Sustainable practices for semi-paralysed people using gesture-link paralysis glove

Arelli Madhavi[1*], *Dukkipati* Likithasree[1], *Sai Deepika* Palacharla[1], *Deevi Sri* Sai Vynika[1], *Muntather* Almusawi[2], Manjunatha[3], *Amit* Dutt[4] and *Ashish* Parmar[5]

[1]Department of AIMLE, GRIET, Hyderabad, Telangana, India.
[2]The Islamic university, Najaf, Iraq
[3]Department of Mechanical Engineering, New Horizon College of Engineering, Bangalore, Karnataka, India
[4]Lovely Professional University, Phagwara, Punjab, India.
[5]Lloyd Institute of Engineering & Technology, Knowledge Park II, Greater Noida, Uttar Pradesh, India.

Abstract. The work addresses the communication barriers experienced by semiparalyzed individuals through the introduction of the "paraglove," a cuttingedge wearable device leveraging Internet of Things (IoT) technology. The paraglove is equipped with flex sensors, seamlessly integrated into the glove, and connected to an ESP32 microcontroller board. The flex sensors detect minimal hand gestures, allowing users to signal for crucial activities such as eating, restrooms, and signalling for emergencies. Through IoT, these gestures are translated into text messages, a process facilitated by the ESP32 microcontroller. The resulting text data is then stored and continuously updated within Google Firebase. To ensure seamless communication, the paraglove utilises the Kodular Companion application. The sustainable information is transmitted to family members or guardians through the application, enhancing the connectivity and support system for individuals with paralysis. The integration of an OLED display sensor directly on the glove provides users with real-time feedback by presenting the interpreted output. The combination of flex sensors, ESP32 microcontroller, IoT technology, Google Firebase, and Kodular Companion application simplifies communication for those facing paralysis and empowers them to engage with the world more effectively. This technological solution addresses the immediate communication needs and contributes to the overall well-being of individuals with paralysis.

1 Introduction

Paralysis is a debilitating condition characterised by the loss of muscle function and control, often caused by damage the nervous system. It profoundly impacts individuals' lives, limiting

* Corresponding author: arelli.madhavi1988@gmail.com

their mobility, independence, and overall quality of life. Paralysis can result from various causes, including spinal cord injuries, strokes, traumatic brain injuries, or neurological disorders. The loss of the ability to move and control one's body hinders daily activities and poses emotional and psychological challenges for individuals and their families.

Paralysis disrupts the normal functioning of the body, impeding the execution of routine tasks that may take for granted. Simple actions such as walking, reaching for objects, or even turning in bed become arduous challenges.

In the realm of medical technology, the Internet of Things (IoT) stands as a transformative force with the potential to sustainably improve the lives of individuals suffering from paralysis significantly. IoT involves the interconnection of devices through the internet, enabling seamless communication and data exchange. The connectivity can be harnessed to create innovative and sustainable solutions that address the specific challenges faced by those with paralysis enhancing their overall well-being.

IoT has the potential to revolutionise the lives of individuals living with paralysis by introducing smart, adaptive solutions that enhance mobility, communication, and overall independence. As technology continues to advance, the integration of IoT in healthcare promises a future where individuals with paralysis can lead more fulfilling lives, breaking down the barriers imposed by their physical limitations. The combination of innovation and compassion through IoT applications holds the key to improving the quality of life for those facing the challenges of paralysis.

The paper is structured as follows: Section 2 provides a comprehensive literature review. Section 3 provides a comparative analysis of the existing approaches. In Section 4, we delve into the components utilized in designing the proposed system. A block diagram outlining the proposed system, accompanied by a concise explanation of the methodology through a flowchart, is presented in Section 5 and Section 6. Section 7 discusses the result analysis. The concluding remarks of the paper, along with future work considerations, are outlined in Section 8.

2 Existing methods

A Graphical User Interface (GUI) was created with the collaboration of Visual Studio (VS) and the Camera Mouse system. The targeted users for this interface are individuals with impairments who have undergone training on the Camera Mouse System before using the program.

Hand gesture recognition technology finds widespread applications in various domains, including the control of mouse and keyboard functionalities, operation of mechanical systems, manipulation of virtual objects, navigation in virtual environments, human/robot interaction, and remote instructional communication. The paper proposes a real-time hand gesture recognition system comprising three stage which are image acquisition, feature extraction, and recognition. Utilizing a digital camera for capturing hand gesture images, the system employs a moment feature extraction method and a neural network for gesture

recognition. Performance testing conducted on actual data demonstrated satisfactory results in hand gesture recognition.

The objective proposed is to develop a compact and user-friendly home automation device utilizing an eye blink sensor. This device aims to control household electrical appliances efficiently, contributing to the reduction of energy wastage. Additionally, it empowers paralyzed individuals to independently manage lighting and fans without external assistance, thereby addressing the ongoing need to improve the daily living conditions of such patients and individuals.

This challenge is particularly pronounced for users with corrective lenses, impacting their ability to focus on the screen. Consequently, further research is necessary to enhance the user-friendliness and accessibility of EyeCom. The system features an infrared detector positioned in front of the eye, illuminating the eye region. The reflected infrared light, carrying electrical signals, is disrupted when the eyelids close, and the change in reflected value is recorded. EyeCom emerges as a valuable tool, enabling individuals with paralysis to actively contribute to the technological world and engage in various tasks independently, from reading newspapers on the computer to utilizing word-to-voice software.

Individuals with disabilities who rely on sign language for communication often face challenges in conveying their messages to non-disabled individuals. In IoT-based Smart Assistance Gloves for Paralyzed People, a novel smart glove has been developed to facilitate the transformation of hand gestures into prerecorded speech, providing a valuable communication tool, particularly for those with paralysis who are unable to vocalize. The smart glove is complemented by a mobile application and message display, enabling users to transmit messages through the Internet of Things (IoT) using gestures instead of traditional sign language. This innovative feature enhances understanding and facilitates appropriate responses from others. The main objective of this proposed method is to create a lightweight, dependable, and user-friendly smart hand glove system, breaking down barriers for individuals with paralysis and enabling their participation in various activities. The system incorporates voice-based hardware, RF modules, and Arduino boards.

3 Proposed method

3.1 Architecture diagram

The proposed idea depicts a special glove that aims to help people with partial paralysis communicate their basic needs more easily. The glove uses finger gestures to streamline communication, and it has integrated sensors that can detect and interpret specific finger movements. To achieve gesture recognition, we have included five flex sensors inside the glove that track changes in resistance associated with finger movements. Each of these sensors generates unique values based on finger flexion, which allows us to identify and interpret specific gestures accurately. Moreover, we have set predefined threshold values for each flex sensor to enhance the accuracy of gesture recognition.

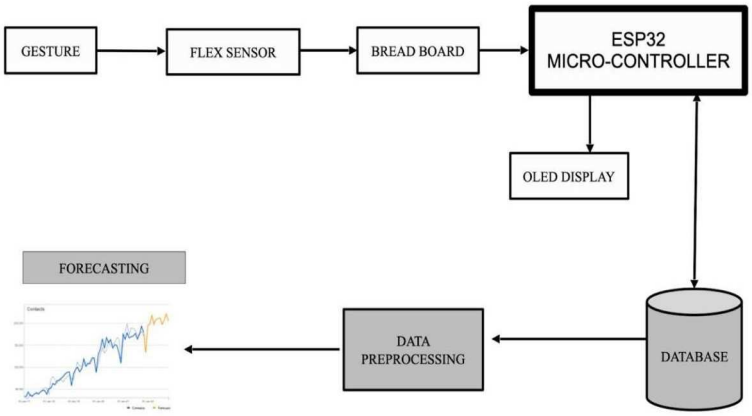

Fig. 1. Proposed system's Architecture diagram

Once the system recognizes a gesture, it sends out alerts through an OLED sensor display and provides voice and text output within the Kodular Companion app in Figure 1. Caretakers can immediately access the information displayed on the OLED text, allowing them to respond promptly to the needs of the paralyzed individual. In situations where the caretaker is not nearby, the voice and text output in the Kodular app become handy tools for remotely monitoring the requirements of the paralyzed individual. The usage of Google Firebase for communication and data transmission, ensuring real-time updates and easy access to information within the Kodular app.

3.2 Proposed methodology:

The ESP32 microcontroller is effectively linked with flex sensors to continuously monitor finger movements for gesture identification, catering to the specific needs of paralyzed individuals. Flex sensors capture gestures, and the data is seamlessly transmitted to Google Firebase through the ESP32's integrated WiFi module. This IoT application is further enhanced with an OLED sensor integrated into the glove, enabling real-time display of the paralyzed person's requirements. This comprehensive Integration empowers paralyzed individuals to communicate their basic needs effortlessly. The modular system optimally divides functionalities, with flex sensors capturing gestures, ESP32 handling data transfer, Google Firebase storing information, and the OLED sensor providing on-the-spot feedback, collectively forming a holistic solution for efficient communication and assistance.

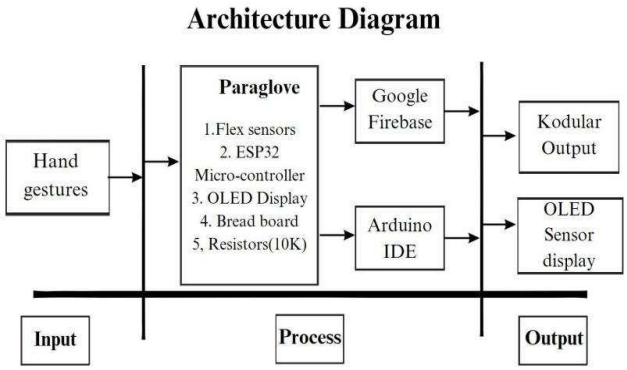

Fig. 2. Architecture diagram.

Module 1: Sensors Input and Processing

In Module 1, Flex sensors on gloves change resistance with finger movement, interfacing with an ESP32 in an Arduino circuit. The ESP32 processes analogue signals, reflecting finger flexion degrees. In the Arduino IDE, the Serial Monitor observes and interprets these resistor values crucial for gesture recognition as shown in Figure 2. Establishing thresholds for each gesture, the ESP32 communicates with the Arduino IDE, updating the Serial Monitor in real time. The mentioned dynamic loop enables continuous monitoring, forming the foundation for gesture recognition within the system.

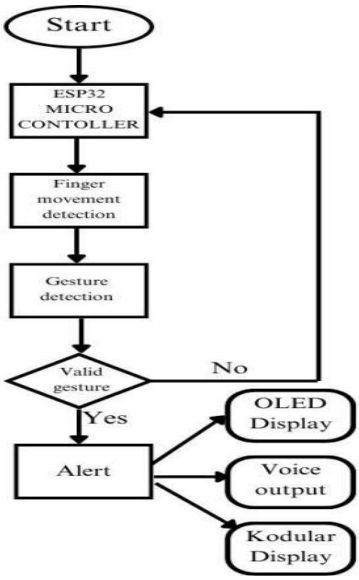

Fig. 3. A Block Diagram

Module 2: Gesture Recognition

The input stage in the architecture is pivotal for recognizing four user gestures. Gesture-1 signifies a request for food, while Gesture-2 indicates a need for water. Gesture-3 represents a request to use the washroom, and Gesture-4, symbolising a rock, signals a need for urgent or emergency care. Each gesture is visually depicted in Figures forming the foundation for subsequent data processing in the architecture diagram in Figure 3.

ESP32 captures finger flexion resistances, processes analogue signals, and sets gesture-specific thresholds in the Arduino IDE. Recognised gestures trigger wireless transmission via Wi-Fi or Bluetooth. The Arduino IDE's Serial Monitor aids in debugging and monitoring, while the receiving end interprets transmitted data for actionable insights, showcasing the system's adaptability in various applications, from human-computer interaction to robotics and assistive technology.

(a) (b)

Fig. 4 (a) Gesture 1 and **(b)** Gesture 2

(a) (b)

Fig. 4 (c) Gesture 3 and **(d)** Gesture 4

Module 3: Cloud Transmission

The ESP32 captures and interprets gesture data, transmitting it to Google Firebase through Wi-Fi. Configured with appropriate credentials, the ESP32 sends formatted HTTP requests to the Firebase API, updating the realtime database with recognised gestures as shown in Figure 4(a), (b), (c), (d). This bidirectional communication facilitates seamless integration, allowing continuous updates and accessibility from various platforms. The Firebase database acts as a dynamic repository, enhancing the system's versatility for analysis, visualisation, and integration. Additionally, an OLED display on the glove provides visual feedback, improving user awareness and creating an interactive communication experience.

Module 4: Output
Recognized gestures yield a multi-modal output: visual feedback on an OLED screen, voice output via Kodular Companion's text-to-speech, and detailed text messages in the Kodular Companion app. The OLED screen provides immediate visual feedback, the Kodular Companion delivers spoken confirmation, and the app displays detailed text representations. This multi-modal system ensures a comprehensive user experience, accommodating diverse preferences and enhancing interaction with the gesture recognition system.

3.3 Modules and their description

3.3.1. Flex sensors:

Purpose: Flex sensors are crucial for detecting the hand gestures of semi-paralyzed individuals. These sensors measure the degree of bending or flexing in the fingers or hand.
Function: Translates hand gestures into electrical signals that can be processed by the microcontroller

3.3.2. ESP32 microcontroller:

Purpose: Serves as the brain of the Paraglove, responsible for processing the signals from the flex sensors and controlling the overall functionality of the device.
Function: Processes hand gestures, notifies family via Google Firebase, and controls OLED screen display.

3.3.3. OLED display:

Purpose: Provides real-time feedback to users, displaying information about the detected hand gestures or conveying important messages. Function: Displays relevant information and feedback, enhancing the user experience and interaction with the device as in Figure 5.

Fig. 5. OLED screen

Fig. 6. Resistors

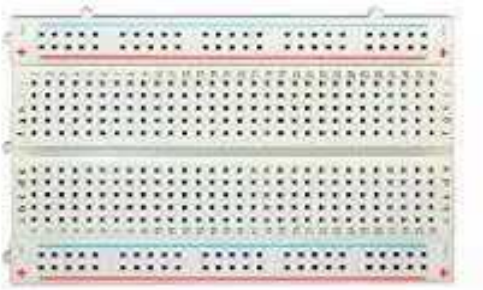

Fig. 7. Breadboard

3.3.4. Breadboard:

Purpose: Used for prototyping and testing the electronic circuit in Figure 7.
Function: Facilitates electronic component connection and arrangement in development.

3.3.5. Resistors (10K):

Purpose: Stabilises and controls the flow of electric current in the circuit in Figure 6.
Function: Limits current through the flex sensors and other components.

4 Results

Experimental results for the project are observed on platforms like Arduino IDE's Serial Monitor, Google Firebase's Realtime Database, and ESP32 microcontroller's OLED sensor, and Kodular Companion App on a mobile phone. These platforms display updated flex sensor values and text, ensuring alignment with desired outcomes. Results are continually updated every three seconds, as set in the Kodular application.

4.1 Output from the serial monitor:

The Serial Monitor is a window that shows us the values of the flex sensor, which happens because the flex sensor's resistance changes. The whole idea behind recognizing gestures is based on these changes in resistance. The Serial Monitor can be found at the top right corner

of the Arduino IDE. After uploading the code into the ESP32 microcontroller, you just click on the Serial Monitor icon. It opens up and displays the flex values for each of the five fingers, along with the text intended for Firebase and the OLED sensor.

4.2 Output from the realtime database:

In the real-time database, we can see the text changing as we make different gestures. It works by creating a "Key" under the URL, where the key represents the specific text corresponding to our recognized gesture. When the text gets updated, the database highlights that section and switches the text to match the new gesture. So, it's like a basic setup where we have a Key associated with a particular Value, and that Value changes to show the recognized gesture's text.
gesture: Text Value
The "gesture" here is included in the Arduino IDE code and thus it is created once the project code is uploaded to the ESP32. The data is continuously updated in a real-time database.

4.3 Output from the OLED sensor:

The little OLED sensor acts like a tiny screen where you can see text messages. It's connected to the ESP32 microcontroller through soldering. The function display.print(F(" ")) is used to update the text in the sensor. To initially show any text on the sensor, we use the OLED Init() function. Both of these functions work together to make the text appear on the sensor display asin Figure 8.

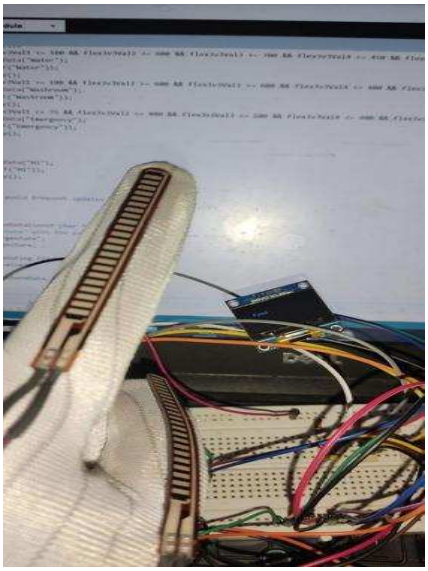

Fig. 8. Output from the OLED sensor

4.4 Output from kodular and kodular Companion:

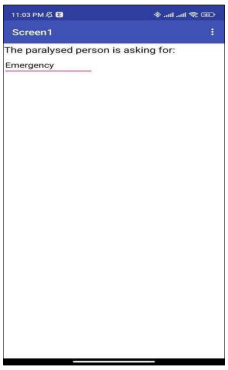

Fig. 9. Output from Kodular and Kodular Companion

4.5 Overall results:

The comprehensive outcomes of the model reflect the overall achievement observed upon project completion. A direct assessment indicates a congruence between the anticipated output and the actual output, demonstrating the successful fulfilment of the proposed method's objectives by the prototype model as in Figure 11. The entire configuration yields outputs from three modules: Modular Companion, Google Firebase, and the OLED sensor. Enclosed are screenshots showcasing the outputs from all modules, substantiating the accomplishment of the proposed method's objectives and requirements.

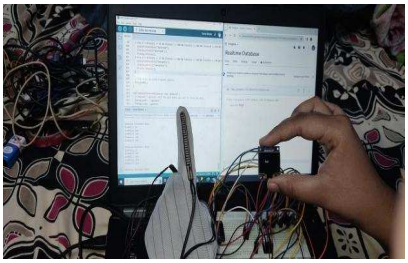

Fig. 10. Output 1

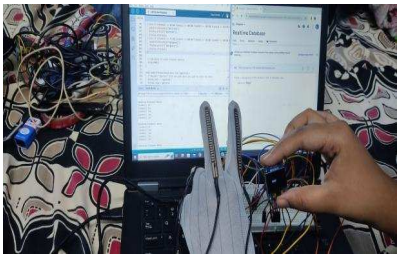

Fig. 11. Output 2

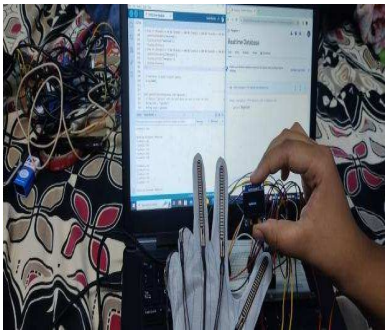

Fig. 12. Output 3

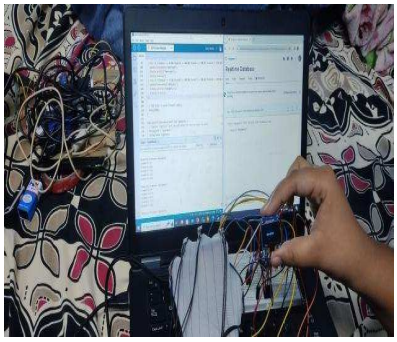

Fig. 13. Output 4

5 Conclusion and future enhancements

The "Paraglove," a revolutionary IoT-enabled wearable with flex sensors, overcome communication barriers for semi-paralyzed individuals. Using an ESP32 microcontroller and Google Firebase, it translates hand gestures into text messages, providing seamless communication with real-time feedback on an OLED display as in Figures 10, 11, 12, and 13. Beyond communication, Paraglove simplifies daily tasks, promoting independence. Future enhancements, like monitoring heartbeat and BP, signify a forward-looking approach to revolutionise assistive technology, promising greater well-being. This groundbreaking project emphasises inclusivity and empowerment for those with mobility limitations in a concise and impactful manner.

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