

Healthcare Monitoring System Using IoT for Paralysis Patients with Alert Mechanism

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Abstract

The increasing prevalence of paralysis and mobility-related disorders has created a strong demand for continuous healthcare monitoring systems, with neurological disorders affecting millions globally and nearly 60% of patients requiring constant assistance, while IoT-based healthcare solutions are projected to grow at over 20% annually. Traditional patient care relies heavily on manual observation and periodic monitoring, which may fail to detect sudden health deterioration, falls, or emergency conditions in time. Furthermore, conventional systems lack real-time alerts, remote accessibility, and interactive assistance features, reducing their effectiveness in supporting paralysis patients. To address these challenges, the proposed IoT-based health assistance system for paralysis patients utilizes the ESP32 microcontroller to develop an intelligent and wearable healthcare solution. The system integrates DHT11 sensors for temperature and humidity monitoring, SpO2 sensors for blood oxygen level measurement, vibration sensors for fall detection, and flex sensors to capture patient movements or specific gestures. When abnormal conditions or predefined triggers are detected, the system activates a voice module to alert nearby caregivers and simultaneously sends real-time notifications through an IoT platform for remote monitoring. This smart system enhances patient safety, enables rapid emergency response, improves caregiver support, and provides a scalable and efficient solution for modern assistive healthcare applications.

Keywords: Assistive Healthcare, Flex Sensors, Health Monitoring System, Internet of Things, Paralysis Patient Care, Real-Time Alerts, SpO2 Monitoring, Vibration Sensor, Voice Alert System

1. Introduction

The increasing prevalence of paralysis and mobility-related disorders has significantly raised the demand for continuous healthcare monitoring and assistive technologies [1]. Neurological disorders affect millions of people globally, with nearly 60% of patients requiring constant assistance for daily activities and health supervision [2]. Additionally, IoT-based healthcare solutions are growing at over 20% annually, reflecting the shift toward connected, real-time medical systems. In environments such as home healthcare, rehabilitation centers, hospitals, and elderly care facilities, there is a critical need for systems that provide continuous monitoring of vital parameters [3], instant

alerts, and remote accessibility to ensure patient safety and improve quality of care.

Problem Statement: Traditional patient care methods rely heavily on manual observation, caregiver supervision, and periodic health checks. While these approaches provide basic support, they are often insufficient for patients with paralysis who require continuous monitoring [4]. Sudden health changes, falls, or distress conditions may go unnoticed between monitoring intervals. Additionally, conventional systems lack automation, real-time alert mechanisms, and remote connectivity, making it difficult for caregivers to respond promptly in emergency situations [5]. The absence of interactive assistance features also limits patient independence and

communication, especially for individuals with restricted mobility.

In real-time scenarios, these limitations lead to several critical challenges that can adversely affect patient outcomes. Sudden drops in oxygen levels, temperature fluctuations, or accidental falls may not be detected immediately, delaying medical intervention [6]. Patients with limited mobility may be unable to communicate their needs effectively, increasing dependency on caregivers [7]. Furthermore, the lack of real-time monitoring and remote alert systems prevents timely response, especially in home-based care settings. The absence of gesture-based interaction or automated assistance further reduces patient comfort and safety [8]. These challenges highlight the need for an intelligent, IoT-based health assistance system capable of continuous monitoring, fall detection, gesture recognition, and instant alert generation, ensuring enhanced patient safety, improved caregiver support, and efficient management of paralysis-related conditions.

2. Literature Survey

Lamercy et al. [9] proposed robotic and wearable sensor technologies for clinical assessment in neurorehabilitation, focusing on quantitative measurement of motor functions. Haghshenas-Jaryani et al. [10] proposed a hybrid exoskeleton robotic device for hand rehabilitation, combining mechanical assistance with sensor feedback for therapy.

Yang et al. [11] proposed an Internet of Things (IoT)-enabled stroke rehabilitation system using a smart wearable armband and machine learning for motion analysis. Lee et al. [12] proposed an IoT-enabled omnidirectional mobile system for home-based rehabilitation of upper and lower limbs. Postolache et al. [13] proposed a remote monitoring system for stroke rehabilitation using IoT and virtual reality to provide interactive therapy and real-time feedback.

Chowdhury et al. [14] proposed smart gloves for assisting people with speech disability by

translating hand gestures into communication signals. Filipowska et al. [15] proposed a machine learning-based gesture recognition glove that utilized sensors and classification algorithms for accurate gesture detection. Ji et al. [16] proposed a dataglove for sign language recognition using wearable inertial sensors to capture hand movements.

Dhiman et al. [17] proposed an IoT-enabled smart glove for brain stroke rehabilitation that monitored hand movements and provided feedback for therapy. Ozlem et al. [18] proposed a cloud-based control system with textile-based IoT gloves for telerehabilitation applications, integrating sensing and actuation for remote therapy. Ucar et al. [19] proposed an Internet of Medical Things (IoMT)-based smart glove for continuous vital sign monitoring in athletes, integrating sensors for health tracking and performance optimization.

3. Proposed System

Figure 1 illustrates the architecture of an IoT-based smart assistive and health monitoring system built around the ESP32. The system integrates multiple input sensors such as flex sensors for gesture recognition, vibration/MEMS sensor for motion detection, DHT11 for temperature and humidity monitoring, and SPO2 sensor for oxygen level measurement. A regulated power supply (RPS) ensures stable operation. The ESP32 processes the sensor data and generates outputs through an LCD display, voice module, and IoT connectivity. This system is particularly designed to assist the mute community by converting hand gestures into voice output while simultaneously monitoring health parameters. The system consists of five main sections:

1. RPS
2. Input Section
3. Output Section
4. ESP32 Microcontroller

5. Automatic Play and Record (APR) Voice Module

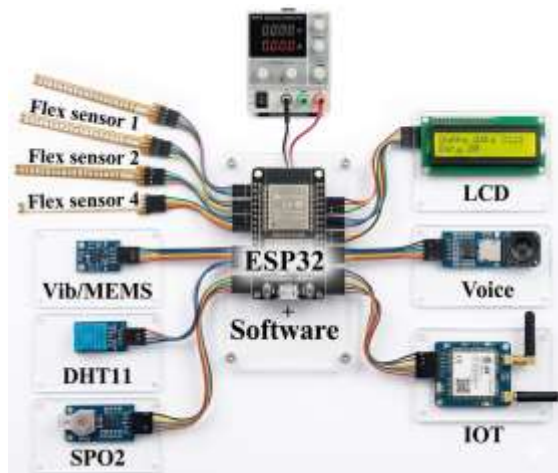


Figure 1. IoT-Based Smart Assistive Health and Gesture Recognition System.

Step 1: Power Supply Initialization: The regulated power supply converts AC voltage into stable 5V DC and powers the ESP32, sensors, LCD, and voice module

Step 2: Gesture Input using Flex Sensors: Flex sensors detect finger bending by varying resistance. These variations are interpreted as specific gestures or sign language inputs.

Step 3: Motion Detection using Vib/MEMS Sensor: The vibration/MEMS sensor detects hand movements or gestures, improving gesture recognition accuracy.

Step 4: Environmental and Health Monitoring: The DHT11 sensor measures temperature and humidity, while the SPO2 sensor monitors oxygen levels, enabling real-time health tracking.

Step 5: Data Processing by ESP32: The ESP32 processes all sensor inputs using embedded programming and maps gestures to predefined voice outputs. It also analyzes health parameters for monitoring.

Step 6: Output Display and Voice Generation: The LCD displays detected gestures and system status. The APR voice module converts recognized gestures into

speech, helping communication for the mute community.

Step 7: IoT-Based Monitoring: The ESP32 transmits data to an IoT server via Wi-Fi. Users can monitor system data through a mobile application using a TCP Telnet connection (IP: 192.168.4.1, Port: 23).

3.1 Working Procedure

The flowchart as shown in Figure 2 captures hand gestures using flex sensors, processes them through the ESP32, and converts them into voice output using the APR module. Simultaneously, it monitors health parameters and uploads data to the IoT platform for remote access. This integrated system enhances communication for the mute community while providing real-time health monitoring and smart connectivity.

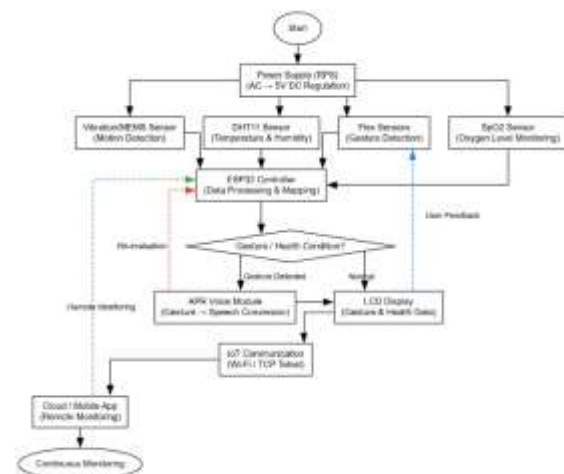


Figure 2. Proposed Flowchart.

The circuit is based on the ESP32 microcontroller as shown in Figure 3, which acts as the main processing unit, interfacing with various sensors and output modules. Below is a detailed explanation of the circuit components and pin configurations:

Power Supply Section:

- A step-down transformer converts high AC voltage to a lower level.
- A bridge rectifier (D1, D2, D3, D4) converts AC to DC.

- A 7805-voltage regulator ensures a stable +5V DC supply.
- Capacitors (1000 μ F and 100 μ F) smoothen the voltage, and an LED with a 330-ohm resistor indicates power status.

Sensor Connections:

- Flex Sensor: Connected to GPIO 6, 16, 17, and 23 for gesture recognition.
- SPO2 Sensor & DHT11 Sensor: Connected to GPIO 7 & 22 for health monitoring (oxygen levels and temperature).
- Voice Module: Connected to GPIO 2, 4, 5, 18, 19, and 21, enabling audio output.

Output Devices:

- 16x2 LCD Display: Connected to GPIO 12, 13, 14, 25, 26, and 27, displaying sensor readings.
- IoT Module: Connected to GPIO 0 and 3, enabling remote monitoring and connectivity.

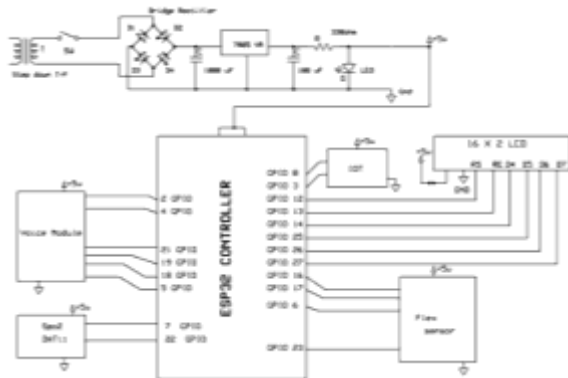


Figure 3. Schematic Diagram.

4. Results and Discussion

Figure 4 shows the hardware prototype of the IoT-Based Health Assistance System for paralysis patients. The system integrates ESP32, flex sensors, SpO₂ sensor, DHT11 sensor, vibration sensor, LCD display, and buzzer to monitor patient health and assistance requests. The ESP32 processes sensor data and

communicates with the IoT platform for remote monitoring.

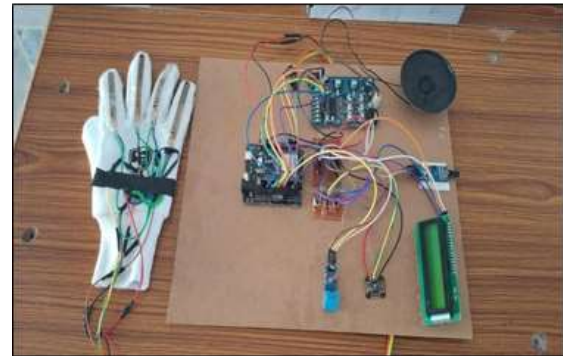


Figure 4. Hardware Implementation of IoT-Based Health Assistance System.

Figure 5 shows the glove integrated with flex sensors that detect finger movements of the paralysis patient. Each finger movement corresponds to a specific command such as requesting water, medicine, food, or help for the washroom.



Figure 5. Flex Sensor Glove for Patient

Assistance Commands.



Figure 6. IoT Web Dashboard Monitoring Output

Figure 6 shows the IoT dashboard displaying health parameters and patient requests in real time. The system updates temperature, humidity, SpO₂ level, heart rate, fall detection status, and emergency alerts on the IoT server for remote monitoring.

Figure 7 shows the LCD display output when the patient activates flex sensor commands. Messages such as “Need Food,” “Need Water,” “Need Medicine,” and “Help for Washroom” are displayed to notify caregivers about the patient's requirements.



Figure 7. Commands from Patient Displayed on LCD.

5. Conclusion

The proposed IoT-based health assistance system for paralysis patients offers a reliable and intelligent solution to enhance patient care by integrating continuous monitoring, real-time alerts, and interactive assistance features. By utilizing the ESP32 microcontroller along with DHT11, SpO₂, vibration, and flex sensors, the system effectively tracks vital parameters, detects falls, and interprets patient gestures for communication. The inclusion of a voice module ensures immediate local alerts to caregivers, while IoT connectivity enables remote monitoring and timely intervention during emergencies. This reduces dependence on constant manual supervision and improves response time in critical situations. Furthermore, the system enhances patient independence, safety, and quality of life by providing a smart and automated healthcare support mechanism.

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