of bots that serve as a communication bridge between the device and caregivers by:

- Notifying instant messages when sensor data indicates critical conditions such as an irregular heartbeat or falls
- Securing and reliably communicating by end-to-end encryption.
- Making it accessible across various platforms for Android, iOS, and desktops.[7]

IV. SYSTEM IMPLEMENTATION

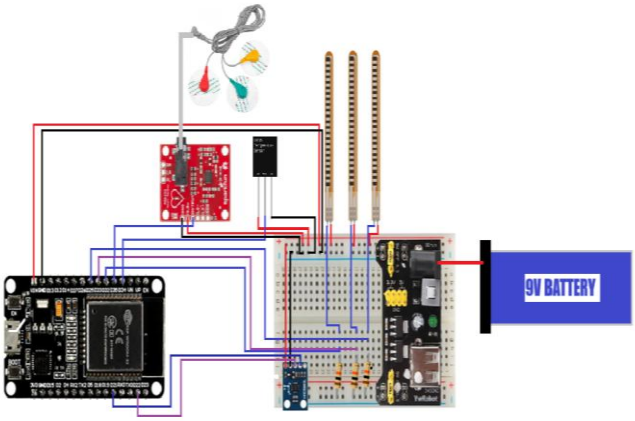

Fig. 1: Circuit diagram of the proposed prototype

The health monitoring system combines various devices to capture, process and transmit health information. Here is a simplified conceptualization of its main connections:

A. Power Supply:

The system is powered by a 9V battery. The power module steps down the voltage to 3.3V or 5V according to the requirement. This will allow compatibility with the components like the ESP32 microcontroller and sensors (e.g., LM35 and AD8232), allowing for stable operation even in portable or remote setups.

B. Sensor Connections:

Every sensor is connected to the ESP32 microcontroller for smooth data acquisition:

- **Flex Sensors:** Detect bending or movement and are read via a voltage divider circuit. Output is routed to the ESP32's analog GPIO pins, GPIO25, GPIO32, and GPIO33 to calculate movement data.
- **Temperature Sensor (LM35):** Supplies an analog output that is proportional to body temperature, connected to GPIO34 to monitor in real-time.
- **ECG Sensor (AD8232):** The sensor captures heart activity. Its analog output is sent to GPIO35 to capture waveforms of ECG to be further analyzed.
- **Accelerometer (HMC5883L**): Detects motion and falls and communicates with ESP32 using I2C protocol on SDA and SCL pins for three-axis acceleration data.

PROJECT WORKFLOW:

The functional block diagram of the proposed prototype depicted in Fig.2 makes use of hand gloves mounted with flex sensors, which recognize movements and commands. The movements display certain messages on the desktop screen and send notifications to caregiver's mobile phones via a Telegram bot. [7] In addition, the patient's temperature and heart rate are continuously recorded by the LM35 and ECG sensors. As a result, the data is sent to the IoT server using an ESP32 microcontroller. The IoT server then displays this information online graphically.[1]

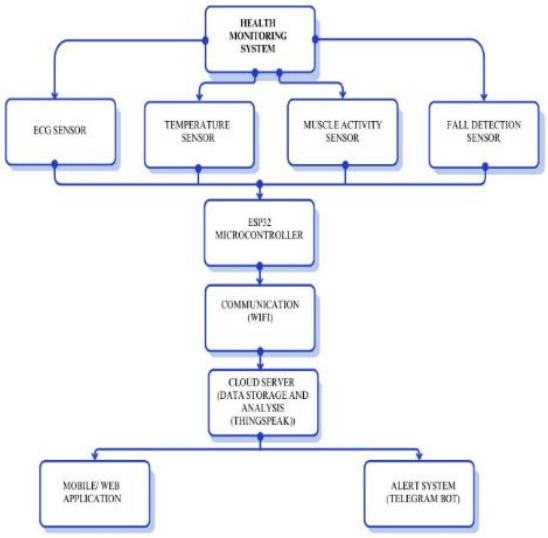

Fig. 2: Functional block diagram of the proposed prototype

If the patient's condition worsens such as the person is about to fall, then it is detected by the fall detection sensor and alerts the caregiver.

i. Health Monitoring Platform:

This system integrates advanced sensors in monitoring vital health metrics: heart activity, body temperature, and movements, falls. Collecting, then processing this data, it assures both the care-giver and the users' timely insights to stay one step ahead of potential issues affecting their health.

ii. Key Sensors:

- **ECG Sensor:** This sensor keeps track of heart activity by identifying irregular rhythms or potentially problematic cardiac concerns, all of which can be information for early intervention.[2]
- **Temperature Sensor:** Tracks constant body temperature, aiding real-time detection of fever or other signs of disease.
- **Muscle Activity Sensor:** Records and provides a track of muscle activity during the process of rehabilitation, to warn for any unusual patterns.[1]
- **Fall Detection Sensor:** Is sensitive to sudden movements and/or changes in posture, alerts the caregivers to possible falls

iii. ESP32 Microcontroller:

The ESP32 core is responsible for collecting raw data from sensors and presenting it in user-friendly formats, such that smooth exchange with cloud platforms and mobile applications would be possible.

iv. Communication with Wi-Fi:

The system can send health information to the cloud in real time by using its on-board Wi-Fi. This allows one to monitor health metrics from anywhere due to a simple app or web interface. The communication is efficient, ensuring it shares data quickly and securely.

v. Cloud Connection with ThingSpeak:

ThingSpeak is an intelligent storage hub and an analysis hub that acts as a central nerve for the system.

Live Dashboards: Graphs reflecting easy-to-read heart and temperature activity will be clear-cut about the patient's health situation.

Fig. 3: Physical connections (Back)

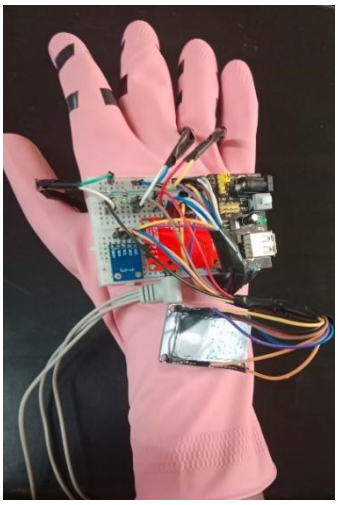

Fig. 4: Physical connections (Front)

V. RESULTS AND DISCUSSIONS

The IoT-based health tracking system was designed to help paralyzed patients by monitoring their health consistently and giving caregivers updates timely. During testing, it demonstrated how technology could serve as a vital tool to improve patient care.

A. Continuous Health Monitoring

The system tracked important health measures such as heart rate, body temperature, respiratory rate, and oxygen saturation. It sent the information wirelessly to a cloud platform; this updated caregivers about the patient's status in real-time.

B. Monitoring Movements and Postures

These may be motion sensors that equipped the system to detect sitting, lying down, and moving around. It may also recognize unusual activities in the patient, such as long periods of inactivity, falls, and other abnormalities, thus alerting care providers to act regarding immediate safety concerns for the patient.

C. Instant emergency alerts

The system was programmed to alert caregivers in case of abnormal health readings, such as low oxygen levels or irregular heart rhythms. It also alerted the caregivers for emergencies like falls or prolonged immobility, so they could act quickly to prevent further complications.

D. Comprehensive Health Records

All the data was safely stored in the cloud, creating a health history that caregivers and doctors could easily access. Such records made it easier to track patterns, adjust treatments, and monitor the patient's progress over time.

E. Reliable and Accurate Performance

The system was consistent in delivering reliable and accurate readings, equal to those of standard medical devices. Although network outages occasionally caused minor delays, the system was very effective in delivering consistent monitoring and timely updates.

```
Data sent successfully.
Temperature: 24.58 °C
Flex Sensor 1 Status: Normal
Flex Sensor 2 Status: I need food
Flex Sensor 3 Status: Normal
ECG Value: 1879
ECG Status: Normal heart rate
HMC5883L Magnitude: 27774.11
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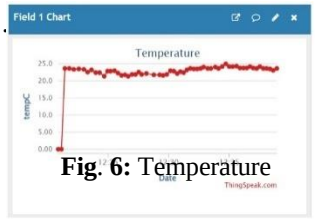

Fig. 6: Temperature

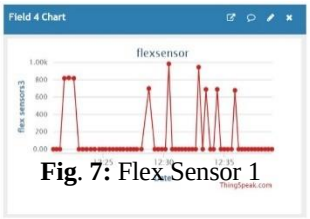

Fig. 7: Flex Sensor 1

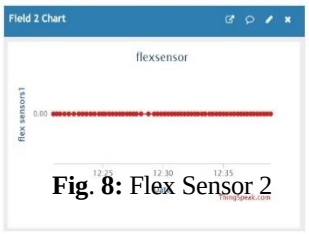

Fig. 8: Flex Sensor 2

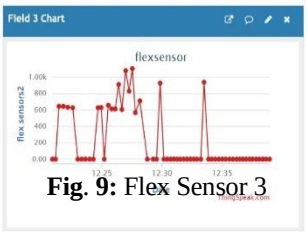

Fig. 9: Flex Sensor 3

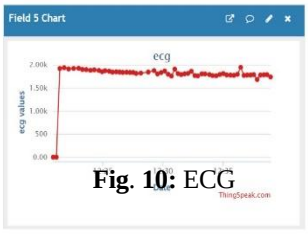

Fig. 10: ECG

Fig. 11: Fall Detection

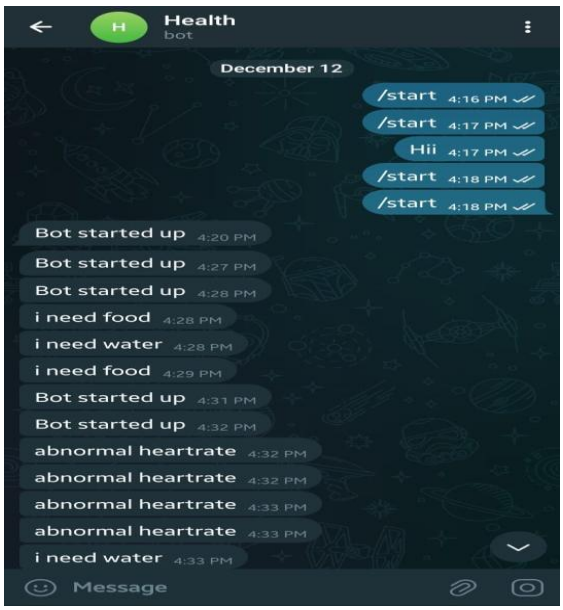

Fig. 12: Alerts Obtained on Telegram Bot

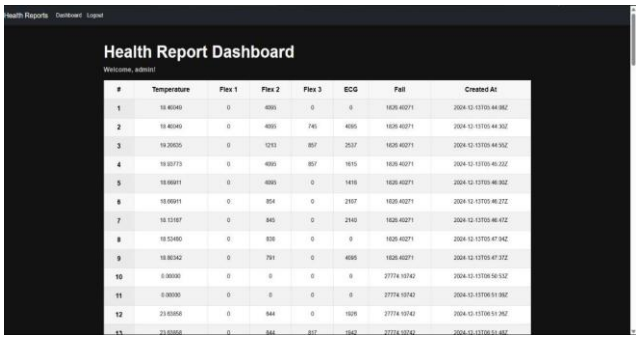

Fig. 13: Data displayed on the Web App

VI. CONCLUSION

The IoT-Based Health Tracking System transforms the care offered to paralysis patients by amalgamating advanced sensors with cloud technology for monitoring several vital health parameters, like heart rate, body temperature, and movement patterns. The system tracks real time and visualizes data to be used on platforms, such as ThingSpeak it empowers caregivers as well as healthcare providers who can make informed decisions promptly and provide customized care for patients.
It improves patient safety through the capability to send alerts on abnormal conditions. This solution is convenient, thus reducing the need for patients to visit hospitals frequently for continuous remote monitoring. It is reliable and cost-effective, hence highlighting the potential of IoT in the improvement of healthcare delivery; thus, this solution is highly valuable to patients who require continuous oversight and proactive management of their health.

VII. FUTURE WORK

Although the IoT-Based Health Tracking System is very useful for monitoring paralysis patients, it can be taken a step further in capabilities.

- **Integration of More Sensors**
  The addition of more sensors to monitor blood oxygen levels, respiratory rate, or glucose levels can add an even more complete understanding of the patient's health. AI and Predictive Analytics. This will identify patterns in the health data that can predict, for example, the risk of seizures or pressure sores before they happen.
- **Stronger Encryption as well as Privacy Regulations compliance**
  Future versions can include better forms of encryption and adherence to privacy rules to keep confidential patient data.
- **Mobile application**
  An app dedicated would provide caregivers with immediate alerts and could easily keep track of how patients' health is on a user-friendly interface for them.
- **Multi-Patient Support**
  Expanding the system to monitor multiple patients simultaneously would be invaluable for hospitals and clinics.
- **Enhanced Power Management**
  Low-power sensors or renewable energy sources like solar panels could ensure that monitoring is uninterrupted by optimizing energy use.
- **Telemedicine**
  Adding telemedicine features would allow doctors to consult remotely, analyze data, and provide prescriptions, thus making care more accessible to patients with mobility challenges.
- **Wearable Devices**
  Transforming the system into a compact, wearable device would make continued monitoring more convenient and practical for the patient.

ACKNOWLEDGEMENT

We would like to express our heartfelt gratitude to our institution, Bangalore Institute of Technology for generously supporting throughout this study by providing all the resources and facilities required. We also extend our sincere thanks to the Department of Electronics and Communication Engineering for their invaluable guidance.

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