

GESTURE BASED ASSISTIVE COMMUNICATION SYSYTEM

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Abstract - Paralysis severely limits a patient's ability to communicate basic needs, creating a need for reliable assistive technologies. This paper presents a Gesture-Based Assistive Communication Smart Glove designed to enable paralysis patients to convey messages through simple hand gestures. Flex sensors are used to detect finger movements, while an ESP32 microcontroller processes the sensor data and maps gestures to predefined text messages. These messages are transmitted via Wi-Fi using a web server and displayed on the caregiver's mobile phone for immediate assistance. The system focuses on a low-cost, portable design that improves patient independence and enhances caregiver responsiveness. The proposed solution provides an effective communication aid for individuals with mobility impairments.

1. INTRODUCTION

Paralysis is a medical condition that results in the loss of muscle function in parts of the body, significantly affecting a patient's ability to communicate and perform daily activities independently. Individuals suffering from paralysis often face difficulty in expressing their basic needs, such as requesting food, water, or assistance, which can lead to discomfort and delayed care. Traditional communication methods for such patients rely heavily on constant caregiver presence or complex assistive devices, which may be expensive, difficult to operate, or inaccessible in resource-limited settings.

Advancements in embedded systems and wearable technology have enabled the development of affordable assistive devices that enhance patient independence and caregiver responsiveness. Gesture-based communication systems, in particular, provide an intuitive and efficient way for patients to convey messages using simple hand movements. By detecting finger bending patterns through flex sensors and processing the data using a microcontroller, meaningful text messages can be generated and delivered to caregivers in real time.

This project proposes a Gesture-Based Assistive Communication Smart Glove that utilizes flex sensors to detect hand gestures and an ESP32 microcontroller to process the sensor data. The recognized gestures are mapped to predefined text messages and transmitted via Wi-Fi using a web server, allowing caregivers to view the messages on their mobile phones instantly. The system is designed to be low-cost, portable, and easy to use, making it suitable for continuous assistance in home and healthcare environments.

The proposed solution aims to improve the quality of life for paralysis patients by enabling reliable communication, reducing dependency on caregivers, and ensuring timely assistance through simple and effective technology.

2. LITERATURE REVIEW

1. Gesture Recognition System Using Flex Sensors

Author: Deli Feng, Cheng Zhou, Jipeng Huang, Gangyin Luo, and Xin Wu

The paper proposes a wearable gesture recognition system that captures finger bending and hand movements using flex sensors and an inertial sensor. The system integrates a smart glove, Bluetooth communication, and an Android application to convert gestures into readable outputs. An LSTM-based deep learning model with transfer learning enhances recognition accuracy and adapts to different users. Experimental results show over 92–94% accuracy for both static and dynamic gestures, proving the system is reliable, portable, and useful for improving communication for hearing-impaired individuals.

2. GSM-Based Smart Glove for Gesture Recognition and Health Monitoring

Author: K. N. Rajesh, P. Keerthana, M. Priyadharshini, and S. Vignesh

This paper presents a smart glove designed for paralysis patients that combines gesture recognition with health monitoring. Flex sensors detect hand movements to communicate predefined messages via GSM, while integrated sensors monitor vital parameters such as heart rate and body temperature. The system provides real-time alerts and remote communication, offering an affordable and portable assistive solution to improve patient safety, independence, and caregiver support.

3. Head Gesture Recognition System Using Gesture Cam

Author: R. T. Bankar, S. S. Salankar

Through the use of a Gesture Cam, the system captures pictures and employs computer vision techniques to identify head movements. The system is designed to assist individuals with disabilities who are paralyzed from head

movement by using facial recognition methods such as the Viola-Jones algorithm. This involves taking photographs of an individual's head and identifying its location in various ways when it is turned left, right or forward. It comprises three primary parts: image capture and gesture recognition, as well as motion detection algorithms like accelerometers and tactile sensors.

4. IoT Translator for Sign Language Based on Glove

Author: S. Mathupriya, D. Roopa, M. Subashini

This research presents an IoT-based system that translates sign language gestures into voice output using a smart glove. The system is designed to help people with hearing and speech disabilities communicate with others who do not understand sign language. The smart glove is equipped with ADXL335 accelerometer sensors that detect hand movements and finger gestures. These sensor signals are processed using an Arduino microcontroller and transmitted through a Bluetooth module to an Android device, where the gestures are converted into voice messages. The proposed system can recognize multiple gestures with high accuracy and provides an efficient, low-cost communication solution for speech-impaired individuals. It also demonstrates the potential of integrating IoT devices with assistive technologies to improve communication and accessibility.

5. Modelling of Sign Language Smart Glove Based on Bit Equivalent Implementation Using Flex Sensor

Author: Nitin Thoppey Muralidharan et al.

This paper presents a smart glove developed to help people with speech and hearing impairments communicate more easily with others. The glove uses five flex sensors placed on the fingers to detect hand movements and gestures. These sensor signals are processed by an Arduino Uno, which converts the gestures into text messages that can be displayed on a screen. The system works in two modes: one for commonly used phrases and another for alphabets, allowing users to express both simple messages and complete words. Since the system uses only flex sensors, it is simple, low-cost, and easier to implement compared to camera-based gesture recognition systems. This smart glove can make communication more convenient and effective for people who rely on sign language.

3. METHODOLOGY

The developed Gesture based assistive communication system with health monitoring was built using a structured design. In the starting system requirements were analyzed and suitable literatures were reviewed to find suitable technologies. Flex sensors were developed into a wearable glove to record the movement of fingers, here ESP32 was used as the main micro controller for data collection,

processing it and for wireless communication. In health monitoring it includes the sensors MAX30102 for heart rate and SpO2 measurement and LM35 for the temperature measuring, these both sensors are interfaced with the main microcontroller. The collected data were processed using the predefined gesture recognition algorithm and linked to corresponding messages. The web-based interface was proposed to display the detected hand gesture along with the real-time health parameters. The completed system was tested to evaluate accuracy, responsiveness and consistency.

Implementation methodology block diagram.

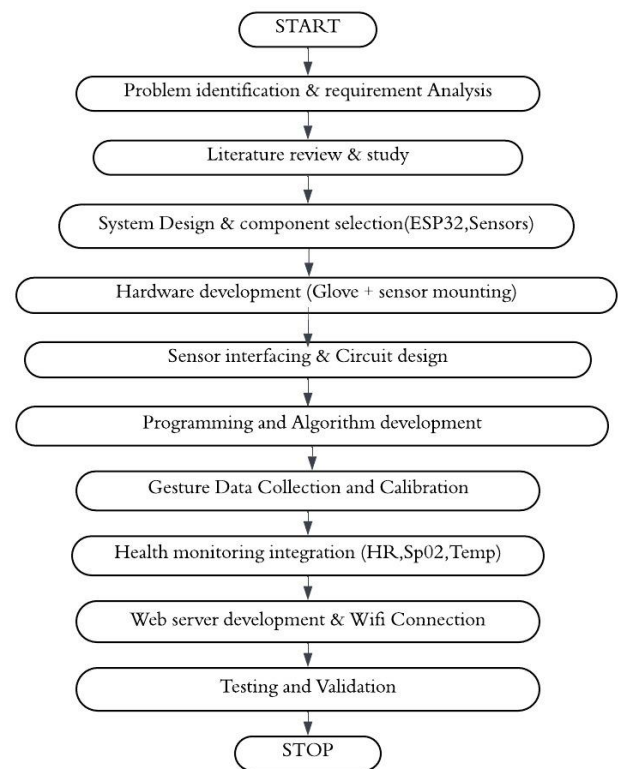


Fig 1: Methodology

4. SOFTWARE INTERFACE

[1]. Data set creation

A customized dataset was created to train the gesture recognition model using signals obtained from flex sensors attached to the glove. The data collection was conducted with the participation of 25 individuals who performed a predefined set of hand gestures using four fingers: index, middle, ring, and little fingers. The flex sensors placed on these fingers measure the bending of each finger and produce analog signals according to the level of finger movement.

These analog signals were read by the ESP32 microcontroller through its analog input pins and converted into digital values using the built-in Analog-to-Digital Converter (ADC). Each gesture generated a unique pattern of

sensor readings depending on the bending positions of the fingers.

The obtained sensor values were then manually recorded in an Excel sheet for further analysis and processing. In the dataset, each row represents a single gesture instance, while the columns store the values from the four flex sensors corresponding to the four fingers. An additional column was used to label each gesture (such as a, b, c, and d), allowing the machine learning model to associate specific sensor patterns with their corresponding gestures.

To enhance the robustness of the dataset, multiple samples of each gesture were collected from all participants. This helps capture variations in hand movements and finger flexibility among different users. The finalized and labeled dataset was subsequently used to train and test the LSTM-based gesture recognition model, enabling the system to learn gesture patterns and accurately classify different gestures.

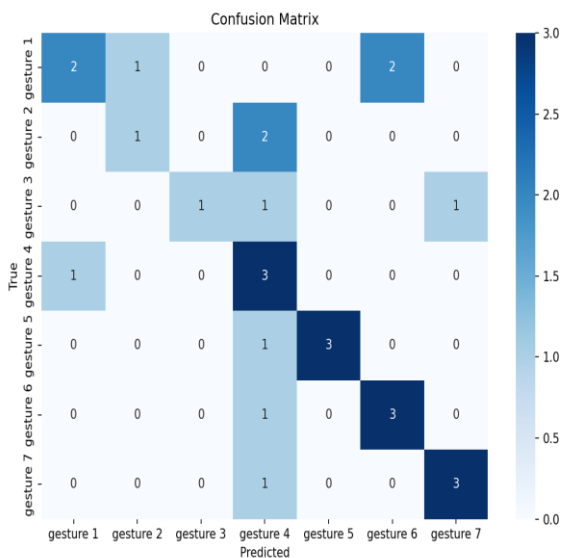


Fig 2:Confusion matrix

The effectiveness of the gesture recognition model was assessed using a confusion matrix. This matrix presents a comparison between the actual gesture classes and the gestures predicted by the model. The values along the diagonal indicate correctly recognized gestures, whereas the values outside the diagonal represent incorrect classifications. The results indicate that the majority of gestures were accurately identified, confirming the reliability of the proposed gesture recognition system.

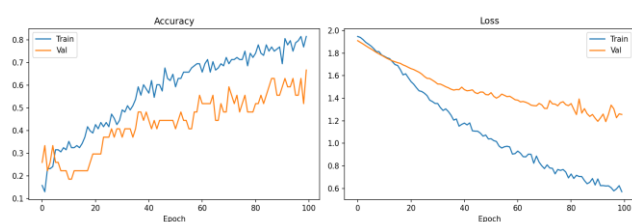


Fig Training and validation

The figure shows the training and validation performance of the gesture recognition model over multiple epochs. The accuracy graph indicates that both training and validation accuracy increase gradually, showing that the model learns gesture patterns effectively. The loss graph shows a decreasing trend, indicating that the prediction error reduces during training. These results demonstrate that the model improves its performance as the training progresses.

[2] Gesture Detection Using Threshold and LSTM

In the proposed system, gesture recognition is achieved using data collected from four flex sensors mounted on the index, middle, ring, and little fingers of the glove. These sensors generate analog signals that vary according to the bending of each finger. The signals are read by the ESP32 microcontroller through its analog input pins and converted into digital values for processing.

One approach used for gesture identification is the **threshold-based method**. In this technique, a specific threshold value is defined for each flex sensor. When a finger bends, the sensor output increases and is compared with the predefined threshold. If the measured value exceeds this limit, the system recognizes the corresponding gesture. For instance, when the sensor value of the middle finger crosses the threshold, the system may interpret the gesture as "Water," while other finger movements represent different predefined messages. This method is simple to implement, computationally efficient, and suitable for real-time applications.

In addition to the threshold approach, an LSTM-based gesture recognition method is also employed. For this method, sensor readings collected from multiple participants are organized and labeled to form a dataset. The Long Short-Term Memory (LSTM) model is trained using this dataset so that it can learn the patterns associated with different finger movements. During system operation, real-time sensor values are provided to the trained LSTM model, which analyzes the input pattern and predicts the appropriate gesture.

Thus, the system is capable of recognizing gestures using either the threshold-based technique or the LSTM-based model. While the threshold method provides a straightforward rule-based solution, the LSTM model offers improved accuracy and better adaptability to variations in user hand movements.

5. HEALTH MONITORING

The proposed system also includes a health monitoring module to track important physiological parameters of the user. This module uses sensors such as the MAX30102 and LM35 to measure vital signs in real time.

The MAX30102 sensor is used to monitor heart rate and blood oxygen saturation (SpO₂). It works by emitting light through the skin and detecting the amount of light absorbed

by the blood, which helps estimate the pulse rate and oxygen level. At the same time, the LM35 temperature sensor measures the body temperature and produces an analog voltage proportional to the temperature.

The ESP32 microcontroller continuously reads the data generated by these sensors and processes the values to determine the user's health condition. The measured parameters are then compared with predefined normal ranges. If the values remain within the normal limits, the system continues monitoring the user's health status. However, if any abnormal condition such as irregular heart rate, low oxygen level, or high temperature is detected, the system generates a health alert.

This monitoring process runs continuously, enabling the system to provide real-time observation of the user's vital signs and ensuring timely alerts in case of abnormal health conditions.

6. DESIGN AND IMPLEMENTATION

The operation of the proposed system follows the sequence shown in the flowchart. The process begins when the system is powered on. After power activation, the ESP32 microcontroller is initialized to control the overall functioning of the system.

Once the microcontroller is ready, the sensors connected to the system are initialized. The flex sensors attached to the fingers are prepared to measure finger bending. These sensors generate analog signals based on the movement of the fingers.

The ESP32 continuously reads the sensor values through its analog input pins. After collecting the sensor readings, the system checks whether a gesture has been performed. If no gesture is detected, the system continues monitoring the sensor values.

When a gesture is detected, the system analyzes the sensor pattern to identify the specific gesture. After recognizing the gesture, the corresponding predefined text message is generated and sent for communication.

Finally, the system repeats the same process continuously to detect gestures in real time and allow users to communicate effectively through hand movements.

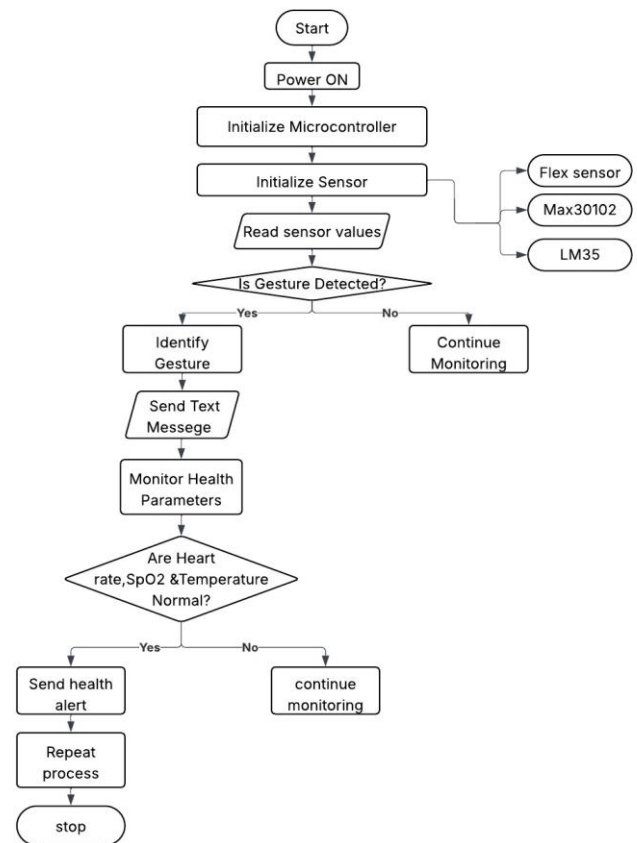


Fig 4: Flowchart of the proposed gesture-based communication and health monitoring system.

FUTURE SCOPE

The proposed system can be further improved by enhancing both the hardware and software components. In the future, additional sensors and advanced machine learning techniques can be integrated to improve the accuracy of gesture recognition and support a larger number of gestures. The system can also be expanded to recognize complete sign language sentences instead of only basic words or phrases.

Another possible improvement is the development of a dedicated mobile application and a more advanced web interface for better visualization and data management. Voice output features can also be integrated so that the recognized text messages can be converted into speech, making communication even more effective. In addition, the device can be made more compact and wearable by using smaller components and wireless modules. These improvements can make the system more reliable, user-friendly, and suitable for real-world applications in assisting people with speech and hearing impairments.

7. RESULTS

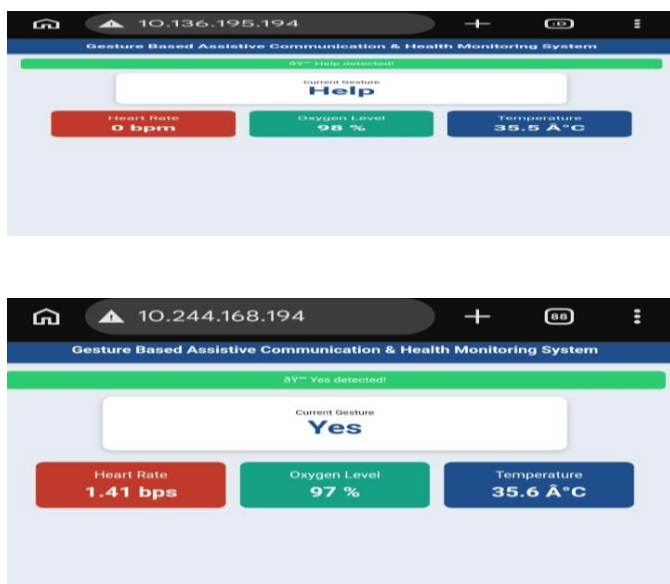
The system successfully converts hand gestures into text messages that are displayed on a mobile phone. When the user performs a gesture, the flex sensors detect the bending

of the fingers and send the corresponding signals to the microcontroller. The software processes these signals using the recognition method and identifies the intended gesture. After recognition, the system generates the corresponding message and sends it to the smartphone through a wireless communication module.

The received message appears on the mobile phone screen, allowing others to easily understand the user's communication. During testing, several gestures representing different words and phrases were performed, and the correct messages were displayed on the phone. The results show that the system can effectively translate hand gestures into readable messages, enabling easier communication for individuals with speech or hearing difficulties.

7.1 SOFTWARE OUTPUT

Results obtained in web server:



7.2 HARDWARE OUTPUT



Fig: Hardware outlook

3. CONCLUSIONS

The proposed system provides an effective solution for gesture-based communication using flex sensors and an ESP32 microcontroller. Finger movements are detected and converted into text messages, allowing easier interaction for users with speech or hearing difficulties. In addition, the system monitors important health parameters such as heart rate, SpO₂, and body temperature. The integration of gesture recognition and health monitoring in a single wearable device demonstrates a practical and reliable approach for improving communication and user safety.

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BIOGRAPHIES



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