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Development of IoT-based Paralysis Patient Healthcare with Hand Gesture Recognition using ESP32

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Paralysis is the inability to move and, in some cases, unable to feel in a portion or the entire body. This condition could be transitory or long term. In addition, the current market options to cater paralysed patients are often bulky and expensive, limiting access outside hospitals. To address this dilemma, the project focuses on creating an affordable, user-friendly device that uses hand movements to control the system through an accelerometer and gyro, wirelessly transmitting data to a receiver. Vital signs such as temperature, BPM, and SpO2 are monitored and displayed on both the OLED screen and a mobile app via a Blynk server. During the functionality performance, the number of errors that occurred during the testing of the smart IoT system's functionality was zero, indicating a high level of reliability in the IoT system. During testing, the system recorded 0% functional error and achieved an average accuracy of 80%, outperforming earlier systems that ranged between 40 to 60%. In short, this proposed system enhances healthcare access, improves care quality, and offers patients more independence and peace of mind.

Keywords: BPM; IoT; Spo2; accelerometer; paralysis

I. INTRODUCTION

A condition or impairment that substantially impairs an individual's functioning in comparison to the norm for that person or group is referred to as paralysis (de Freitas *et al.*, 2022). The majority of these patients are either temporarily or permanently dependent on their caregiver. People with total paralysis suffer not only just from physical disability but also from the agony of the inability to communicate and express their feelings (Mensah-Gourmel *et al.*, 2023). These people, in most cases, are not able to convey their needs because they are unable to speak. Although there are state-of-the-art techniques for healing or treating paralysis, the aim of care is to help patients cope with their condition while maximising their level of independence (Chunyan, *et al.*, 2024).

By facilitating remote monitoring and improving patient care, the development of Internet of Things (IoT) technology has revolutionised healthcare systems (Abderahman Rejeb, 2023). IoT in particular offers enormous promise to help individuals with disabilities, including paralysis, by offering creative ways to monitor, communicate, and provide support. It might be difficult for people with paralysis to communicate with caretakers or healthcare professionals and to explain their requirements. This difficulty highlights

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the necessity of an effective and user-friendly healthcare system. The creation of an Internet of Things (IoT)-based system that recognises hand gestures to allow paralysed people to engage more freely and independently is one promising strategy (Mahmoud *et al.*, 2021).

Hand gesture recognition provides a simple and non-invasive way for patients to interact with their surroundings and operate gadgets. The device can record even minute hand movements and convert them into useful commands by using motion detection sensors, like gyroscopes and accelerometers (Caro-Álvaro *et al.*, 2024). This system's use of the ESP32 microcontroller offers a robust and reasonably priced framework for handling gesture inputs and facilitating wireless device connectivity (Babiuch & Postulka, 2021). In addition to providing patients with control over their surroundings, this technology makes it easier for them to communicate with caregivers, enabling more individualised and responsive healthcare services.

Furthermore, due to its adaptability, low power consumption, and integrated Wi-Fi and Bluetooth capabilities, the ESP32 microcontroller is essential to this Internet of Things (IoT) healthcare system. Because of these characteristic features, the ESP32 is perfect for wireless connection and real-time data processing. This allows the system to transmit critical health data, like blood oxygen levels (SpO2), heart rate (BPM), and body temperature, to a mobile application for remote monitoring (Uddin, 2024; Sumana *et al.*, 2024). Hand gestures give patients a degree of autonomy that may not be available with typical healthcare technologies by making it simple to activate orders, to ask for assistance, track their own health indicators, or operate external devices.

In conclusion, a major advancement in the treatment of paralysed patients has been made with the creation of an Internet of Things-based healthcare system that uses the ESP32 microcontroller to recognise hand gestures. This project's primary goal is to close important gaps in patient autonomy, monitoring, and communication by providing an easy-to-use, reasonably priced solution that improves care quality and patient's quality of life. Healthcare professionals can deliver more individualised, timely, and effective care by combining gesture recognition and Internet of Things technologies, enabling paralysed people to live more respectable and independent lives (Osama *et al.*, 2023). In this paper, the project's study methodology is explained in Section 2. The results are shown in Section 3, and the closing thoughts are given in Section 4, accordingly.

II. LITERATURE REVIEW

The healthcare sector has been greatly impacted by the quick advancement of several technical disciplines, especially in the provision of creative patient monitoring and communication solutions. IoT-based healthcare solutions present a chance to improve caregiving and increase autonomy for paralysed patients, who frequently struggle with movement and communication. This review of the literature looks at the state of research in three important areas that are pertinent to the creation of an Internet of Things-based healthcare system for patients with paralysis: the use of the ESP32 microcontroller in wearable health monitoring devices, hand gesture recognition as a communication tool, and IoT technology in healthcare. By investigating these topics, one can learn more about the possible advantages and difficulties of creating an intelligent healthcare system that uses gesture recognition and the Internet of Things to cater to the unique requirements of patients with paralysis. Below is a brief exploration of these apps' solutions.

A. Automated Paralysis Patient Healthcare System

In a recent study (Gaikad *et al.*, 2021), a system was proposed that enables patients to display messages on an LCD screen using simple movements from any body part with remaining mobility. Additionally, the system ensures that when no one is present to attend to the patient, a message is sent via GSM in the form of an SMS conveying their needs. By tilting the device at specific angles, patients can easily communicate messages, offering an effective way for them to express their needs. However, the system is primarily communication-centric and lacks continuous physiological monitoring (e.g., Peripheral Capillary Oxygen Saturation (SpO_2), Beats Per Minute (BPM), and temperature trends), while its evaluation remains largely qualitative with no formal repeatability, error-rate, or reliability analysis; moreover, the absence of IoT cloud integration, mobile dashboard support, and quantified validation metrics, together with GSM-based communication, introduces latency and scalability limitations. This project also suffers from limited bandwidth, slew rate, and precision in high-speed applications due to limited-only processes analogue signals by its conventional accelerometer component. The system reported in both in (Gaikad *et al.*, 2021) and Table 1 employed an Arduino UNO with a GSM module, restricting real-time communication to SMS-based alerts only, which limited responsiveness and continuous monitoring.

B. Health Monitoring and Observatory System for Paralysed Patients using Blynk Application

In this paper (Varghese *et al.*, 2022), the author proposed a project that incorporated sensors that monitor vital signs and assist patients in communicating their needs. The data is stored in a dedicated database, and through an IoT platform like the Blynk application, alerts or abnormal conditions can be quickly identified and shared with caregivers and doctors, ensuring timely responses. The proposed system employs multiple sensors for continuous patient monitoring, with data collected and sent to an Arduino microcontroller for further processing. The system utilises a Wi-Fi module to transmit metrics to the Blynk app via the Internet of Things (IoT) app. Parameters such as patient movements are tracked, recorded, and updated every 2 seconds. The system remains functional even with poor network conditions by using SMS protocols as backup. Although the system demonstrates strong physiological monitoring capability, patient-initiated communication remains limited, as gesture recognition is primarily employed for movement detection rather than semantic, intent-based communication (e.g., food, water, or emergency), while increased system complexity and power consumption further constrain practicality; moreover, the evaluation emphasises functional demonstration over rigorous validation, with no explicit analysis of functional error rates, thereby limiting the assessment of system reliability. Furthermore, without an LCD screen at the patient side, users would rely solely on alerts or external systems to interpret data, which may reduce the system's effectiveness in situations where immediate visual feedback is important. The system also described in (Varghese *et al.*, 2022) and based on Table 1 incorporated Wi-Fi or Bluetooth connectivity through Arduino Nano or NodeMCU, which increased system complexity and communication latency despite offering improved wireless capabilities.

C. IoT-Based Solution for Paraplegic Sufferer to send Signals to Physician via Internet

The paper (Srinivasan *et al.*, 2023) highlights the hospitals and non-profits organisations that often care for people with paralysis who cannot move parts of their body or communicate due to lack of motor coordination. To help them, this project proposed a system that detects small body movements to display messages on an LCD or send SMS notifications when personal care isn't possible. The system tracks vital signs like heart rate using photo plethysmography and continuously transmits this data to a doctor's station, where it is monitored. If abnormalities are detected, an alarm alerts the staff, and an SMS is sent to doctors with the patient's room number. However, this device can be worn on clothing or a finger, making it easy for patients to use. The system's reliance on an RF + GSM architecture increases overall complexity and susceptibility to interference, while limited cloud visualisation falls short of modern IoT healthcare platforms; moreover, despite demonstrating basic functionality, the absence of quantitative performance metrics together with a lack of systematic evaluation and limited sensor diversity, significantly constrains the assessment of robustness, scalability, and clinical relevance. Some more, the Bluetooth-based systems are limited in range and less suitable for remote caregiving. In both in (Srinivasan *et al.*, 2023) and based on Table 1 as well, the design lacked comprehensive sensor integration and depended on limited user interaction methods, such as basic pulse or flex sensors, further constraining system performance and responsiveness.

D. IoT-Based Automated Paralysis Patient Monitoring System

According to the paper (Kumar *et al.*, 2024), this study focuses on developing a system that enables patients to send messages through simple finger gestures. This device can be either attached to the finger or integrated into their clothing. This project is carried out by busing an Arduino UNO microcontroller to monitor and assist patients, likely those with mobility impairments, based on the usage of flex sensors. The system integrates a 16x2 LCD display, a 5V power supply, an APR 33A3 playback controller for audio feedback through a 5-ohm speaker, as well as a GSM 800C module to send messages to caretakers. The flex sensors are likely positioned on the patient's body to detect movement, triggering specific outputs such as text on the LCD, audio alerts, or messages to caretakers based on the sensor data. Yet, the system relies solely on a GSM module for communication, which limits its functionality in areas with poor cellular coverage. In (Kumar *et al.*, 2024) and based on Table 1 also, the use of basic feedback mechanisms such as LCD displays or speakers resulted in slower system response and higher power consumption.

Table 1. Key Comparison of Previous Works

Feature	**(Gaikad *et al.*, 2021) & (Kumar *et al.*, 2024) (GSM Systems)**	**(Varghese *et al.*, 2022) (Wi-Fi System)**	**(Srinivasan *et al.*, 2023) (BT + NodeMCU)**	**Proposed System**
Platform	Arduino UNO	Arduino Nano	Arduino Nano	ESP32 + ESP8266
Communication	GSM (SMS only)	Wi-Fi (Blynk)	Bluetooth	Wi-Fi + Blynk + OLED + BT
Sensor Set	Pulse, Flex	Pulse, Temp, Movement	Pulse, Temp, Fall	Pulse, Temp, SpO_2, Accel/Gyro
Alert System	LCD, Audio (basic)	App + SMS fallback	LCD	OLED, Blynk App, LED, Buzzer
Data Update Rate	On request / delayed	2 sec	Not specified	Real-time streaming
Real-Time Monitoring	✗	✓	✗	✓ (Live + Historical)
Average Accuracy	40%–60%	~60%	~50%	80% (Fig. 6)
Power Efficiency	Moderate to High (GSM)	Moderate	Low	High (80–100 mA)
Gesture Complexity	Limited (2–3 gestures)	Not focused	Basic movement	Up to 4 distinct gestures

III. METHODOLOGY

Figure 1 depicts the proposed system which utilises the ESP32 microcontroller, known for its dual-core processor and integrated Wi-Fi and Bluetooth capabilities, in order to process various inputs and provide corresponding outputs. Additionally, for the justification for each sensor placements are carefully described by referring to section 4 with illustration of Figure 3. The primary objective of the system is to keep track of the health status of the paralysed patients. The system uses a pulse oximeter sensor to detect the patient's heart rate in Beats per Minute (BPM), oxygen level via the SpO2 detector, as well as a temperature sensor to track body temperature in order to accomplish this. It has multiple sensors, including the ESP8266 microcontroller for possible extra Wi-Fi connectivity, the MLX90614 infrared temperature sensor for non-contact temperature readings, the MAX30100 pulse sensor for heart rate monitoring, and finally the MPU6050 accelerometer and gyroscope for motion and orientation detection. It is powered by a 6V rechargeable battery. A patient's hand motions, including up, down, left, and right movements, can be deciphered using an MPU6050 sensor. The device can convert these gestures into pre-programmed messages that are shown on an OLED screen by recording their motions and patterns. Patients can express their necessities or messages without using words thanks to this arrangement, particularly those who have restricted movement or speech impairments. By detecting accelerations and gyroscopic motions, the MPU6050 sensor may identify shifts in the patient's hand position or gestures. The system can identify unique hand movements, link them to pre-established codes, and show the associated messages on the OLED screen by putting particular algorithms or gesture recognition techniques into practice. Despite their physical restrictions, this technology gives patients a way to communicate and connect by helping them convey their needs or messages effectively to the caregivers.

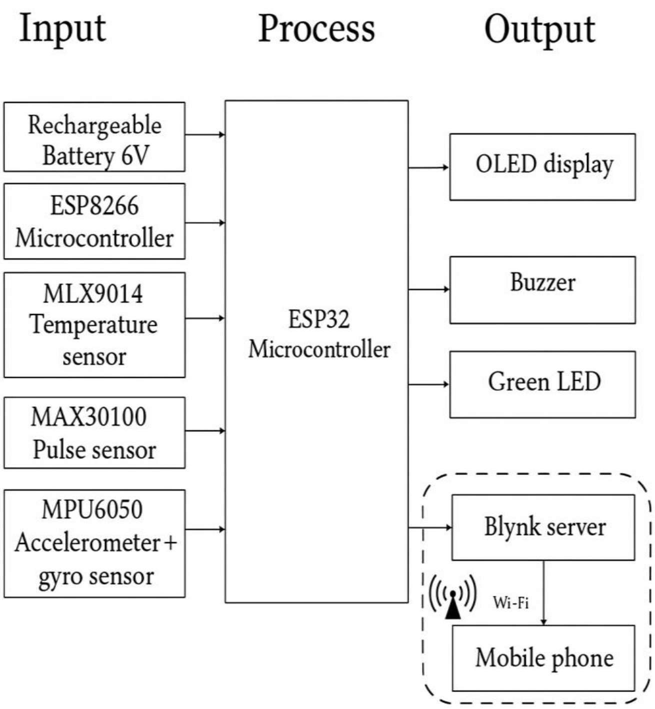

Figure 1. Block diagram of the proposed system

Technically, the gesture recognition algorithm utilises raw accelerometer and gyroscope data captured from the MPU6050 sensor. The data is filtered using a complementary filter to combine accelerometer and gyroscope inputs for more accurate orientation estimation. Preprocessing stage includes noise reduction using a moving average filter. Then, the system segments gestures by identifying peaks in acceleration and angular velocity that exceed predefined thresholds. Each gesture (e.g., up, down, left, right) is classified by comparing vector patterns of motion (ΔX, ΔY, ΔZ) with stored templates. While the current approach uses threshold-based classification for real-time responsiveness, the system uses a threshold-based classification method for gesture recognition. When the MPU6050 detects motion exceeding predefined acceleration and gyroscope thresholds in the X, Y, or Z axes, it maps the motion to one of the four gestures (up, down, left, right). These thresholds were empirically tuned during calibration.

In addition, the ESP8266 sensor, which uses photo plethysmography to identify variations in blood volume within any organ of the body, is coupled to the pulse oximeter of the MAX30100 pulse sensor. Variations in light intensity correlate with these changes in blood volume. The MAX30100 sensor measures the absorption of light at various wavelengths to determine blood oxygen saturation (SpO_2). It estimates the ratio of oxygenated haemoglobin to total haemoglobin in the blood by measuring the difference in light absorbed by oxygenated and deoxygenated haemoglobin using red and infrared LEDs. In order to calculate the heart rate as input signals, this ratio directly converts into a SpO_2 value. The ESP32 processes these detected inputs, then outputs its corresponding data to an OLED display for visual feedback in real time and can activate a green LED or buzzer for alerts, as well. An OLED screen will specifically show the sensor data collected, together with the body temperature, BPM, SpO_2, and motions recognised, respectively. When the data is shown, a buzzer will sound to notify the caregiver if the value surpasses the threshold. When the body temperature falls below 35°C or rises above 37.5°C, the buzzer will sound accordingly. Likewise, if the heart rate drops below 50 bpm or rises above 100 bpm, it will activate. When the heart rate is recognised, a green LED will blink. Furthermore, a Blynk server is connected to the system via Wi-Fi, allowing for remote monitoring via a mobile device. This setup is appropriate for IoT-based healthcare applications since it enables real-time monitoring of health-related indicators and prompt alert production. The system's monitoring versatility is increased by the Wi-Fi connection, which enables remote data access and control and responding to patient needs in real time. Although the ESP32 is capable of handling most functionalities, the ESP8266 was integrated as a dedicated submodule to manage Wi-Fi communication during high sensor load conditions, ensuring uninterrupted data transfer to the Blynk server efficiently. This division of tasks reduces the processing burden on the ESP32, hence enhancing the system responsiveness and stability.

The ESP32 microcontroller and IoT-based paralysis patient healthcare system's operational sequence is illustrated in the flowchart in Figure 2. System initialisation and sensor configuration come first, then a Wi-Fi connection takes into stage to allow for real-time data transfer. After reading temperature sensor data, the ESP32 determines whether the temperature has risen above a predetermined point. If it has, it sounds a buzzer and notifies the Blynk App. If not, it then looks for anomalies in the SpO_2 or pulse levels. When there are no abnormalities, it uses an accelerometer or flex sensor to keep an eye out for hand gesture input or the pressing of an emergency button. The system refreshes the Blynk App dashboard and performs a matching action if a predefined gesture is recognised; if not, it keeps logging all data. To guarantee prompt help and communication for the paralysed patient, the entire procedure is set up to operate in a loop, enabling constant monitoring, data logging, and alerting.

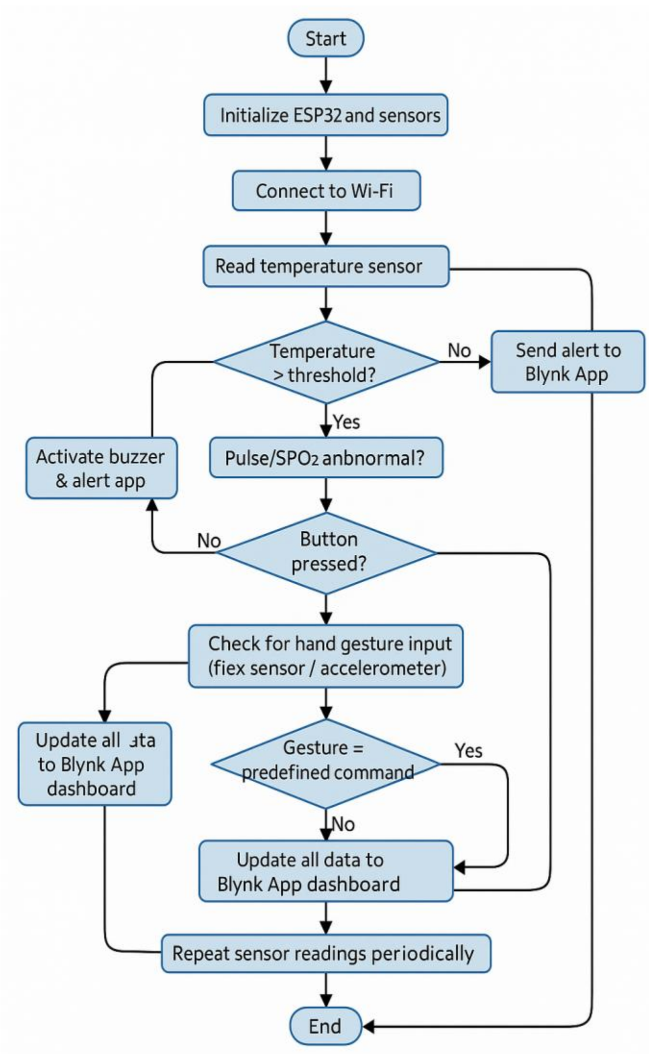

Figure 2. Flow chart of the proposed system

IV. RESULT AND DISCUSSION

The diagram illustrated in Figure 3 presents the integration of ESP32 and ESP8266 microcontrollers alongside a suite of sensors such as the MAX30100 pulse oximeter, MLX90614 temperature sensor, and MPU6050 gyroscope and accelerometer which showcased a highly efficient glove-based system. This combination facilitated seamless data capture and transmission. The synchronised operation of these components allowed for the accurate collection of pertinent information. Upon detection through the MLX90614, MAX30100, and MPU6050 sensors, the OLED screen sequentially presented critical details including the patient's name, body temperature, gesture messages, BPM, and SpO_2 values, thus offering a user-friendly interface for real-time vital sign monitoring. Apart from that, the Figure 3 also presented the placement strategy prioritises measurement accuracy, signal integrity, user accessibility, and system reliability. By physically separating sensing, processing, and alert components, the design minimises interference while supporting robust real-time monitoring and repeatable operation. The sensors and modules are strategically positioned to maximise measurement accuracy, signal integrity, and user accessibility while ensuring reliable system operation. The MLX90614 is placed externally and unobstructed to enable accurate non-contact infrared temperature sensing without thermal interference from nearby components. The MAX30100 is located at an accessible edge to allow direct finger contact, ensuring reliable photoplethysmography (PPG) for heart rate and SpO_2 measurements with minimal motion artefacts. The MPU6050 is positioned away from vibration sources to accurately capture intentional gestures and motion dynamics. The OLED display is mounted at a visible angle to provide immediate visual feedback of physiological data and system status, while the buzzer is placed externally to ensure audible alerts are clearly heard during emergency conditions. The green LED is located near the main controller to serve as a quick visual indicator of system operation. The ESP32, acting as the primary controller, is centrally placed to minimise wiring length and enhance processing efficiency, whereas the ESP8266 is positioned nearby to support communication offloading and improve network reliability. Collectively, this placement strategy reduces interference, improves usability, and supports robust, repeatable real-time patient monitoring.

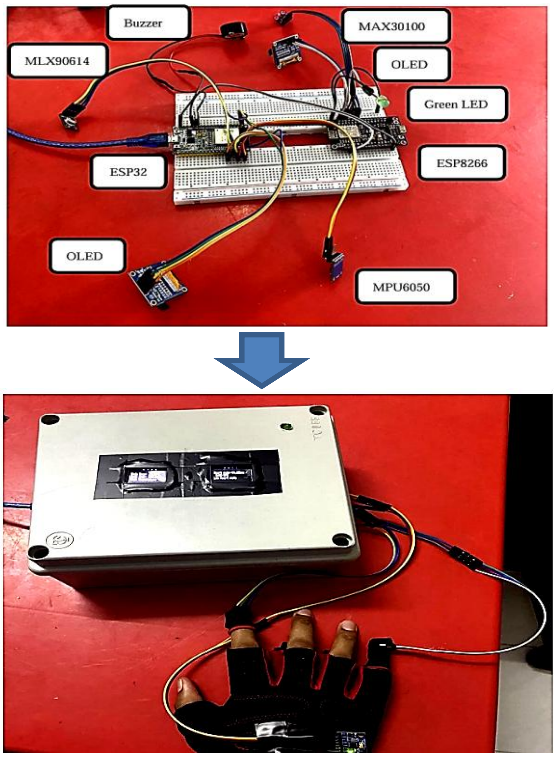

Figure 3. Full hardware prototype

The customisable interface system as depicted in Figure 5 empowers users to configure the dashboard layout and establish personalised alerts, aligning the system precisely with their specific requirements or preferences for a tailored user experience. Refer to the Figure 5(a) illustrates the real-time body temperature monitoring interface of the patient. The circular gauge displays the instantaneous temperature value (29.49 °C), while the line graph below shows the temperature trend over time, enabling observation of gradual variations. The buzzer status indicator is included to provide a visual cue for alert activation when abnormal temperature thresholds are exceeded. In this instance, the stable temperature trend and inactive buzzer indicate a normal physiological condition without emergency alerts. Next is the Figure 5(b) presents the accelerometer sensor readings used to detect patient movement. The semi-circular gauges represent acceleration magnitudes along different axes, allowing the system to interpret motion intensity and direction. The accompanying graph labelled BuzzerStateAccelerometer shows the alert response triggered by movement patterns over time. The buzzer state is currently shown as OFF, confirming that the detected motion remains within predefined safe thresholds and does not require immediate attention. Follow by that is the Figure 5(c) depicts the heart rate monitoring module, where the circular indicator shows the current heart rate value of 50 BPM, and the time-series graph illustrates BPM fluctuations over extended periods. This representation enables both instantaneous assessment and long-term trend analysis of cardiovascular activity. The relatively consistent pattern suggests a stable cardiac condition, while the system remains capable of issuing alerts if abnormal BPM thresholds are detected. Thereafter is the Figure 5(d) shows the SpO_2 monitoring interface, which provides a clear and intuitive visualisation of blood oxygen saturation levels. The gauge displays a value of 95%, indicating adequate oxygenation. This parameter is critical for detecting hypoxemia in paralysed or immobilised patients. The dashboard presentation allows caregivers to quickly assess respiratory health, with alert mechanisms configured to trigger if SpO_2 values fall below safe limits. While in Figure 4, it showcases the corresponding system notifications which collectively serve as a comprehensive communication and monitoring system for a paralysis patient, allowing them to signal emergencies, express basic needs, and monitor health parameters even with limited physical ability.

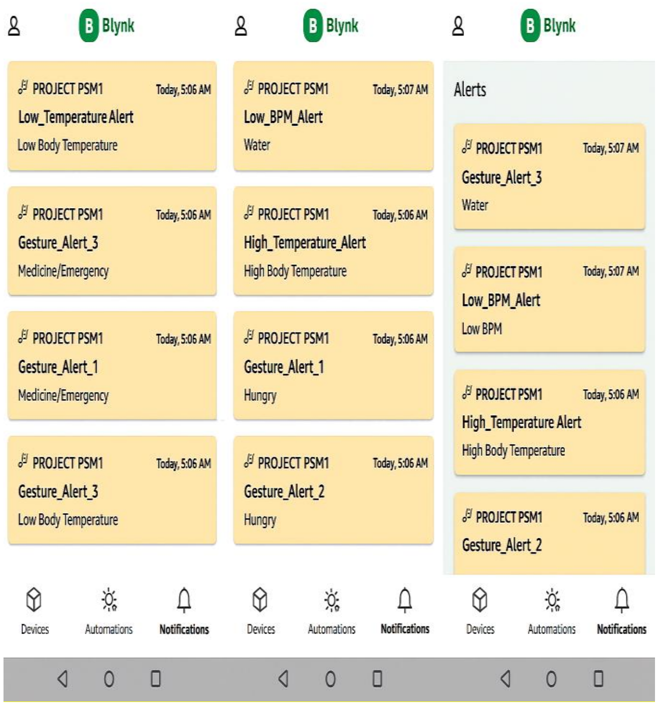

Figure 4. Sample of Blynk Notification

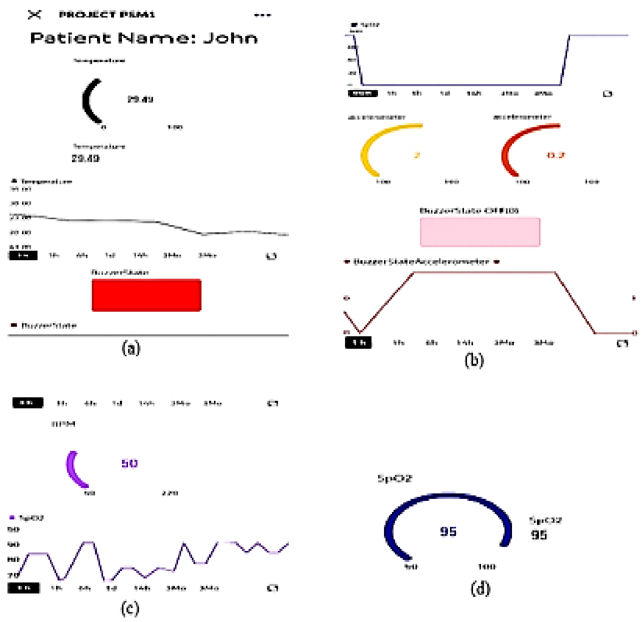

Figure 5. Blynk Graphical user interface of remote monitoring

The graph in Figure 6 shows that the proposed method consistently delivers higher accuracy across all trials, maintaining an accuracy level around 80%, while the previous method in (Shanmugamuraj *et al.*, 2023) experiences a noticeable dip in accuracy around the second trial and generally performs between 40% and 60% throughout accordingly. This is because the ESP32 and ESP8266 in the proposed method offer superior energy efficiency through built-in Wi-Fi, Bluetooth, and advanced power-saving modes, while providing higher accuracy with faster processing capabilities and real-time data handling. This eventually outperformed the Arduino Nano used in the previous benchmarking method which lacks integrated wireless modules and advanced power management.

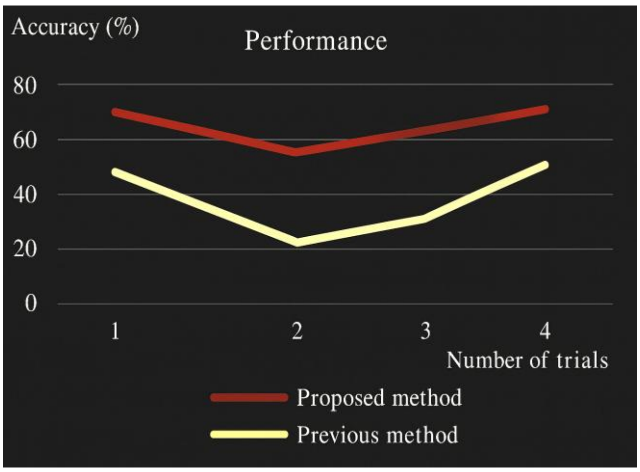

Figure 6. System performance accuracy

While referring to Figure 7 that showcases other system performance testing of the developed IoT-based paralysis healthcare system, it shows that the proposed system demonstrated strong performance in terms of responsiveness and energy efficiency. The average latency measured from gesture input to output response (display or alert) was between 180–220 milliseconds, suitable for real-time interaction. In comparison, traditional Arduino Uno-based systems using GSM modules (e.g., SIM900A) exhibited higher latency, averaging 350–400 milliseconds due to slower processing and overhead in GSM communication (Kate *et al.*, 2022). Similarly, Arduino Nano systems paired with ESP8266 Wi-Fi modules showed latency of 300–350 milliseconds with higher power draw owing to limited processing capability and external module overhead (Faisal *et al.*, 2019). In terms of power consumption, the proposed ESP32-based system operated at 80–100 mA, enabling a battery life of 12–14 hours on a full charge, outperforming the GSM- and ESP8266-based solutions, which typically operate at 120–150 mA with shorter battery cycles. These improvements are due to the ESP32's integrated Wi-Fi/Bluetooth modules and advanced sleep modes.

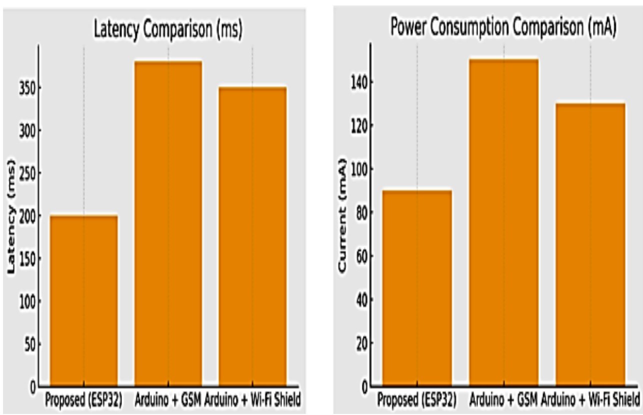

Figure 7. Related system performance testing

In the meantime, the glove-based IoT healthcare system for paralysis patients was tested through simulated patient scenarios as shown in Table 2 to validate its practical functionality. Using accelerometers embedded in gloves, the system accurately detected directional gestures, such as upward for "Emergency/Medicine", leftward for "Hungry", rightward for "Water", and downward for "Washroom". This were carried out by interpreting variations in X and Y-axis values. These gestures triggered corresponding alerts in the Blynk application and activated the buzzer signals, thus providing real-time notifications. The MAX30100 pulse oximeter and MLX90614 temperature sensors recorded critical vital signs like BPM and body temperature. Alerts were reliably generated when thresholds were breached (e.g., <35°C or >37.5°C, BPM <50 or >100). The accuracy of gesture recognition and sensor performance was consistent when tested across multiple trials. Although real patients were not involved, the tests with simulated input closely reflected the use-case conditions, demonstrating robust gesture identification, fast alert transmission, and high responsiveness. This confirms the system's readiness for preliminary deployment in home-based care environments.

Table 2. Simulated scenarios of Field testing

Gesture Type	X-Axis Value	Y-Axis Value	Alert Triggered	Buzzer State	Temperature (°C)	BPM	System Response
Medicine/Emergency	+2.4	+9.5	Gesture_Alert_1	1	36.5	95	Alert sent to caregiver
Hungry	-4.4	-10.0	Gesture_Alert_2	1	37.6	88	Blynk notification
Water	+9.6	+2.4	Gesture_Alert_3	1	36.8	102	High BPM alert sent
Washroom	-9.3	-0.1	Gesture_Alert_4	1	34.8	48	Low temp & BPM alert
No Movement (Idle)	-0.9	-0.4	No Alert	0	36.2	76	No alert generated

Lastly, the Table 3 summarises the evaluation results, confirming consistent and error-free system functionality. Although the sampling is limited, these preliminary findings provide insights into the system's functionality and performance improvement, thus laying the foundation for understanding its operation accordingly under current conditions. The prototype consists of 26 distinct functional operations. Repeatability testing over 10 trials (260 total function executions) recorded zero functional failures, resulting in a measured functional error rate of 0%.

Table 3. Repeatability test

Trial	Total functional Operations	Detected errors	Functional error rate (%)
1	26	0	0
2	26	0	0
3	26	0	0
4	26	0	0
5	26	0	0
6	26	0	0
7	26	0	0
8	26	0	0
9	26	0	0
10	26	0	0
11	26	0	0
12	26	0	0
13	26	0	0
14	26	0	0
15	26	0	0

V. CONCLUSION

The developed IoT-based healthcare system with hand gesture recognition using ESP32 has proven to be a practical and efficient solution for assisting paralysis patients. Its high average accuracy of 80% was 20 to 40% greater than that of previous approaches, which ranged from 40 until 60%. Three vital health indicators, which are blood oxygen level (SpO2), heart rate (BPM), and body temperature are successfully tracked by the system in real time environment. In order to help patients, express their essential needs without speaking, it also supports four different hand gestures: up, down, left, and right, respectively. When problematic health readings are recognised, such as a temperature above 37.5°C or a BPM above 100, alerts are instantaneously triggered, guaranteeing a prompt reaction through the OLED display and mobile app. It is economical and appropriate for home care since it uses inexpensive parts like sensors and an ESP32. All things considered, this system provides a straightforward, precise, and affordable healthcare option that improves patient safety and freedom. Future enhancements will include machine learning models such as Support Vector Machines (SVM) or Convolutional Neural Networks (CNNs) trained on gesture datasets to improve recognition accuracy and handle more complex gestures. In addition, will involve comprehensive experimental validation with real users and large-scale testing, including long-term testing to evaluate battery life and system robustness across diverse environments.

VI. ACKNOWLEDGEMENT

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